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Assessment of Pre and Intraoperative Indications of Salter Innominate Osteotomy in Developmental Dysplasia of hip (DDH) in Children Aged (18-36) Months

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Abstract: Background**:** The management of developmental dysplasia of the hip aims for early diagnosis and treatment. It is claimed that adequate acetabular remodelling is possible only during the first18 months of life. After this, satisfactory development cannot always be assured by non-operative treatment following closed reduction (Salter and Dubos 1974). Innominate osteotomy was originally designed for children with delayed presentation of developmental hip dysplasia and those in whom earlier treatment had failed to produce remodeling (Salter 1961). Reorientation of the acetabulum makes the reduced hip more stable, increases the load-bearing area of the acetabulum in the weight-bearing position, and does not alter its shape or volume. Aims of study**:** 1-Assess the accuracy of pre-operative acetabular index (AI) measure as an indicator of salter osteotomy in comparing with the intraoperative assessment regarding the stability of the hip in children aged (18—36)months. 2-compare the results of open reduction with and without salter's osteotomy in the management of developmental dysplasia of hip(DDH) in this age group. Patients And Methods**:** Sixty one patients,(82)hips involved with developmental dysplasia of the hip. they were treated by open reduction with or without salter innominate osteotomy in AL-wasity teaching hospital from November 2015 to November 2017. The mean period of follow up was 17.2 months. we include patients aged 18--- 36 months. children with neuromuscular disease and children with recurrent dislocation after previous open reduction were excluded.Of the (61)patients there were(52)girls and (9) boys,(36)bilateral(15 of them operated unilateral and 21 operated bilateral) and (25)unilateral (9 right and 16 left). Results:1-acetabular dysplasia is confirmed when the pre-operative acetabular Index(AI)IS more than 30 , which is found to be a weak indicator for salter's osteotomy, in contrast with the intraoperative indications of it. 2-The results revealed that the mean value of the acetabular index was significantly reduced($p \leq 0.05$) after one year of surgery with two modalities of surgery, where the mean value of acetabular index was reduced from 33.8 to 27.5 with open reduction technique while it was reduced from 39.7 to 23.1 with salter technique. 3-The results revealed there was a significant difference in the mean value of CEA between the two types of surgeries and that of Salter technique was higher than of open reduction(p-value0.03). 4-The results showed nearly similar outcomes and no significant difference was reported according to MC key when the outcome assessed in term of excellent, good and fair between the open reduction and salter open reduction groups. 5- the postoperative radiological results according **to** Severin grades are, grade I;1.2%of total (1.8% in group 2),grade II; 85.4%(88.0% in group 1 and 84.2%in group 2), grade III; 9.8% of total(4.0%in group 1 and 12.2% in group 2) and in grade IV; 3.6% of total(8.0% in group 1 and 1.8% in group 2) despite this difference it is not significant (p-value 0.7). 6-The finding showed there was no significant difference(p=0.2) between two modalities of surgery regarding the associated complication. Conclusion:-1-The preoperative radiological measures (AI) which determine acetabular dysplasia, is a weak indicator for the need of salter inomenate osteotomy. 2-the intraoperative test of stability is found to be a reliable indicator for pelvic osteotomy (salter) to achieve a stable hip. 3-Open reduction in association with osteotomy of the iliac bone as described by Salter presented a statistically significant improvement in the angular parameters measured on the patients' radiographs, from before to after the operation. 4-Reorientation of the acetabulum makes the reduced hip more stable, increases the load-bearing area of the acetabulum in the weight-bearing position. 5-Avascular necrosis (AVN) and residual acetabular dysplasia are the two main complications of developmental dysplasia of the hip (DDH) treatment.

Keywords: DDH, open reduction, salter osteotomy, stability test, clinical and radiological assessment.

INTRODUCTION

Developmental dislocation of the hip (DDH) is a gradually progressive disorder that is associated with distinct anatomic changes, many of which are initially reversible. It is a malformation of anatomic structures that have developed normally during the embryologic period. Relatively gentle forces, persistently applied, are probably the cause of such deformations. [Dunn, P. M, 1976]

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DDH generally includes subluxation (partial dislocation) of the femoral head, acetabular dysplasia, and complete dislocation of the femoral head from the true acetabulum.

In a newborn with true congenital dislocation of the hip, the femoral head can be dislocated and reduced into and out of the true acetabulum. In an older child, the femoral head remains dislocated and secondary changes develop in the femoral head and acetabulum. [Kelly, D, 2013]

EPIDEMIOLOGY

Developmental dislocation of the hip (DDH) is one of the most frequent deformities in children. [Ning, B. *et al*., 2014]

Most newborn screening studies, usually based on physical examination techniques, suggest that some degree of hip instability can be detected in 1 in 100 to 1 in 250 babies. Actual dislocated or dislocatable hips are much less frequent, being found in 1 to 1.5 of 1,000 live births. Late presentation of developmental dysplasia of the hip (DDH) is found in approximately 4 per 10,000 children. [Vaccaro, A. R]

ETIOLOGY

The etiology of DDH is known to be due to both genetic and environmental factors. [Crawford, H, 2012]The left hip is more affected (60%) and the right hip is less affected (20%) in situations of unilateral disorders, while bilateral disorders are less frequent (20%).[Guarniero, R, 2010]

The risk factors for DDH include:- female sex, ligamentous laxity, white skin color, primiparity, young mothers, breech presentation at birth, family history, oligohydramnios, newborns with greater weight and height, newborns with deformities of the feet or spine and postnatal positioning (swaddling). [Crawford, H, 2010][Guarniero, R, 2010]

Ligamentous Laxity

The newborn’s response to maternal relaxin hormones may explain the higher incidence of DDH among girls. These hormones, which produce the ligamentous laxity that is necessary for the expansion of the maternal pelvis, cross the placenta and induce laxity in the infant. This effect is much stronger in female than in male children. [From Tachdjian’s pediatric orthopedics, 4thedition, 2008]

Wynne Davies in 1970 proposed that hereditable ligamentous laxity was one of two major mechanisms for the inheritance of DDH. She believed this was an autosomal dominant characteristic with incomplete penetrance. [Wynne-Davies, R, 1970]

In SS. coleman's study of Navajo families hip dysplasia in one family member increased the risk for other family members five times.[Coleman, S. S, 1968]

Newborns with DDH have also been found to have a higher ratio of collagen 3 to collagen 1 than control subject, suggesting a connective tissue abnormality in those with DDH.[Jensen, B. A. *et al*., 1986]

In a study of laxity by distraction of the symphysis pubis, infants with DDH had twice the amount of distraction of the symphysis as control subjets.[Andren, L, 1962]

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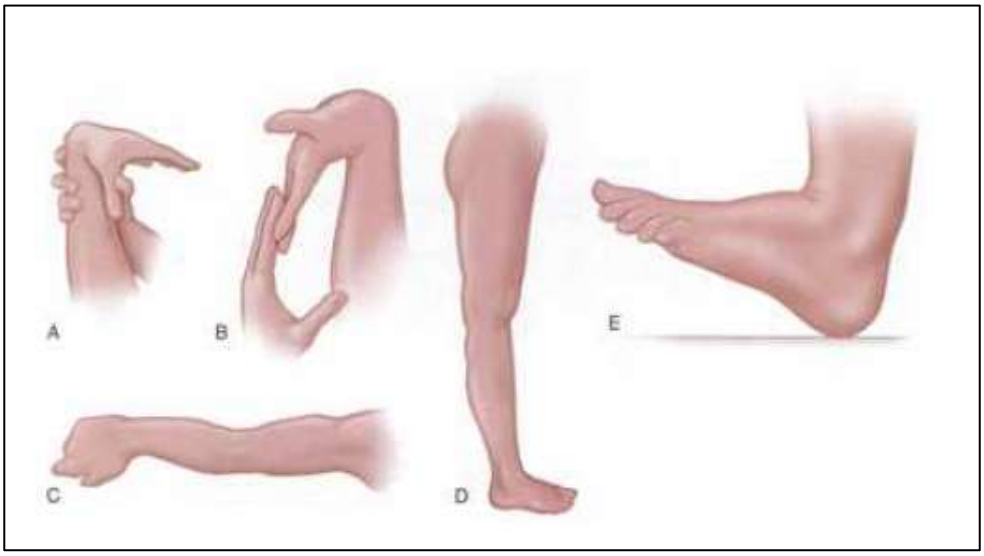

Figure 1-1: Wynne –Davies' criteria for ligamentous laxity. A, Flexion of the thumb to touch the forearm. B, Extension of the fingers parallel to the forearm. C, Hyperextension of the elbow 15 degrees or more. D, Hyperextension of the knee 15 degrees. E, dorsiflexion of the ankle 60 degrees (From Tachdjian's pediatric orthopedics, 4thedition, 2008,Vol 1.P.640).

2. Prenatal positioning is strongly associated with DDH

Muller and Seddon found that 16% of infants with DDH were born in breech presentation.[Muller, G. M. *et al*., 1953]The breech effect is most notable when the knees are extended, with an incidence of 20% for a frank breech, on other hand the footling breech position, in which the single hip is flexed is associated with only a 2% incidence of DDH. [Suzuki, S. *et al*., 1986]

Artz and associates reported a 7.1% incidence of unstable hips in girls born in breech presentation. [Artz, T. D. *et al*., 1975]

The incidence of DDH is also higher in first-born children, twins, and in pregnancies complicated by oligohydramnios [Carter, C. O. *et al*., 1960]. These findings suggest that there is an intrauterine crowding effect on the developing hip. This argument is bolstered by an increased incidence of other postural abnormalities (torticollis, metatarsus adductus) in children with DDH.[Carter, C. O. *et al*., 1964][Hummer, C. D. *et al*., 1972][Kumar, S. J. *et al*., 1982]

Clubfoot has not been shown to have a significant relationship to DDH while calcaneovulgus shows some association. [Westberry, D. E. *et al*., 2003]
Left hip is more often involved than the right. Because the most common intrauterine position has the left hip adducted against the maternal sacrum.[Dunn, P. M, 1976]

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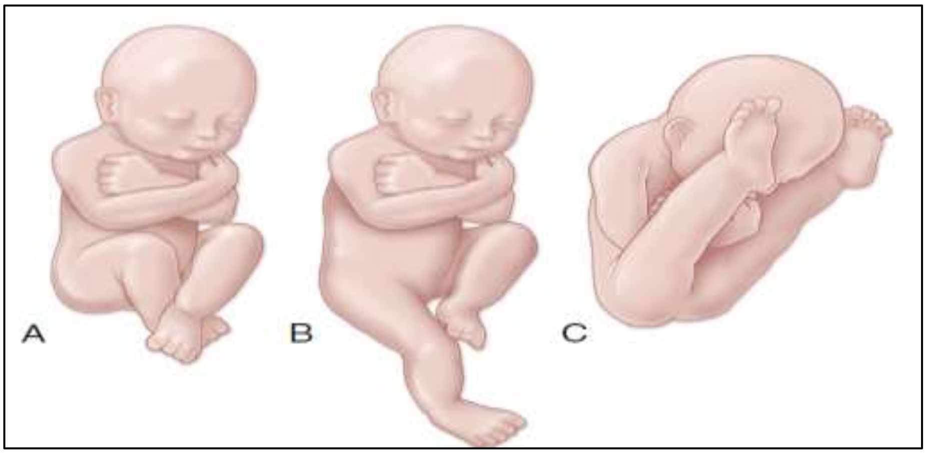

Figure 1-2: The breech position, associated with developmental dysplasia of the hip (DDH). A: A double breech position is associated with a low incidence of DDH. B: A single footling breech is associated with a 2% risk of DDH. C: A frank breech, especially with the knees extended, is associated with a 20% risk of DDH. (From Tachdjian's pediatricorthopaedics,4th edition, 2008, Vol 1.P.640)

3- **Postnatal Positioning:**
People who wrap their newborn babies in a hip-extended position, such as native Americans also in Iraq who use cradleboard have much higher incidence of DDH than other populations.the mechanism of action is believed to be a placement of the hips in full extension against the normal neonatal hip flexion contracture.[Herring, J. A. *et al*., 1983](Fig 1-3).

