Sarcouncil Journal of Medical Series

ISSN(Online): 2945-3550

Volume- 03| Issue- 01| 2024

Research Article **Received:** 02-12-2023 | **Accepted:** 28-12-2023 | **Published:** 30-01-2024

LUDLLOF'S (Medial) Approach Open Reduction of Developmental Dysplasia of the Hip in Children below 16 Months of Age

***Dr. Hayder Rashid Majeed*[1] *and Dr. Ali Hassoon Hameed*[2]**
[1]*AL- Imam Alhussain Medical City, Iraq*
[2]*Alnajaf Health Institute, Alhaydaria General Hospital, Iraq*

Abstract: Developmental dysplasia of the hip generally includes subluxation (partial dislocation) of the femoral head, acetabular dysplasia, and complete dislocation of the femoral head from the true acetabulum in addition to teratogenic type. 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 adaptive changes in the bony and soft tissue components of the hip. This is a prospective study started from November 2012 to November 2014, done on 90 children (25 boys, 65 girls) with (110) developmentally dysplastic hips below age of 16 months in AL Basra General Hospital, all of them were evaluated preoperatively excluding the teratological and neuromuscular causes. Management started by closed reduction with or without adductor tenotomy followed by immediate intraoperative hip arthrogram to assess the outcome in reference to the concentric profile of reduction and its stability in the accepted safe zone. Twenty five patients (29 hips) out of the 90 patients (7 boys, 18 girls) have failed closed reduction as proved by the intraoperative arthrogram and were subjected to immediate open reduction utilizing the medial approach (Ludloff's). Medial Ludloff's approach is a good hip approach to be utilized in the open reduction of congenital hip dislocation in the patients younger than one year of age, this represented in the dramatically less operative time comparing to other approaches, with less blood loss, less postoperative pain during hip movements resulted in early improved range of movement, no scarring in the anterolateral region to the hip making it easily to be operated on in the future if required, less risks for postoperative infection, redislocation, and major neurovascular injury. It also have a favorite technical operative advantage in that it create a direct path with the shortest way to attach dealing with a major obstacle of reduction, namely the Iliopsoas tendon. The main drawback is the risk of injuring the Medial circumflex femoral artery with a weighted opportunity for postoperative avascular necrosis of the femoral head. This can be decreased by a careful surgical dissection and manipulation, the operating surgeon must keep the MCFA in his mind all the time, or else its injury could invite a painful failure to both the surgeon and his patient. We recommend more studies to compare between both of the 2 approaches (anterolateral and medial) with a big sample and for a long period of follow-up till beyond bone maturity to assess more confidently the pro and cons of each in dealing with those difficult cases of DDH who require an open reduction for their remedy.

Keywords: Dysplasia, Hip joint, Dislocation.

INTRODUCTION

Definition: Developmental dysplasia of the hip generally includes subluxation (partial dislocation) of the femoral head, acetabular dysplasia, and complete dislocation of the femoral head from the true acetabulum in addition to teratogenic type. 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 adaptive changes in the bony and soft tissue components of the hip. (Canale & Beaty, 2008)

Incidence and risk factors:
Most newborn screening studies, usually based on physical examination, 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 hip (DDH) is found in approximately 4 per 10,000 children. (Orthopedic knowledge)

HIGH-RISK FACTORS FOR DEVELOPMENTAL DYSPLASIA OR DISLOCATION Of THE HIP

Breech position
Female gender
Positive family history or ethnic background (e.g., Native American)
Lower limb deformity
Torticollis
Metatarsus adductus
Oligohydramnios

Etiology:
Although there is no single cause of DDH, a number of predisposing factors have been identified:

A-Ligamentous laxity is related to DDH in several ways:
1-The newborn's response to maternal relaxine hormones may explain the higher incidence of

***Corresponding Author:** Dr. Hayder Rashid Majeed

DOI- https://doi.org/ 10.5281/zenodo.10593556

DDH in girls. (Tachdjian's pediatric orthopaedics, 2008)

2- 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, 1986)

3 -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 subjects. (Andren, L, 1962)

B- 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, 1953). The breech effect is most noticeable when the knees are extended, with an incidence of 20% for a frank breech. On other hand the footling breech position, in which the hips are flexed is associated with only a 2% incidence of DDH. (Suzuki, S, 1986) 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)

Classification:

1- Teratogenic type: Occurs early in fetal life and result in sever acetabular dysplasia, usually bilateral and associated with other congenital deformity. It is found in arthrogryposis, myeloid dysplasia, and hypotonia. (Ferguson, A. L, 1975)

2-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 acetabulum.