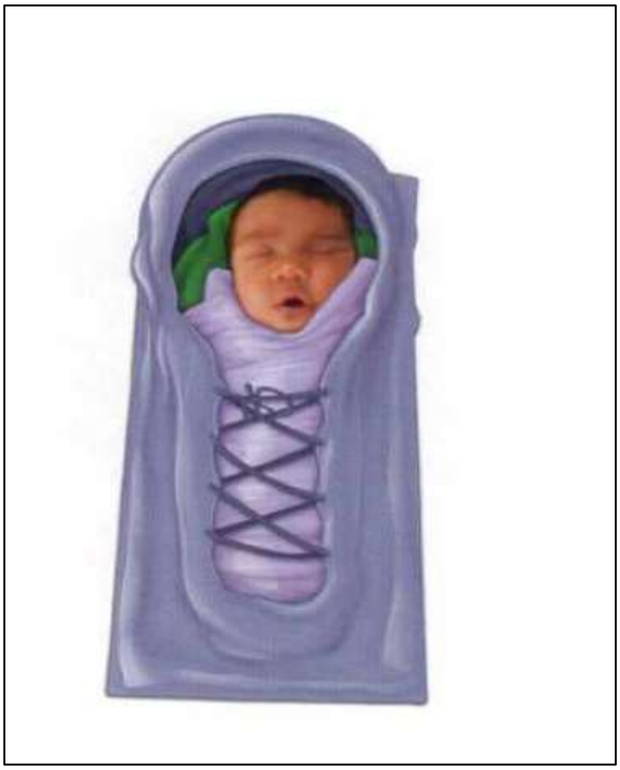

Figure 1-3: Postnatal positioning in extension, as in this child on Iraq cradleboard, contributes to developmental dysplasia of the hip. (From Tachdjian's pediatric orthopedics,4th edition, 2008, Vol 1.P.641).

4. Racial predilection
Blacks and Asians have relatively low incidences of DDH, whereas Whites and Native Americans have a higher incidence. [From Tachdjian’s pediatric orthopedics, 4thedition, 2008]

Classification:
1- Teratogenic type: occurs early in fetal life and result in severe Acetabular dysplasia, usually bilateral and associated with another congenital deformity. It is found in arthrogryposis, myeloid

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dysplasia, hypotonia[Ferguson, A. L, 1975].It will be considered no more in this study.

2- Developmental hip dislocation: this characterized by the ability of the new borns femoral head to dislocate or reduce into and out of the true acetabulum. In older child the femoral head remains dislocated from the true acetabulum and secondary changes develop, such as inverted labrum, abnormal ligamentum teres, and joint capsule laxity.[Bennett, G. C, 1987]

3- Dislocation due to acetabular dysplasia: here the hips not dislocated at birth, but subluxated and dislocated during growth,especially at weight-bearing age, due to shallow slanting of the acetabulum. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

PATHOPHYSIOLOGY

Normal Hip Development

The hip joint begins to develop at approximately the seventh week of gestation. The concave shape of the acetabulum is determined by the structure (femoral head) within the acetabulum. [Crawford, H, 2010][Watanabe, R. S, 1974][Fuller, D, 1974]

The labrum also contributes significantly to the development of acetabular depth; thus any excision of the labrum during the treatment of DDH is ill-advised. [Weinstein, S. L, 20000]In DDH this labrum has a disadvantage because of it's enfolding into the joint causing obstruction and preventing reduction.[Mac Ewen, D, 1987]

The proximal femur has a complex and often misunderstood growth pattern. The development of the proximal segment of the femur occurs through a combination of appositional growth and epiphyseal growth.[Siffert, R. S, 1981]

In the normal femur, an ossification center appears in the center of the femoral head between the fourth and seventh months of postnatal life. This center grows until physeal closure during late adolescence.

Excessive pressure on the cartilaginous upper femur can cause a loss of vascular perfusion, which results in the necrosis of the chondrocytes.

Muscle imbalance can also significantly affect the growth and morphology of the upper femur. Excessive adductor pull or inadequate abductor muscle function results in a valgus deformity of the upper femur. [Gage, J. R. *et al*., 1980][Schofield, C. B. *et al*., 1990]

Hip Development with Developmental Dysplasia of the Hip

At birth, the affected hip will spontaneously slide into and out of the acetabulum. For this to occur, the posterosuperior rim of the acetabulum has to have lost its sharp margin and become flattened (fig. 1-4).

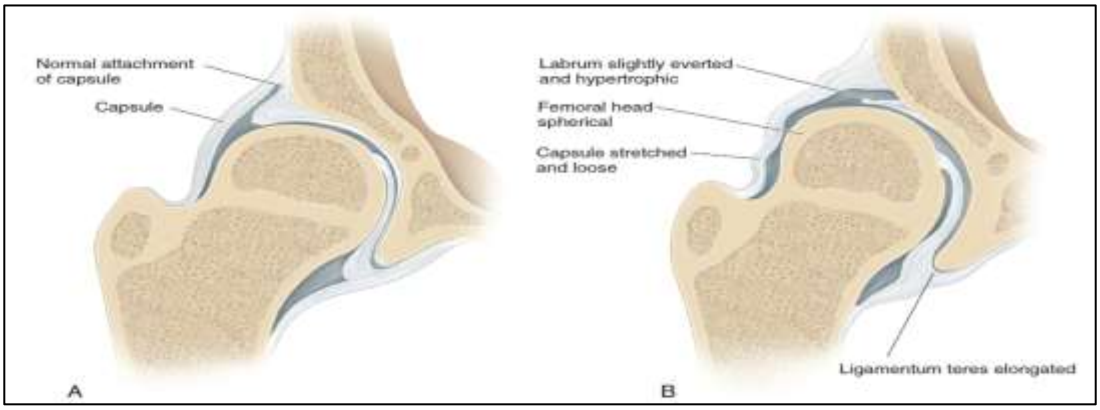

Fig. 1-4 Pathology of the **unstable** hip

The sliding of the head in and out produces a"clunk" by the neolimbus (a ridge of thickened articular cartilage arises along the posterosuperior acetabular wall)(fig. 1-5). [Ponseti, I. V, 1978][Ponseti, I. V, 1978]

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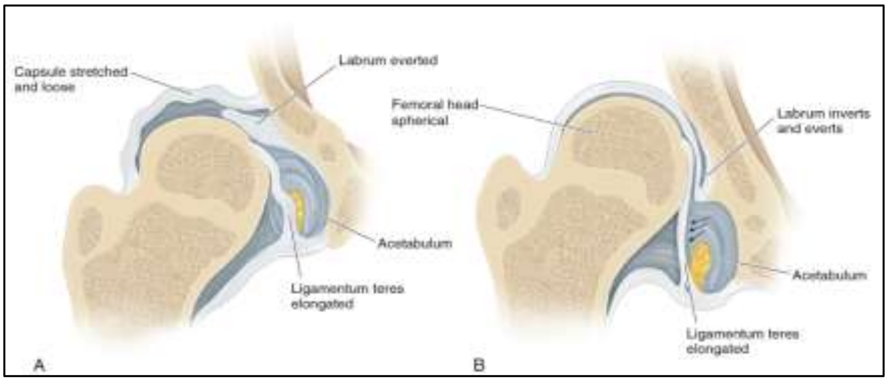

Fig. 1-5 Pathology of the **dislocatable** hip

Some hips that are unstable at birth spontaneously reduce and become normal, with complete resolution of the aforementioned anatomic changes. Other hips eventually remain out of the socket permanently, and many secondary anatomic changes take place gradually:

●Pulvinar (fatty tissue in the depths of the acetabulum) thickens and may impede reduction (Fig. 1-6).

●The ligamentum teres also elongates and thickens.

●The transverse acetabular ligament is often hypertrophic as well, and it may impede reduction.

● More important, the hourglass shape of the inferior capsule of the hip leading to a smaller opening in diameter than the femoral head. The tight iliopsoas contributes to this narrowing (Fig. 1-7). [Ishii, Y. *et al*., 1980]

The femoral changes are minimal and include an increase in anteversion and some flattening ofthe femoral head as it lies against the ilium.

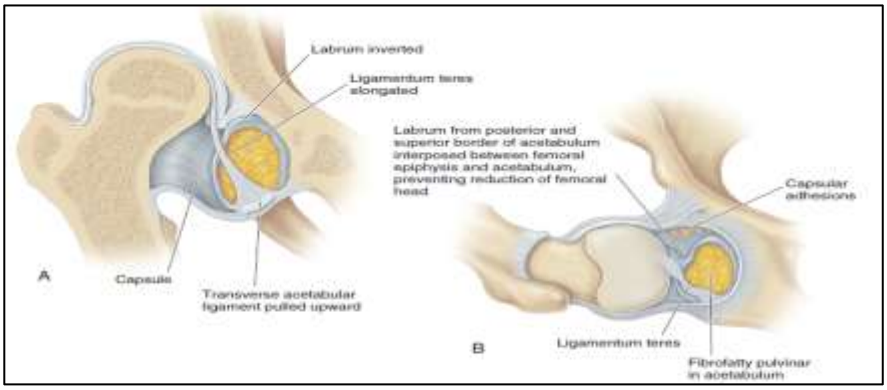

Fig. 1-6 Pathology of the dislocated hip that is irreducible as a result of intraarticular obstacles.

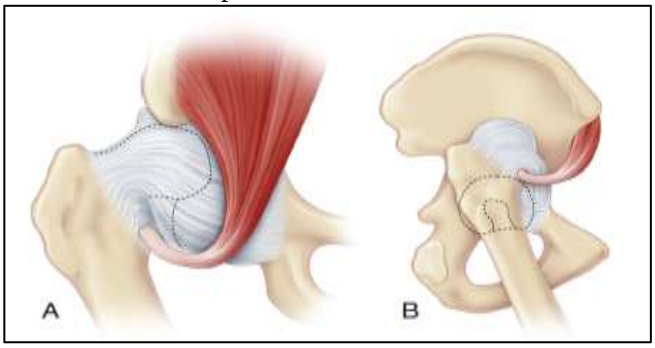

Fig. 1-7 the iliopsoas tendon as an obstacle to closed reduction. **A** Anterior view.**B**, Lateral view

It is extremely important to realize that the acetabular structure is not impeding the femoral head from entering the acetabulum. Rather, the constricted hip capsule is forcing the head against the acetabular rim and it tends to push this rim into the acetabulum.

After the femoral head has been reduced, the thickened acetabular rim may still impede the deep

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seating position of the femoral head. If the reduced position is maintained, the thickened acetabular rim gradually flatten out and allow the head to seat deeply. Known clinically as "docking the head," this was described by Severin in 1941. [Severin, E, 1941]

The femoral head itself is usually deformed into a globular shape as a result of pressure against the lateral portion of the acetabulum, and it may not be congruous with the acetabulum at the time of reduction; however, this anatomic situation also eventually resolves if the reduction is maintained. [Ishii, Y. *et al*., 1980]

When a stable reduction is obtained, the acetabulum gradually remodels(increases the depth of the acetabulum, and the acetabular angle gradually becomes more horizontal). During the acetabular remodeling period, secondary ossification centers often appear prematurely in the acetabulum. [Weinstein, S. L, 2000]

If the hip remains dislocated, additional changes occur during the growth and development of the acetabulum.

●The acetabular roof becomes progressively more oblique.
●The concavity gradually flattens, and the medial wall of the acetabulum thickens (seen radiographically as a thickening and alteration of the shape of the teardrop body).
●Excessive anteversion of the acetabulum, thus providing diminished coverage of the femoral head. [Ludloff, K, 1913]

To a point, these changes are reversible, but the exact upper age at which hip reduction will result in normal acetabular development is uncertain. Harris suggested that a hip reduced by the time a patient was 4 years old could achieve "satisfactory" acetabular development. He found that significant acetabular growth continued through 8 years of age. [Harris, N. H, 1976].

The muscles that insert at the proximal femur are foreshortened and more horizontally oriented (Fig. 1-8).

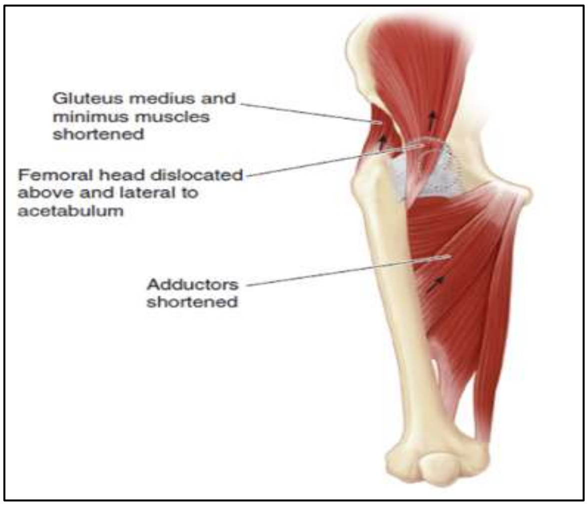

Fig. (1-8)

NATURAL HISTORY

If the diagnosis of DDH is missed at birth, the resultant scenarios of the affected hip are as follows:

- It can become **normal**
- It can become **subluxated**(Subluxation is used when the femoral head is not in full contact with the acetabulum. The radiographic findings of subluxation include a widened teardrop femoral head distance, a reduced center-edge angle, and a break in the Shenton line).
- It can become completely **dislocated**(Dislocation specifies that the femoral head is not in contact with the acetabulum).
- It can remain reduced with **acetabular dysplasia**(Dysplasia refers to a radiographic finding of increased obliquity and the loss of the concavity of the acetabulum, with an intact Shenton line)

Dysplasia is a direct result of abnormal forces across the acetabulum. The lateralization of the femoral head results in increased forces over a smaller unit area with an increase in the sheer

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vector. Increased sheer vectors affect the physes of the acetabulum.[Crawford, H, 2010]

Cooperman and associates reported that all dysplastic hips without subluxation with a center-edge angle of fewer than 20 degrees sustained osteoarthritic changes over 22 years of follow-up [Cooperman, D. R. *et al*., 1983]

In the long term, the natural history of early hip degenerative disease will depend on:

● **Presence or absence of a false acetabulum:** The presence of a false acetabulum predisposes the 'joint' to an early degenerative changes, which in turn produces pain and reduced range of motion.

● **Bilaterality:** Generally bilateral dislocations have a better range of motion with less gait abnormality. They, however, develop hyperlordosis, which can lead to lower back pain. Unilateral dislocation can develop limb length inequality, ipsilateral valgus knee deformity with a laxity of the medial collateral ligament, degenerative changes in the lateral compartment of the ipsilateral knee, gait disturbances and secondary scoliosis.

● **Hip congruency:** Subluxed hips will develop an early degenerative disease in all patients by the third or fourth decade of life. Even in hips that are well reduced but show acetabular dysplasia, this will eventually lead to subluxation and its consequences as described above. Although dislocated hips with a false acetabulum can also develop degenerative changes, it is less severe with a later onset than those with subluxated hips.[Crawford, H, 2010]

FIG.1-9 Dysplastic hip

fig.1-10 subluxated hip

CLINICAL EXAMINATION:

Physical examination findings according to age in developmental dysplasia of the hip joint[From Tachdjian's pediatric orthopedics, 4thedition, 2008]:

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NEONATE	WALKING CHILD
Dislocatable	Remains dislocated
Reducible	Klisic sign
Klisic sign	Decreased abduction
INFANT	Galeazzi sign
Dislocatable (occasionally)	Limp
Reducible (occasionally)	Short leg
Klisic sign	Increased lordosis (bilateral)
Decreased abduction	
Galeazzi sign	

Neonate (up to one month): Dislocatable(Barlow's test), Reducible(Ortolani's test), klisic's sign[From Tachdjian's pediatric orthopedics, 4thedition, 2008]

(Fig 1-11).

Figure 1-11: klisic's sign (the examiner places the middle finger over the greater trochanter,and the index finger on the anterior superior iliac spine, A: with a normal hip an imaginary line drawn between the two fingers points to the umbilicus. B: When the hip is dislocated the trochanter is elevated and the line projects halfway between the umbilicus and the pubis).. (From Tachdjian's pediatric orthopedics,4th edition,2008, Vol 1.P.637-674).

Infant (up to one year): Barlow's test (Dislocatable,occasionally),Ortolani's test (Reducible occasionally) , klisic's sign ,Decreased abduction , Galeazzi's sign (apparent shortening of the femur ,as shown by the differences in knee levels as assessed in a child lying on a firm table with the hips and knees flexed at right angles) , Asymmetry of the thigh folds and of the popliteal and gluteal creases.[From Tachdjian's pediatric orthopedics, 4thedition, 2008]

Walking child

The unilateral dislocated hip produces distinct clinical signs in a walking child. Although some authors have suggested that children with DDH are late to start walking, more recent studies have shown no significant delay. [Dunn, P. M, 1990][Kamath, S. U. *et al*., 2004]

The affected side appears to be shorter than the normal extremity, and the child toe-walks on the affected side. With each step, the pelvis drops as the dislocated hip adducts, and the child leans over the dislocated hip; this is known as an abductor lurch or Trendelenburg gait.

As in the younger child, there is limited abduction on the affected side, and the knees are at different levels when the hips are flexed (Galeazzi) sign.In the walking child, bilateral dislocation is more difficult to recognize than a unilateral dislocation. There is usually a lurching gait on both sides, but some children mask this rather well, showing only

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an increase in the dropping of the pelvis during the stance phase .

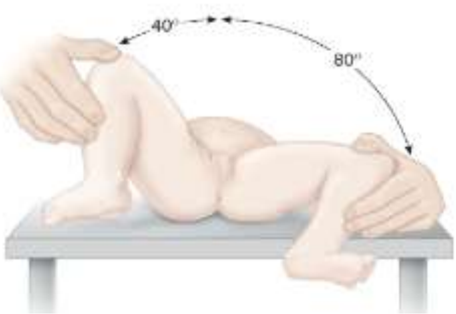

Fig. 1-12 13 Limited abduction

Fig. 1-13 galeazzi sign

Excessive lordosis is common, and it is often the presenting complaint. The lordosis is the result of hip flexion contracture, which is usually present. The knees are at the same level, and abduction is symmetric but limited. There is usually an excessive internal and external rotation of the dislocated hips. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

Radiographic Evaluation
Radiography

Plain radiography of the pelvis usually demonstrates a frankly dislocated hip in individuals of any age, in newborns with typical DDH, however, the unstable hip may appear radiographically normal. As the child reaches 3 to 6 months of age, the dislocation will be evident radiographically, but the examiner must be familiar with the landmarks of the immature pelvis to recognize the abnormality.

Several classic lines are helpful in evaluating the immature hip (fig. 1-14).[From Tachdjian's pediatric orthopedics, 4thedition, 2008]

Another useful measurement is the acetabular index. It averages 27.5 degrees in normal newborns, and it decreases with age. At 6 months of age, the mean is 23.5 degrees. By 2 years of age, the index usually decreases to 20 degrees. Thirty degrees is considered the upper limit of normal (fig. 1-15). [Hensinger, R. N, 1986][Kleinberg, S. *et al*., 1936]

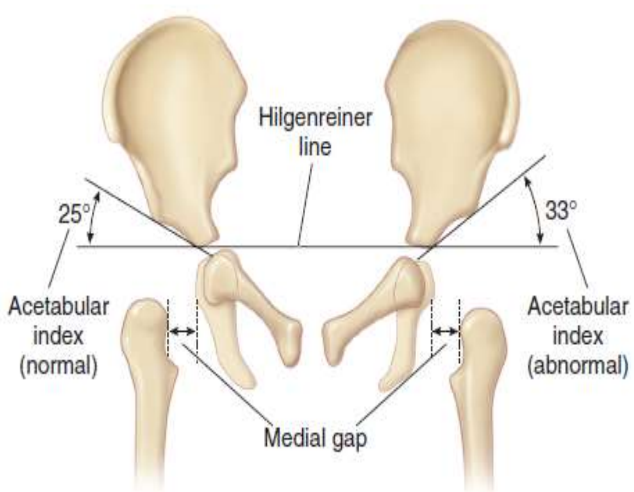

fig. 1-14

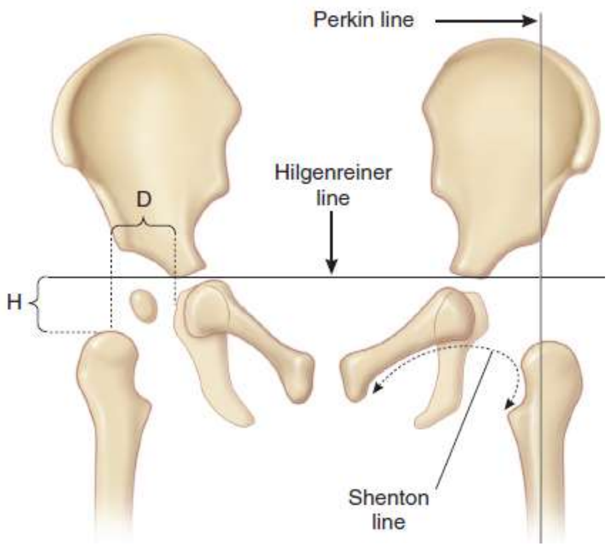

fig. 1-15

A helpful radiographic projection is the Von Rosen view, in which both hips are abducted, internally rotated, and extended. [Von Rosen, S, 1956] In the normal hip, an imaginary line extended up the femoral shaft intersects the acetabulum. When the hip is dislocated, the line crosses above the acetabulum.

Another measure of acetabular dysplasia is the acetabular index of depth to width in which the depth of the central portion of the acetabulum is divided by the width of the acetabular opening, with normal being more than 38%. [Murphy, S. B. *et al*., 1995]

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The femoral head extrusion index represents the percentage of the femoral head that lies outside of the acetabulum (fig 1-16).

The increase in carcinogenic risks from the cumulative radiographs taken to manage an average DDH case has been estimated to be less than 1%. [Bone, C. M, 2000]

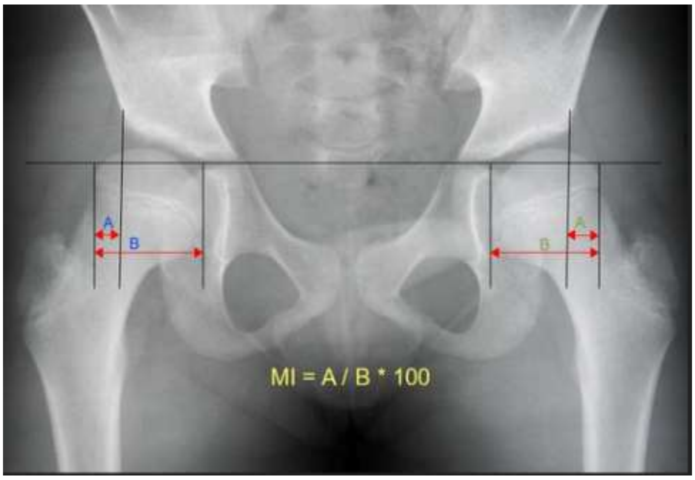

fig 1-16

ULTRASONOGRAPHY

The neonate's hip is a difficult structure to image with standard radiographic techniques because the hip is composed primarily of cartilaginous tissues. Ultrasonography shows the soft anatomy of the hip and the relationship of the femoral head and acetabulum very well. [Graf, R, 1984]

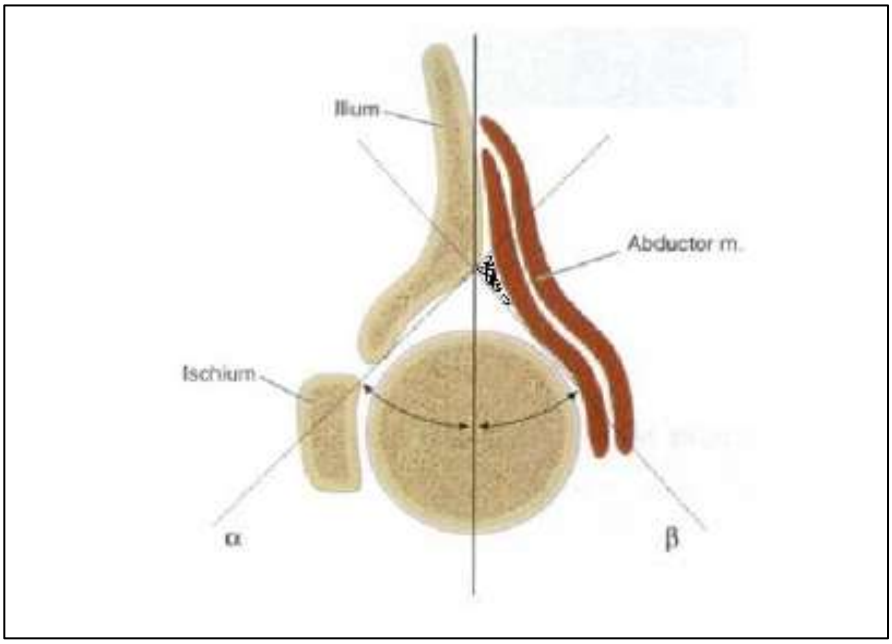

Figure 1-17: Measurement of alpha (α) and beta (β) angles on ultrasonography the alpha angle is the angle between the baseline and the roof of the bony acetabulum. The beta angle is the angle between the baseline and the cartilaginous acetabular roof. (FromTachdjian's pediatric orthopedics,4th edition,2008, Vol 1.P.656).

Arthrography

The arthrographic anatomy of the hip was well described by Severin in 1941. Arthrography is helpful in determining:-

(1) Whether mild dysplasia is present,

(2) Whether the femoral head is subluxated or dislocated,

(3) Whether manipulative reduction has been or can be successful,

(4) To what extent any soft structures within the acetabulum may interfere with complete reduction of the dislocation,

(5) The condition and position of the acetabular labrum (the limbus), and

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(6) Whether the acetabulum and femoral head are developing normally during treatment.[Kelly, D, 2013][Severin, E, 1941]

Magnetic Resonance Imaging
Magnetic resonance imaging affords excellent anatomic visualization of the infant's hip but is not commonly used because of the expense involved and the need for sedation.[Kelly, D, 2013]

Treatment
Aims of treatment

- Obtain a concentric reduction
- Maintain stability of the hip
- Stimulate normal growth and development of the hip
- Prevent complications

Age-based guidelines for treatment of Developmental Dysplasia of the Hip:
Neonate: place in Pavlik harness for 6 weeks. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

1 to 6 months: place in Pavlik harness for a time approximately equal to the age at which stability is attained plus 2 months.[Kelly, D, 2013]

6 to 18 months: traction? , a closed reduction.if closed reduction is successful, place in a cast for 3 months. If closed reduction is unsuccessful perform the open reduction. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

18 to 36 months (toddler): For these children with well-established hip dysplasia, open reduction with femoral or pelvic osteotomy, or both, often is required. Persistent dysplasia can be corrected by a directional proximal femoral osteotomy in very young children. If the primary dysplasia is acetabular, pelvic redirectional osteotomy alone is more appropriate.

Many older children require femoral and pelvic osteotomies if significant deformity is present on both sides of the joint. [Kelly, D, 2013]

Open Reduction
An open reduction is needed if:
(1) Closed reduction fails (primary indication);
(2) If after closed reduction the hip remains very unstable;
(3) If stability after closed reduction can only be achieved by holding the hip in an extreme degree of abduction or internal rotation; or
(4) If the reduction is not concentric.

This surgical option is indicated by pathology rather than by age because open reduction may be required in children younger than 6 months and closed reduction occasionally can be successful in children 18 months old. [Kelly, D, 2013]

In this age group, the goals of treatment should be to:

- remove the blocks of reduction with releases of the adductor longus and the iliopsoas for the extra-articular blocks and address the intra-articular blocks listed above by opening the hip joint
- openly reduce the hip; it is important that the reduction is carried out without any tension as it may result in AVN
- maintain the reduction; this can be achieved with a good capsulorrhaphy. [Crawford, H, 2010]

Open reduction can be performed through an anterior, anteromedial, or medial approach; the choice depends on the experience of the surgeon and the particular dislocation.[Kelly, D, 2013]

The anatomical blocks to a reduction would be:

- Extra-articular blocks: (adductor longus and iliopsoas)
- Intra-articular blocks (in order of decreasing Importance):

(The hourglass joint capsule, hypertrophied ligmentum teres, transverse acetabular ligament, inverted labrum, and pulvinar). [Crawford, H, 2010]

The anterior approach
Affords better exposure and allows the surgeon to perform a capsulorrhaphy and pelvic osteotomy can be performed through this approach if necessary. [Kelly, D, 2013][From Tachdjian's pediatric orthopedics, 4thedition, 2008]

The medial (Ludloff) approach
Utilizes the interval between the iliopsoas and the pectineus, minimal dissection is required with this approach, and the obstructions to reduction are encountered directly. The disadvantages of the medial approach are a limited view of the hip, the possible interruption of the medial femoral circumflex artery(has been reported to be associated with a higher incidence of osteonecrosis10% to 15%), and the inability to perform a capsulorrhaphy.[Kelly, D, 2013][From Tachdjian's pediatric orthopedics, 4thedition, 2008]

If there is an inverted limbus, medial pulvinar or large ligamentum teres, then the medial approach is contraindicated.

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The anteromedial
Approach described by Weinstein and Ponseti actually is an anterior approach to the hip through an anteromedial incision. The hip is approached in the interval between the pectineus muscle and the femoral neurovascular bundle. This approach is recommended for children 24 months old or younger. Access to the lateral structures for dissection or osteotomy is impossible with this approach.[Kelly, D, 2013]

Concomitant Osteotomy
The use of a concomitant osteotomy of the ilium, acetabulum, or femur at the time of open reduction remains controversial. Innominate osteotomy, acetabuloplasty, proximal femoral varus derotation osteotomy, or femoral shortening osteotomy might increase the stability of open reduction.

Zadeh *et al*. used concomitant osteotomy at the time of open reduction to maintain stability of the reduction in whom the following test of stability after open reduction was used

1. Hip stable in neutral position—no osteotomy
2. Hip stable in flexion and abduction—innominate osteotomy
3. Hip stable in internal rotation and abduction—proximal femoral derotational varus osteotomy
4. Hip stable in flex, internal rotation, and abduction—innominate osteotomy with or without proximal femoral varus derotational osteotomy
5. Double-diameter" acetabulum with anterolateral deficiency—Pemberton-type osteotomy. [Zadeh, H. G. *et al*., 2000]

Aside from the need for osteotomy at the time of open reduction to maintain stability, there also are concerns about residual acetabular dysplasia. Better results have been reported in children younger than 30 months of age who were treated with combined open reduction and Salter osteotomy than in those treated with a staged procedure. Concomitant osteotomy should be done at the time of open reduction when necessary to maintain a safe, stable reduction. If open reduction is stable without an osteotomy, a bony procedure for residual deformity should be considered at the time of the open reduction in an older child (>18 months) and used with caution even in younger infants when needed.[Kelly, D, 2013][Zadeh, H. G. *et al*., 2000]

Pelvic Osteotomy
Operations on the pelvis, alone or combined with open reduction, are useful in congenital dysplasia or dislocation of the hip to ensure or to increase stability of the joint.

In an older child, a pelvic osteotomy can be combined with femoral osteotomy to correct femoral and acetabular abnormalities. [Kelly, D, 2013]

Osteotomy of the innominate bone (Salter)
Is useful only when any subluxation or dislocation has been reduced or can be reduced by open reduction at the time of osteotomy in a child 18 months to 8 years old. The entire acetabulum together with the pubis and ischium is rotated as a unit, with the symphysis pubis acting as a hinge. The osteotomy is held open anterolaterally by a wedge of bone, and the roof of the acetabulum is shifted more anteriorly and laterally. The osteotomy is contraindicated in patients with non concentric hips or severe dysplasia.[Kelly, D, 2013][Salter, R. B, 1966]

When the hip is extended, the femoral head is insufficiently "covered" anteriorly, and when it is adducted, there is insufficient coverage superiorly.[Kelly, D, 2013]

The indications for the Salter osteotomy are acetabular dysplasia that persists after primary treatment and acetabular dysplasia discovered in an untreated child.

The failure of the acetabular angle to improve within 2 years after reduction and persistent dysplasia after the age of 5 years are definite indications for the procedure. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

Children who are younger than 18 months old usually do not have iliac wings that are thick enough to support the bone graft. For children who are older than 9 or 10 years, the surgeon may not be able to achieve enough movement of the acetabular fragment to cover the femoral head adequately. It has been reported that the acetabular angle will be improved by an average of 10 degrees with the use of the Salter osteotomy.[Morscher, E, 1978]

The Salter osteotomy increases the tension on the muscles that cross the hip anteriorly, and it mildly increases the limb length.Complications are often the result of a lack of attention to the details of the

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procedure. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

Structures that are at risk of injury during a Salter innominate osteotomy, as follows:

1. The lateral femoral cutaneous nerve may be injured during an anterior approach.
2. The nutrient vessels to the tensor fasciae latae muscle can be injured if retraction is too prolonged.
3. The sciatic nerve can be crushed or irritated by an inadequate sub-periosteal approach during the pull on the Hohmann retractor.
4. An inadequate sub-periosteal application of the medial Hohmann retractor can damage the obturator nerve.
5. Too prolonged retraction of the iliopsoas muscle can cause compression of the femoral nerve.[Kelly, D, 2013]

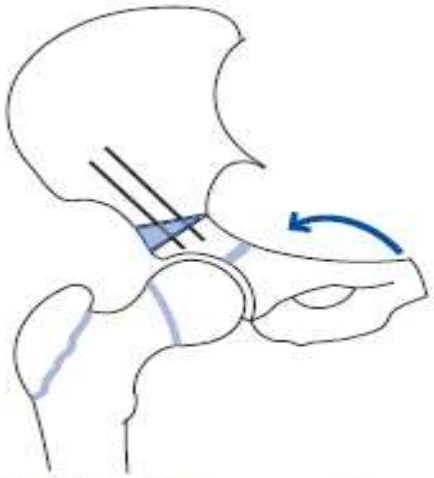

Fig. (1-18)

The following are prerequisites for the success of this operation:

1.The femoral head must be positioned opposite the level of the acetabulum.
2. Contractures of the iliopsoas and adductor muscles must be released .
3.The femoral head must be reduced into the depth of the true acetabulum completely and concentrically.
4.The joint must be reasonably congruous.
5. The range of motion of the hip must be good, especially in abduction, internal rotation, and flexion. [Kelly, D, 2013]

Femoral Osteotomy

Different forms of femoral osteotomy may be needed in order to achieve a stable reduction. The femoral osteotomy can be either subtrochanteric or intertrochanteric.[From Tachdjian's pediatric orthopedics, 4thedition, 2008]

Surgeons who recommend femoral osteotomies advise an operation on the pelvic side of the joint only after:-

(1) The femoral head has been concentrically seated in the dysplastic acetabulum by such an osteotomy,
(2) The joint has failed to develop satisfactorily, and
(3) The growth potential of the acetabulum no longer exists.

Opinions differ widely as to the age at which the acetabulum loses its ability to develop satisfactorily over a femoral head concentrically located, although 8years appears to be most frequently cited upper age limit after which little benefit is derived from femoral osteotomy alone. [Kelly, D, 2013]

■Derotation osteotomy

If after open reduction the anteversion requires significant internal rotation for the reduction to be stable, a derotation osteotomy is indicated. The derotation osteotomy corrects the associated femoral anteversion, reducing the need for extreme internal rotation in the post-operative cast position. This reduces the incidence of avascular necrosis.

■Varus derotation osteotomy

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If the hip remains stable only in abduction and internal rotation, a varus derotation osteotomy is necessary.

■Femoral shortening

In older children, a femoral shortening osteotomy may be necessary to enable reduction of the hip.Shortening is also needed if the hip is so high riding that it is unstable following reduction due to increased tension from the longitudinal traction necessary to obtain reduction. A femoral shortening osteotomy reduces the tension on the femoral head and reduces the risk of avascular necrosis.[Barlow, T, 1962]

Postoperative Immobilization

Postoperatively, the child is placed in a hip spica cast when the hips are about 20 degrees of flexion and 30 degrees of abduction on each side. This cast is kept on for about 6 weeks, after which follow-up radiographs are taken. A further 6 weeks is required or weaned off with a plastic abduction splint or Petrie cast after cast removal to stabilize the hip and ensure the strength of the capsulorrhaphy.[Crawford, H, 2010]

Hip Abduction Brace

Fig. 1-19

Complications

1. Osteonecrosis

The most serious complication associated with the treatment of congenital dysplasia of the hip in early infancy is the development of osteonecrosis.[Kelly, D, 2013]

AVN occurs when excessive pressure is applied for an extended time to the femoral head, thereby occluding its vascular perfusion. The most common cause is immobilization in a position that places excessive pressure on the femoral head, such as extreme abduction or internal rotation. Internal rotation increases pressure on the femoral head, and it may also contort the capsular vessels.

In addition, AVN may occur when the muscles crossing the hip are so contracted that they compress the reduced femoral head against the acetabulum. AVN can be prevented by avoiding abnormal positions and by performing femoral shortening when the reduction is too tight. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

Potential sequelae of osteonecrosis include femoral head deformity, acetabular dysplasia, lateral subluxation of the femoral head, relative overgrowth of the greater trochanter, and limb-length inequalities; osteoarthritis is a common late complication. [Kelly, D, 2013]

AVN is diagnosed when the femoral head fails to ossify or to grow within 1 year after being reduced. Other findings that indicate the presence of AVN are the widening of the femoral neck within 1 year of reduction, changes in the bone density of the femoral head, and residual deformity that suggests growth disturbance.[Salter, R. B. *et al*., 1969]

The avascular insult may involve only a part of the upper femoral segment, or it may affect the entire femoral epiphysis. The greater trochanter is not

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affected by AVN, and it will continue to grow when capital epiphyseal growth is arrested. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

There are several classification systems for AVN, with the Bucholz-Ogden system being the most widely used (box 1-1).[Bucholz, R. R. *et al*., 1978]

Bucholz-Ogden System		Kalamchi-MacEwen System	
Type I	Irregular ossification Femoral head only Normal growth	Grade 1	Head only Normal development
Type II	Lateral head and metaphysis Caput valgus during adolescence	Grade 2	Lateral head and metaphysis Caput valgus during adolescence
Type III	Whole head and metaphysis Short femoral neck Trochanter high	Grade 3	Central head and metaphysis
Type IV	Medial head and metaphysis	Grade 4	Whole head Short neck Trochanter high

Box 1-1

2: Inadequate Reduction and Re-dislocation
Most often, the surgeon has not adequately exposed the acetabulum to obtain a deep reduction initially. The intraoperative radiographs are often misread, and what appears to be a minor widening of the space between the femoral head and the acetabulum is often the difference between a well-reduced hip and a hip that remains dislocated. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

Reported series find that only one third to one-half of these cases have acceptable results, and the rate of AVN can be as high as 44%.[Danzhou, S. *et al*., 1989][Kamath, S. U. *et al*., 2005]

3: Residual Acetabular Dysplasia
After the reduction of a dislocated hip, the acetabulum begins to remodel in response to the pressure exerted by the femoral head. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

The acetabulum continues to develop for up to 8 years after reduction if the hip is reduced before the patient is 4 years old. [Lindstrom, J. R. *et al*., 1979]

There is good evidence that if, after treatment of the dislocation, acetabular obliquity is still present when the patient is 5 years old, further acetabular development will be inadequate. Thus if significant dysplasia persists until the age of 5 years, a pelvic osteotomy should be performed to ensure the adequate development of the hip. [From Tachdjian's pediatric orthopedics, 4thedition, 2008]

A study by Spence and associates showed better acetabular results with Salter osteotomy as compared with femoral osteotomy. [Lindstrom, J. R. *et al*., 1979]

PATIENTS AND METHODS

A case series study performed on (61)patients,(82)hips involved with developmental dysplasia of the hip. They all were treated at AL-wasity teaching hospital in Baghdad government after approval of the ethical committee of Iraqi board of orthopedic, in a period from November 2015 to November 2017 (including the follow up period which was 12-22 months).

we include patients aged 18-36 months. children with neuromuscular disease and children with recurrent dislocation after previous open reduction were excluded. (2)patients were lost to follow up also excluded.

Of the (61) patients there were(52)girls and (9) boys,(36)bilateral(15 of them operated unilateral and 21 operated bilateral) and (25)unilateral (9 right and 16 left).

***preoperative evaluation:**
1-history:
Taken from the parents and include: name, age, sex, residency, and phone no. , antenatal history, type of delivery, relatives' marriage, family history, walking and diagnosis age and previous management if it was done.

2- examination:
Patients were examined for walking, limited abduction, shortening (Galeazzi sign) , limping, increase lordosis and associated anomalies.

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3-radiography:
x-ray was taken at the time of examination which includes an anteroposterior view of the pelvis was taken for all patients for measuring acetabular index and grading the dislocation according to tonnis classification (fig 2-1) (fig 2-2).

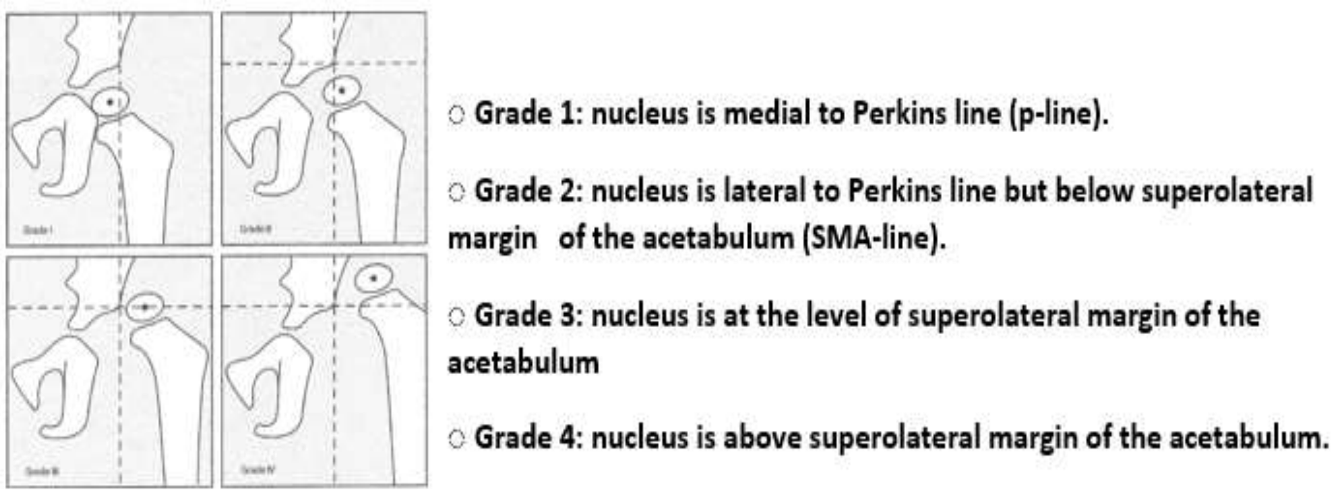

Fig 2-1

Fig(2-2)

4-**investigations**:
laboratory investigations include (CBC, RBS, virology screen, and HIV), anesthetic assessment and fitness for general anesthesia, blood group and cross-matching one pint of blood.

5- operative technique:-
All operations were done under general anesthesia by one surgeon at AL-Wasity teaching hospital.
supine position with a small pad under the hip that will be operated then the site of surgery was prepared with antiseptic and drapping. (fig2-3),(fig2-4),(fig2-5)

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Fig (2-3)

Fig (2-4) Fig(2-5)

Assessment of adductor muscle group of the involved side, if it was tight, then adductor tenotomy will be done by the open method, releasing the adductor group (the adductor longus and adductor brevise) then the wound closed.

Open reduction was done by anterior approach (bikini incision) starting from just inferior to the middle of iliac crest, extending anteriorly to just inferior to the anterior superior iliac spine and continuing to about the middle of the inguinal ligament.

Release the subcutaneous tissue and identify the entry plane between the Sartorius and tensor facia lata muscles, identify the lateral femoral cutaneous nerve and protect it. (fig2-6)(fig2-7)

Fig(2-7) fig(2-6)

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Incise the apophysis of the iliac crest and release the lateral side through subperiosteal dissection and packing it for hemostasis to reduce blood loss.

The Sartorius muscle is preserved, identify the straight head of rectus femoris muscle and apply a stay suture and release it near its origin of anterior inferior iliac spine, release the reflected head of rectus femoris muscle of joint capsule, release the joint capsule of any soft tissue attachment laterally, superiorly and inferomedially, identify iliopsoas tendon and release it near its insertion to the lesser trochanter.

The capsule was opened in a T-shaped incision from the most medial aspect of the capsule to the most lateral, and continue the incision along the anterior border of the femoral head and neck. a stay suture no.1or 2 nylon applied at the angles of the capsule flaps, the ligamentum terese is identified and released from the femoral head and excised from the acetabulum, the acetabular cavity was cleared of soft tissue (pulvinar) and release the transverse acetabular ligament, then another tow stay sutures with no. 1or 2 nylon applied at medial capsule one at most inferomedial capsule and second just above it. then the femoral head gently reduced into the acetabulum.

At this stage and before closure of the joint capsule a test for stability was carried out.[Kelly, D, 2013][Zadeh, H. G. *et al*., 2000]

5-test of stability:-

The aim of this test is to identify the position of maximum stability of the hip and the appropriate osteotomy can then be carried out when necessary to achieve a stable concentric reduction.

We considered a stable open reduction to be present when the hip remained reduced with axial loading with the leg in 30degree of flexion, 30 degrees of internal rotation and 30 degrees of abduction. the component of this position were then removed sequentially beginning with the flexion.

These were the main findings :

1. hip stable in a neutral position: open reduction and capsular repair are sufficed.
2. hip stable in internal rotation and abduction: require proximal femur derotation or varus derotation osteotomy.
3. hip stable in flexion and abduction: require pelvic (salter) osteotomy.
4. hip stable in flexion, internal rotation and abduction: require pelvic (salter) osteotomy and also proximal femur derotation osteotomy. (if a more internal rotation is needed to maintain stable reduction after salter osteotomy) [Zadeh, H. G. *et al*., 2000]. (fig 2-8)

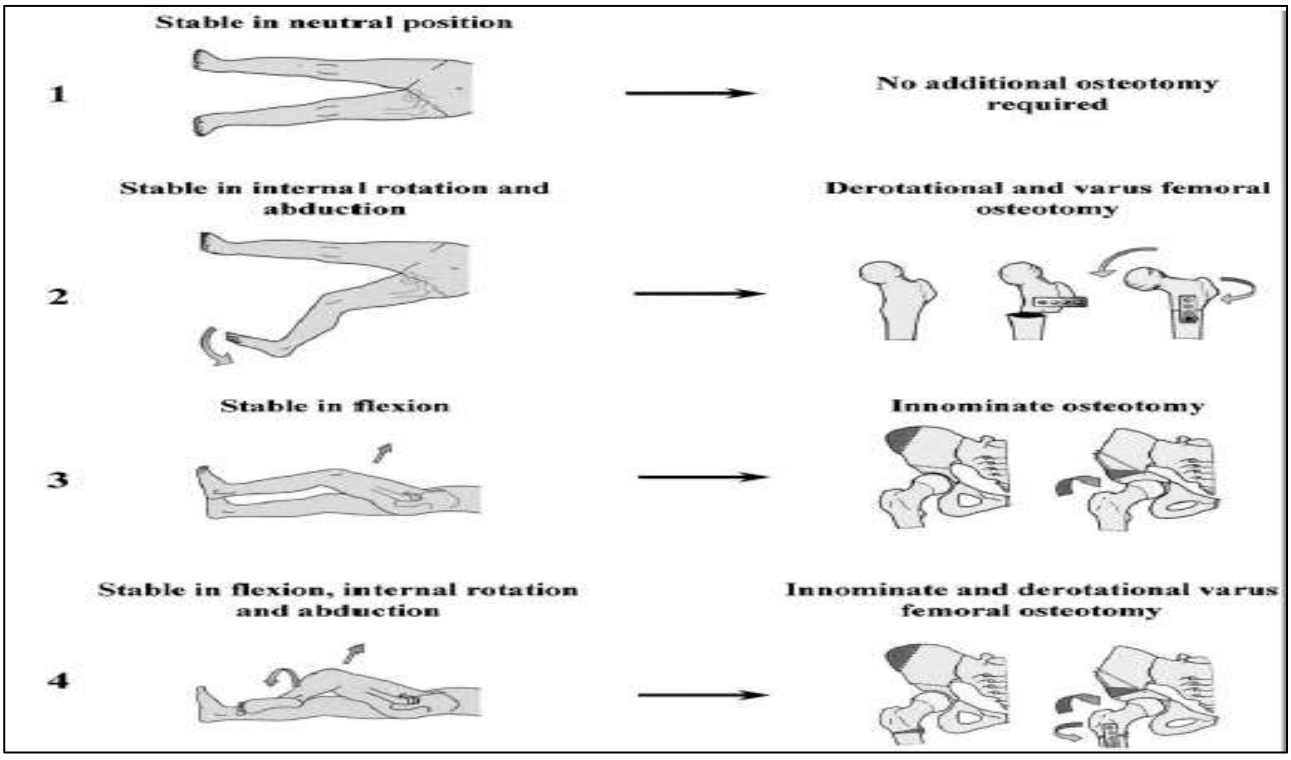

fig (2-8)

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5- if the head becomes displaced superiorly from the acetabulum when the hip is adducted or anteriorly when it is extended or externally rotated, osteotomy of the innominate bone (salter)is performed [55] (fig2-9)(fig2-10)

Fig(2-9)

Fig(2-10)

When salter needs to perform, the medial side of iliac apophysis is released strictly subperiosteally and packing it for hemostasis, continued the release distally till expose the anterior inferior iliac spine.

Right angle forceps inter through the sciatic notch from the medial side to lateral and gently take the Gigli saw, protecting the soft tissue on medial and lateral aspects of the iliac bone and stabilize the pelvis make a straight osteotomy at the innominate bone extended from the sciatic notch to the anterior inferior iliac spine.

A triangular bone graft taken from the iliac wing just proximal to the anterior superior iliac spine, then by towel clip applied to the distal part of osteotomy, pulling it anteriorly, inferiorly and laterally the bone graft then applied at the osteotomy site (opening site),using two k-wires for fixing the osteotomy site with the graft, applied through the site of graft taken (the defect site) proximal to the osteotomy site, directed distally passing through the graft to the distal part of osteotomy bone.check the acetabulum if there is a k-wire in to it. after that reduce the head of femur into the acetabulum and check the stability again.

After confirming the reduction and stability of the hip joint, close the capsule by using the stay sutures taken previously, closing the apophysis of ilium and subcutaneous tissue by absorbable suture and the skin by no. 3/0 nylon in subcuticular suture. (fig2-11)

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Fig(2-11)

Dressing the site of surgery, then one and one half spica cast applied by using spica frame.

The spica lasts for 6-8weeks then changed to abduction broomstick for farther 4-6 weeks then removed.

At day zero all the patients were given a single dose of IV. antibiotic with an x-ray of the pelvis. (fig2-12)(fig2-13)

Fig (2-12)

fig(2-13)

6-postoperative follow up:
The patients were discharged at day one post-operation, the first visit for follow up after 2 weeks to check the patient's condition and state of spica. another visit after 6 weeks to change the spica to abduction broomstick and x-ray of the pelvis were done, then after 4-6 weeks of the last follow up to remove the cast and x-ray of the pelvis were taken and measure the acetabular index and center-edge angle.

A periodic visits every 12 weeks for a pelvic x-ray to document the measures of the acetabular index and center-edge angle.

The period of follow up was 12-22 months (mean 17.2m) depending on:

1. Clinical evaluation according to modified **McKay** criteria (box 2-1).
2. Radiological evaluation according to **Severin** criteria which depend on center edge angle after reduction that consider more than 19 degrees, center edge angle normal below 3 years old child (box 2-2) [Severin, E, 1941].
3. Avascular necrosis of the femoral head was graded by the criteria of kalamchi and MacEwen (box 2-3).

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Box 2-1

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

Box 2-2

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.

Box (2-3)

Type	Criteria
I	Changes confined to the ossific nucleus
II	Type I plus lateral physeal damage (coxa valga)
III	Type I plus central physeal damage (coxa brevis)
IV	Total damage to the head and physis
V	Unclassifiable

Fig(2-14)

fig(2-15)

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Fig(2-16)

fig(2-17)

fig(2-18)

fig(2-19)

Fig(2-20)

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RESULTS

The findings of current study indicated that the mean age of studied group was 26.1m.±6.7SD, 85.2% was females, 62.3% was delivered by normal vaginal delivery and 67.2% was in cephalic presentation, 14.8% had family history of the disease, 86.9% had no previous surgery that related to this medical condition, 59% had bilateral involvement and 64% had left side affected and salter open reduction was needed for 69.5% of cases according to the intraoperative assessment as displaced in table.1.

Table 1: descriptive characteristics of the studied group

		No.	%
Age	≤2 years	30	49.2%
	>2 years	31	50.8%
Gender	Male	9	14.8%
	Female	52	85.2%
Delivery mode	C/S	23	37.7%
	NVD	38	62.3%
Presentation	Breech	20	32.8%
	Cephalic	41	67.2%
Relative parents	Yes	27	44.3%
	No	34	55.7%
Family history	Yes	9	14.8%
	No	52	85.2%
Previous surgery	Non	53	86.9%
	CR	5	8.2%
	Spl	3	4.9%
Bilateral/unilateral	Bilateral	36	59.0%
	Unilateral	25	41.0%
Side for unilateral	Lt	16	64%
	RT	9	36%
Type of surgery	OR	25	30.5%
	SO	57	69.5%

OR=Open reduction
SO=salter open reduction

According to tonnis grade and type of surgery; the results showed that the salter technique indicated more with sever grades where the results showed 55.9% of joints in grade two,81.1% of joints in grade three and 80% of joints in grade four were managed by salter open reduction and this difference was statistically significant(p=0.04) as displayed in table 2 and fig.1.

Table 2: association between tonnis grade and type of surgery

Tonnis grade	Type of surgery						p-value
	OR			SO			
	No.	%	%	No.	%	%	
I	1	100.0%	4.0%	0	0.0%	0.0%	0.04
II	15	44.1%	60.0%	19	55.9%	33.3%	
III	7	18.9%	28.0%	30	81.1%	52.6%	
IV	2	20.0%	8.0%	8	80.0%	14.0%	
Total	25	30.5%	100.0%	57	69.5%	100.0%	

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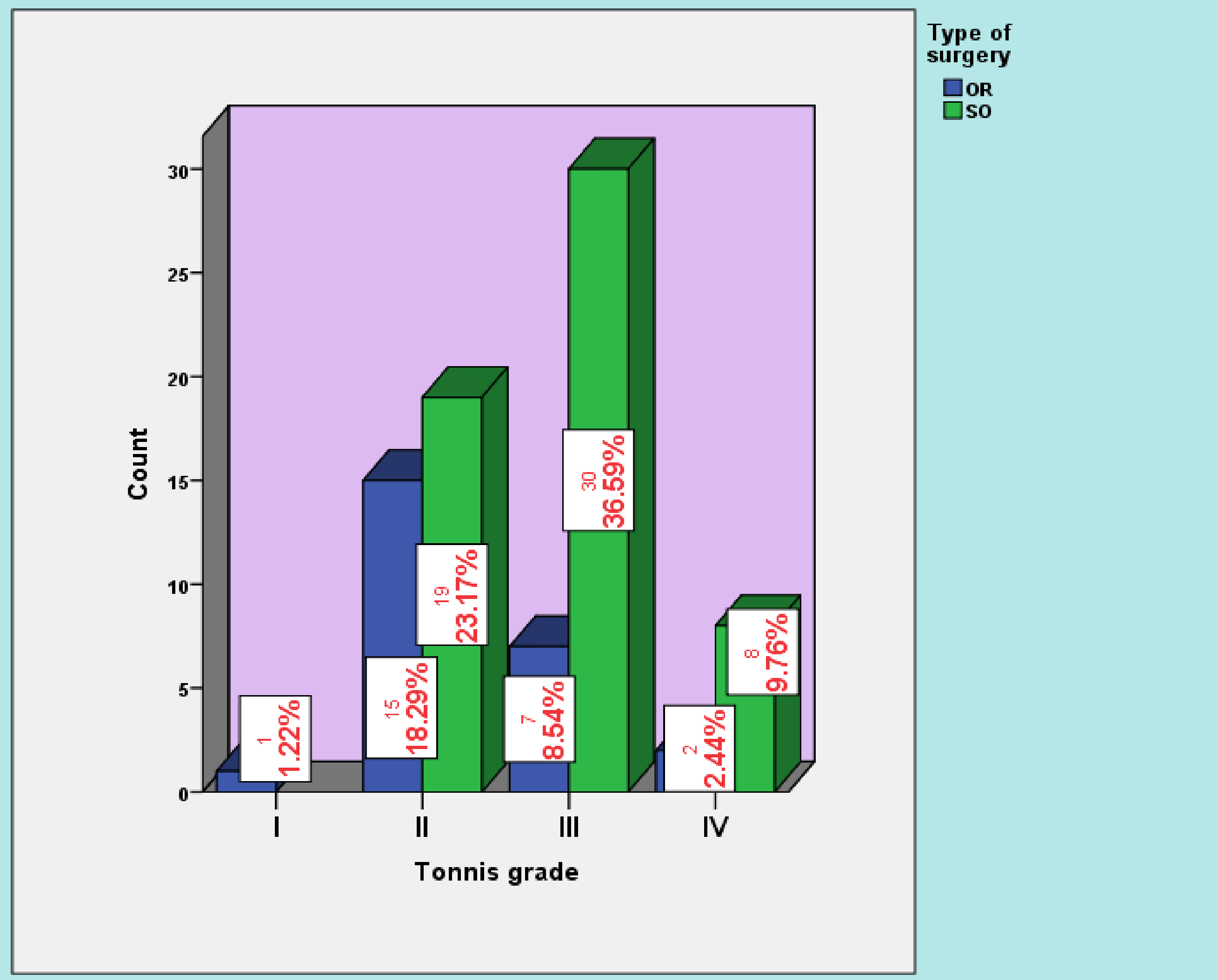

Fig 1: association between tonnis grade and type of surgery

The results revealed that the mean value of the acetabular index was significantly reduced ($p \leq 0.05$) after one year of surgery with two modalities of surgery, where the mean value of acetabular index was reduced from 33.8 to 27.5 with open reduction technique while it was reduced from 39.7 to 23.1 with salter technique as showed in table.3.

Table 3: mean of AI pre and one year after for each type of surgery

Type of surgery		Mean of AI	Std. Deviation	p-value
OR N=25	AI pre-operation	33.8	4.3	0.01
	AI year after	27.5	2.5	
SO N=57	AI pre-operation	39.7	2.8	0.01
	AI year after	23.1	3.4	

AI=Acetabular index

The results demonstrated that difference in the mean value of AI with salter open reduction was significantly higher (p=0.01) than open reduction (16.6,6.3) respectively as seen in table 4.

Table 4: mean difference of AI (pre-op and 1 year after) according to the type of surgery

Type of surgery	Mean of AI	Std. Deviation	p-value
OR(N=25)	6.3	4.5	0.01
SO(N=57)	16.6	4.0	

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The results revealed there was a significant difference in the mean value of CEA between the two types of surgery and that of Salter technique was higher than of open reduction as seen in table.5

Table 5: mean value of CEA according to the type of surgery

Type of surgery	Mean of CEA	Std. Deviation	p-value
OR(n=25)	23.2	4.7	0.03
SO(n=57)	25.9	3.1	

Our data indicated that 61.4% of joint that were corrected by salter open reduction was of equal or more than 2 years old patients while only 16% of joints of more than two years old patients were managed by open reduction as well as that 84% of joints of <2 years old patients were corrected by open reduction and this finding demonstrated that salter open reduction indicated more than open reduction in older patients as seen in table.6 and fig.2.

Table 6: association between age category and type of surgery

		Age groups		Total	p-value
		<2 years	**≥2 years**		
Type of surgery	OR	21	4	25	0.01
		84.0%	16.0%	100.0%	
	SO	22	35	57	
		38.6%	61.4%	100.0%	
Total		43	39	82	
		52.4%	47.6%	100.0%	

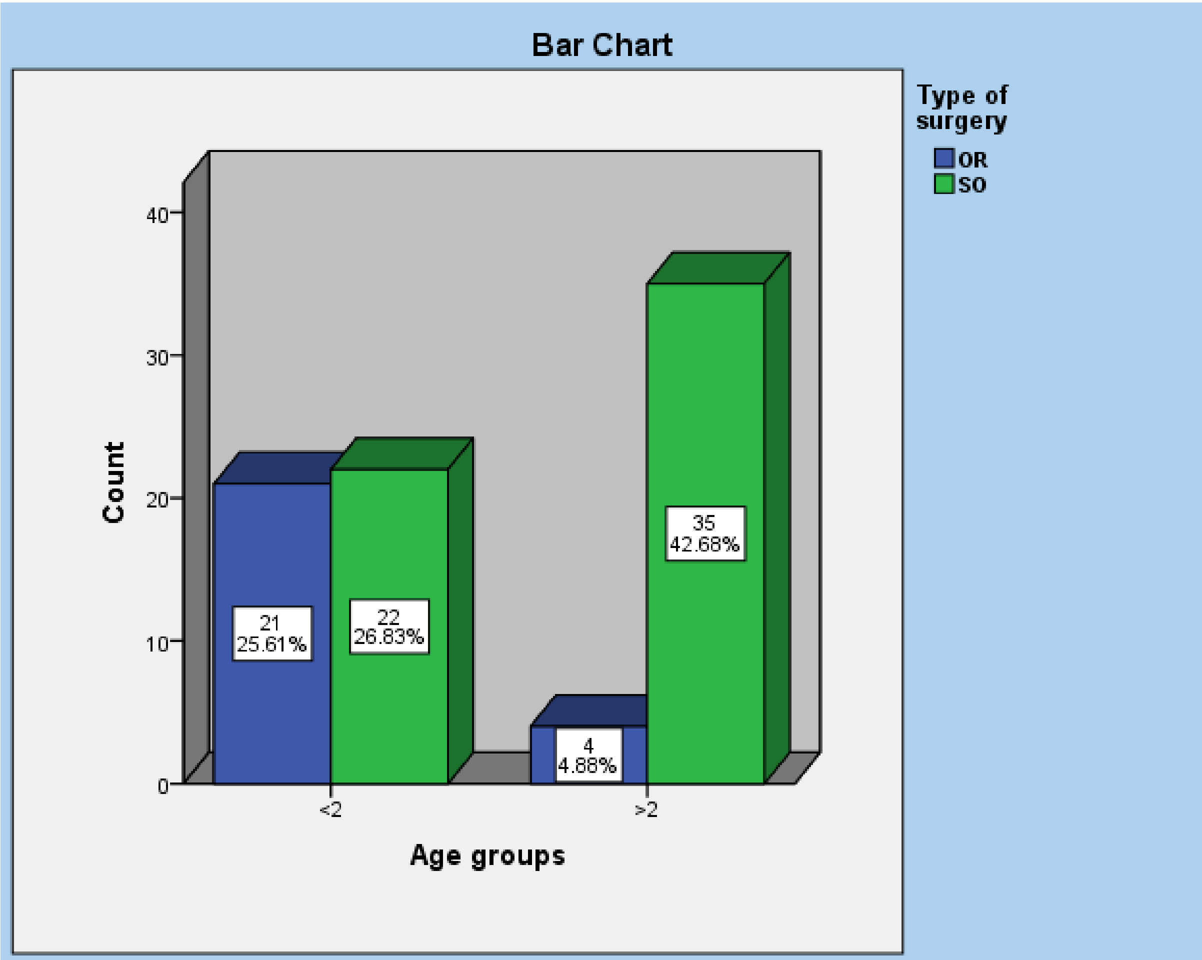

Fig.2: association between age category and type of surgery

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The results showed nearly similar outcome and no significant difference was reported according to MC key when the outcome assessed in term of excellent, good and fair between the open reduction and salter open reduction groups as seen in table7.

Table 7: Association of outcome and type of surgery

MC key	Type of surgery				p-value
	OR		SO		
	No.	%	No.	%	
Excellent	9	36.0%	20	35.1%	0.9
Good	14	56.0%	31	54.4%	
Fair	2	8.0%	6	10.5%	

The most common complication was the AVN(II&III) (4.9% from a total,28.6% of patients with complications) followed by subluxation and superficial infection (3.7% from a total,21.4% of patients with complications). others complications were reported in lower percentages as displayed in table 8.

Table 8: frequency and percentage of complications

Complications	No.	%(from total)	%(from patients with a complication)
AVN (II&III)	4	4.9	28.6
LLD	2	2.4	14.2
SC #	1	1.2	7.1
SPICA SORE	1	1.2	7.1
Subluxation	3	3.7	21.4
Superficial infection	3	3.7	21.4
Total	14	17.1	100.0
0(no complication)	68	82.9	
Total	82	100.0	

The finding demonstrated there was no significant difference regarding the Severin grade and the two types of surgeries. although the frequency of joints in grade two was higher in salter's osteotomy than open reduction only. the difference did not reach the significant level(p=0.7) as seen in table 9; and fig.3.

Table 9: association of Severin grades and type of surgery

		Type of surgery				Total ROW	Total Column	p-value
		ORrow	column	SO row	column			
Severin	I	0		1		1	1	0.7
		0.0%	0.0%	100.0%	1.8%	100.0%	1.2%	
	II	22		48		70	70	
		31.4%	88.0%	68.6%	84.2%	100.0%	85.4%	
	III	1		7		8	8	
		12.5%	4.0%	87.5%	12.2%	100.0%	9.8%	
	IV	2		1		3	3	
		66.7%	8.0%	33.3%	1.8%	100.0%	3.6%	
Total		25		57		82	82	
		30.5%	100.0%	69.5%	100.0%	100.0%	100.0%	

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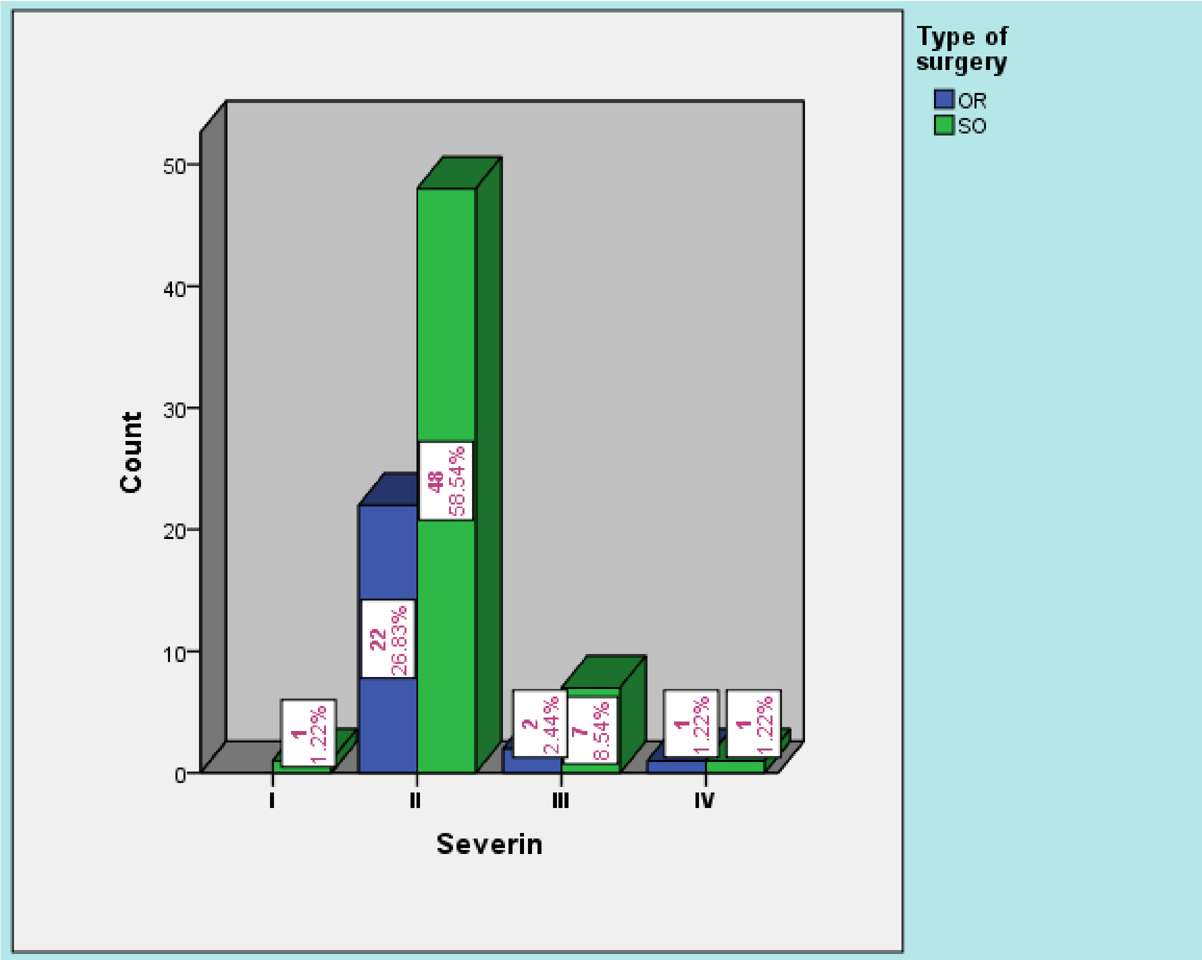

Fig. 3: association of Severin grades and type of surgery

The finding showed there was no significant difference(p=0.2) between two modalities of surgery regarding the associated complication although the limb lingth discrepancy(LLD)(operated side longer) and superficial infection was reported more with salter open reduction as seen in table 10.

Table.10: complications according to the type of surgery

Complications	Type of surgery				
	OR		SO		p-value
	No.	Row N %	Count	Row N %	0.2
AVN(II&III)	0	0.0%	4	100.0%	
LLD	0	0.0%	2	100.0%	
SC #	1	100.0%	0	0.0%	
SPICA SORE	0	0.0%	1	100.0%	
Subluxation	2	66.7%	1	33.3%	
Superficial infection	1	33.3%	2	66.7%	

Statistical Analysis

SPSS version 20 was used for data entry and analysis. Mean and the standard deviation were used to represent the numerical data while frequency and percentage for categorical data. Pairs sample t-test, independent student t-test, and chi-square test were used to confirm significance. $p \leq 0.05$ was considered significant.

DISCUSSION

The treatment for DDH has the basic premise of attaining stable concentric reduction of the hip into the functional weight-bearing position. Instability of the reduction originates from poor positioning of the acetabulum in the anterior and lateral directions. Open Reduction in association with Salter's osteotomy of the iliac bone in order to

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redirect the acetabulum is today a classical treatment method. [Bertol, P, 2004]

The universal addition of a pelvic procedure at the time of open reduction has been advocated by Salter [Salter, R. B, 1978 – Sankar, W. N. *et al*., 2011] and others [Grudziak, J. S. *et al*., 2001; Haidar, R. K. *et al*., 1996] when treating children older than 18 months of age.

Many authors have recommended that open reduction in association with osteotomy of the innominate bone for correction of acetabular dysplasia should be performed on children at a minimum age of 18 months(62)and that the technique described by Salter[Salter, R. B. *et al*., 1974]should be applied to patients at a maximum age of six years.

It has been suggested that the initial preoperative acetabular index may be used as a criterion to add an acetabular procedure to the primary treatment [Harris, N. H. *et al*., 1975]

In our study on (82) hips for patients aged (18---36m) mean age 26.1M (±6.7SD) with a mean period of follow up (17.2Months).

Regarding the radiographic evaluation , the mean preoperative A.I. among the cases studied here was 37.9◦(± 4.3◦SD), SO all of them have acetabular dysplasia, (acetabular dysplasia is confirmed when the pre-operative acetabular Index (AI)IS more than 30)[Canale, S. T. *et al*., 2013]

When compared with intraoperative assessment of the stability after open Reduction (for all the patients),(57)hips of them needed pelvic osteotomy (salter)to achieve a stable hip, and only (25)hips do not need osteotomy.

There for, in the current study the indication that determine the necessity for doing salter osteotomy or not was dependent on the intra-operative assessment to achieve a stable hip. In agreement with our data the following:

-Zadeh, *et al*. used concomitant osteotomy at the time of open reduction to maintain stability of the reduction and reported satisfactory results in 86% of 82 children (95 hips).[A Concomitant osteotomy should be done at the time of open reduction when necessary to maintain a safe, stable reduction]. (Canale, S. T. *et al*., 2013)

-When considered with **M.belen caris and Nicholas M.P. elarke, (2015)**; the preoperative acetabular index was not different in those hips that required a pelvic osteotomy from those that did not, making this measure a poor initial discriminator.

- Bolland, *et al*., (2010) and Albinana, *et al*., (2004) found that, the acetabular index becomes a reliable predictor of the need for pelvic osteotomy only at an average of 1.5 years or 2 years after the hip reduction respectively.
There for in the present study, the patients were divided according to the intraoperative assessment of stability that determine the need for pelvic osteotomy into two groups , group 1: those were treated with open reduction only, and group 2: those were treated with open reduction and salter Osteotomy, in order to record the results.

Regarding the **acetabular index**, in this study, the mean preoperative AI for our patients37.9◦ (± 4.3◦SD), AI of group 1(33.8◦) and of group 2 (39.7◦), one year post-operatively the mean AI are (27.5◦) and (23.1◦) for groups 1 and 2 respectively, in the same line with the following previous studies, that treated the patients with open reduction and salter osteotomy.

Adriana Ferraz, *et al*., (2014) found that the mean preoperative AI was 38◦, and The mean for the late postoperative AI was 18.2◦. **Carvalho Filho, *et al*., (2003)** found a preoperative angle of 39◦and a mean postoperative angle of 22◦. **El-Sayed, *et al***., (2012) found a statistically significant difference between the pre- and postoperative AI values, which diminished from 41.56◦ to 20.41◦ in children younger than four Years. **Bhuyan, (2013)** reduced the AI from 42◦(±5) to 21◦(±2). **Abdullah, *et al***., (2012) obtained a significant improvement in AI in all the 42 hips whom treated, thus decreasing it from 44◦(±2.5) to 23◦(±3). Among 63 children, **Chang, *et al***., (2011) found a mean preoperative AI of 35.4◦ ; the AI six months after the operation was17◦and it was 12.6◦ ten years after the operation.

- In our study, there was a decreasing trend in AI values with open reduction and salter more than with those treated with open reduction alone and the mean difference of AI (pre-op and 1 year after) in group 1was (6.3◦) and in group 2 (16.6◦).The results demonstrated that differences in the mean value of AI with salter open reduction were significantly higher than open reduction alone(p=0.01). a result go with **M. Belen Carsi, *et al*., (2015)** that found a residual acetabular dysplasia described according to Severin's class or as an increased and a nonevolving acetabular index

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was much more likely in the group treated with open reduction alone and found in 37% of children..

In this study, the postoperative **Weberg center-edge angle** obtained in our analysis, in group 1 the mean of CE (23.2◦)while in group 2 the mean of CE (25.9◦), we also observed asignificant difference between the two groups (p-value 0.03).when compared with others that agrees with our data as, **Adriana Ferraz, *et al*., (2014),** Wiberg CE angle obtained was 19.4◦.,28◦found by **Carvalho**, **Filho, *et al*., (2003)** 31◦(±9) and 32.3◦ (±11.9) by **El- Sayed, *et al*., (2012)**.

In the current study, our postoperative radiological results according **to Severin grades** are, grade I ;1.2%of total (1.8% in group 2),grade II; 85.4%(88.0% in group 1 and 84.2%in group 2), grade III; 9.8% of total(4.0%in group 1 and 12.2% in group 2) and in grade IV; 3.6% of total(8.0% in group 1 and 1.8% in group 2) despite this difference it is not significant (p-value 0.7). when considered with other thesis. , **Adriana Ferraz, *et al*., (2014)** there are 65% of the hips had a satisfactory radiographic result(grade I and II). Better results were found by **Carvalho Filho, *et al*., (2003)** with 81% of the hips in classifications I and II; **Rocha, *et al*., (2011)** with 88.9%; **El-Sayed, *et al*., (2012)** with 88% (types I and II); **Bhuyan, (2012)** with 83.3%; and **Yagmurlu, *et al*., (2013),** with 74% showing satisfactory results. **RACHID, K. *et al*., (1996),** grade I and II are 32.4% and 51.4% respectively and grade III;10.8% and Grade IV;5.4%. All of the above results go with ours.

According to the clinical evaluation of **MCkaY** Classification there were as follow; Excellent 36.0% , good 56.0% and fair 8.0% Of total numbers of group 1 and Excellent 35.1%, good 54.4% and fair 10.5% of total numbers of group 2. both are with 0.0% of poor grade ,also there is no significant difference (p- value 0.9).a results that agree with **Chang, *et al*., (2011);** good or excellent clinical results in 89% of hips, at an average of 10 years of follow-up. And **RACHID, K. *et al*., (1996)** excellent 40.5%, good 56.8%, fair 2.7%and poor 0%.

Acetabular dysplasia is directly related to the age at open reduction, increasing from 20% at 6 months to 60% at 32 months or older. Hence, for these authors, children treated at 18 months of age have a probability of 36% to develop acetabular dysplasia. **Albinana, *et al*., (2004)**.

Our data indicated that 61.4% of joint that was corrected by salter open reduction was of equal or more than 2 years old patients, while only 16% of joints of more than two years old patients were managed by open reduction, as well as that 84% of joints of <2 years old patients were corrected by open reduction only and this finding demonstrated that salter open reduction indicated more in older patients. Hence, an incomplete periacetabular acetabuloplasty appears to be a powerful tool to counteract the deleterious effect of intentionally delaying surgery (65).

Regarding the **complications**, in the current study, there is 17.1% of total had a complication and most of these were **Avascular necrosis** (4 patients) represented 28.6% of complications and all these occur in group 2 (a group of salter osteotomy) and it was typed (II&III)as graded by the Criteria of kalamchi and MacEwen. **Subluxation** (3 patients) represented 21.4% of complications and these were 66.7% in group 1 and 33.3% in group 2, also there was **superficial infection**(3 patients) represented 21.4 % of complication(33.3% in group 1 and 66.7% in group 2), and (2 patients) 14.2 % had **a leg length discrepancy** all of them in group 2(the salter osteotomy is mildly increases the limb length)(85).Despite this, the finding showed that there was no significant difference(p=0.2) between the two modalities of surgery.

When considered with Segal, *et al*., (1999) (78) reported a 32% rate of AVN and Sankar, *et al*., (2011) (59) 41% AVN and Yagmurlu, *et al*., (2013) (71) described four cases with avascular necrosis among 27 hips that were operated (14%).

Prado, *et al*., (62) reported (9.5%) of subluxation, **RACHID, K. *et al*., (76) found** (3 of 37 hips) 8.1% AVN, (2 hips) 5.4% secondary subluxation, (3 patients) 8.1% superficial wound infection,(2 patients)5.4% supracondylar fracture of the femur and (1 patient)2.7% significant leg length discrepancy.

Both Tachdjian, (1982) and Fixsen, (1987) suggest that the reasons for failure to maintain a reduced hip are a poorly executed osteotomy, a lax capsulorrhaphy, and excessive femoral anteversion. (76)

Osteonecrosis has been thought to result from excessive pressure over the femoral head or vascular insult. (79,80). It has been postulated to be associated with patient age, degree of displacement, inadequate pre-reduction traction,

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position of immobilization, and methods of treatment. (81,82,83,84)(77).

In our study the cases complicated with AVN mostly (34-36)months of age and high grade at presentation tonnis grade(II and III).

CONCLUSION

1-The preoperative radiological measure (AI) which determines acetabular dysplasia is a weak indicator for the need of salters osteotomy.

2-the intra-operative test of stability is found to be a reliable indicator for pelvic osteotomy (salter) to achieve a stable hip.

3- Open reduction in association with osteotomy of the iliac bone as described by Salter presented a statistically significant improvement in the angular parameters measured on the patients' radiographs, from before to after the operation.

4-Reorientation of the acetabulum makes the reduced hip more stable, increases the load-bearing area of the acetabulum in the weight-bearing position

5- The surgeon should be familial with Salter's prerequisites for the operation and the surgical technique of open reduction.

6-Avascular necrosis (AVN) and residual acetabular dysplasia are the two main complications of developmental dysplasia of the hip (DDH) treatment.

RECOMMENDATIONS:

- A more focusing on the intra-operative assessment in the management of developmental dysplasia of the hip (DDH) is recommended.
- A longer period of follow up is advised.

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LIST OF ABBREVIATIONS:

AI	Acetabular index
AVN	Avascular necrosis
CE	Center edge
DDH	Dvelopmental dysplasia of hip
LLD	Limb length discrepancy
M.	Month
no.	Number
O.R	Open reduction
SC#	Supracondylar fracture
SD	Standard deviation
SO	Salter osteotomy

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