3-Developmental hip dislocation: This characterized by the ability of the newborn's 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 develops, such as inverted labrum, abnormal ligamentum teres and joint capsule laxity. (Bennett, G. C, 1987)

Figure (1-1): Dislocation in DDH

Publisher: SARC Publisher

Figure 1-2: subluxation in DDH

Figure 1-3: Teratological dislocation in DDH

Pathology:

1. the neolimbus, as described by Ortolani in 1976, is a hypertrophied ridge of acetabular articular cartilage that forms in the superolateral aspect of the acetabulum in response to eccentric pressure of the femoral head. (Landa, J. *et al*., 2008)

2. The limbus is a pathologic structure that results when abnormal pressure from the femoral head on the labrum causes the fibro cartilaginous labrum to hypertrophy and form surrounding fibrous tissue. The limbus forms as a result of a secondary adaptive change that occurs with prolonged subluxation or dislocation of the hip. The limbus is able to invert and Evert, and is a potential block to concentric reduction of the dysplastic hip. (Hernandez, R. J, 1984)

Publisher: SARC Publisher

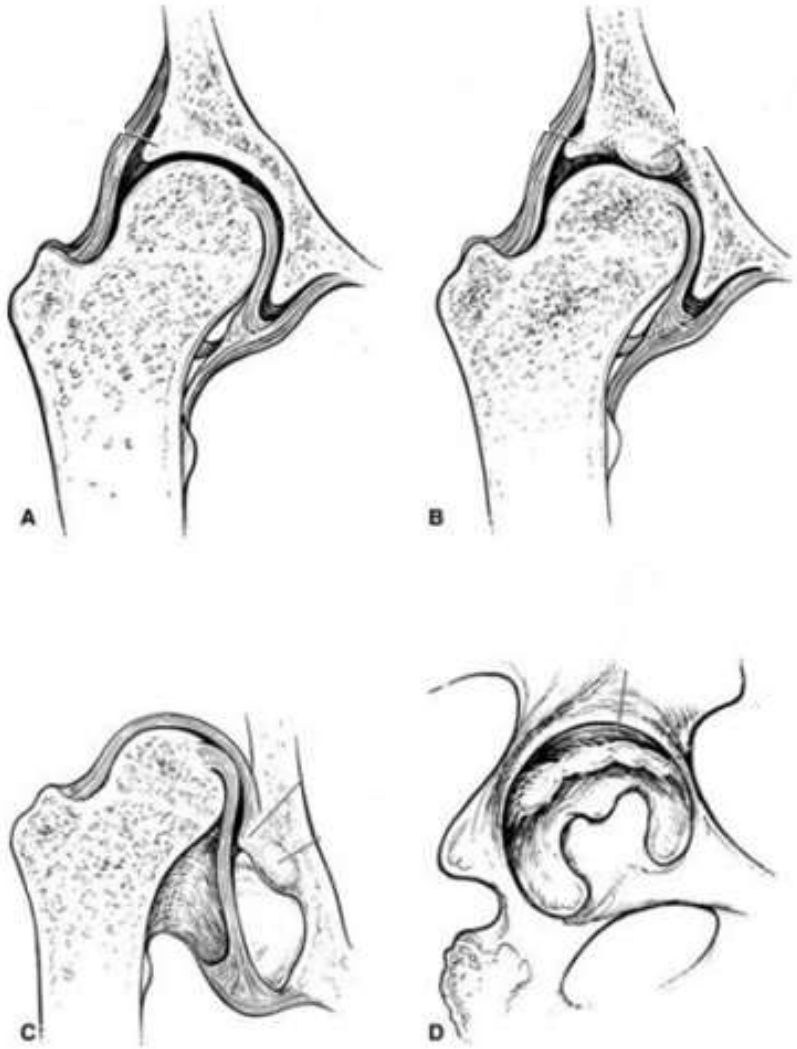

Figure 1-4: Pathology of hip in developmental dysplasia.

THE BLOOD SUPPLY OF THE HEAD OF THE FEMUR: There are extra capsular and intra capsular circulations , Extra capsular circulation depend on medial circumflex artery (MCA)and lateral circumflex artery (LCA) , usually originating from profunda femoris but both may arise from the femoral artery .(Hensinger, R. N, 1974) MCA takes a course between medial part of the capsule and obturator muscles. It appears at the upper border of quadrates femoris as Transverse branch to participate in the cruciate anastamosis near lesser trochanter, and then runs on the Posterior intertrochanteric crest towards the trochanteric fossa. It gives medial and lateral ascending cervical branches coursing subsynovially along the femoral neck. The latter also gives lateral epiphyseal artery. It is the main supply to the head. LCA passes laterally between branches of femoral artery and at lateral border of Sartorius, it shares by its anterior ascending Cervical artery, blood supply to the anterior part of the neck and head of the femur. (Hensinger, R. N, 1974) The four above mentioned branches (lateral, medial, anterior cervical arteries and lateral epiphyseal artery) penetrate the capsule along its femoral attachment, pass beneath the synovium and then branch to supply the metaphysis and epiphysis and form The intra capsular circulation. The epiphyseal plate blood supply is coming from the artery of ligamentum teres.

The distribution will be as following:

1- Postero inferior branch of MCA supply inferomedial part of physis and epiphysis.

2- Postero superior branch supply most of physis and superior part of epiphysis.

3- Lateral epiphyseal artery supply central part of physis.

Publisher: SARC Publisher

4- Anterior ascending cervical artery of LCA supplies metaphysis.

The MCA is more susceptible to compression in extreme abduction .internal rotation, and flexion because:

1- Postero superior branch is compressed by acetabular labrum in Intertrochanteric fossa.

2- Postero inferior branch is compressed by iliopsoas tendon against femoral neck and against acetabular labrum more proximally.

3- Contracted adductor longus, pectineus and iliopsoas tendons with increased tension on vessels compress MCA furtherer. (Hensinger, R. N, 1974)

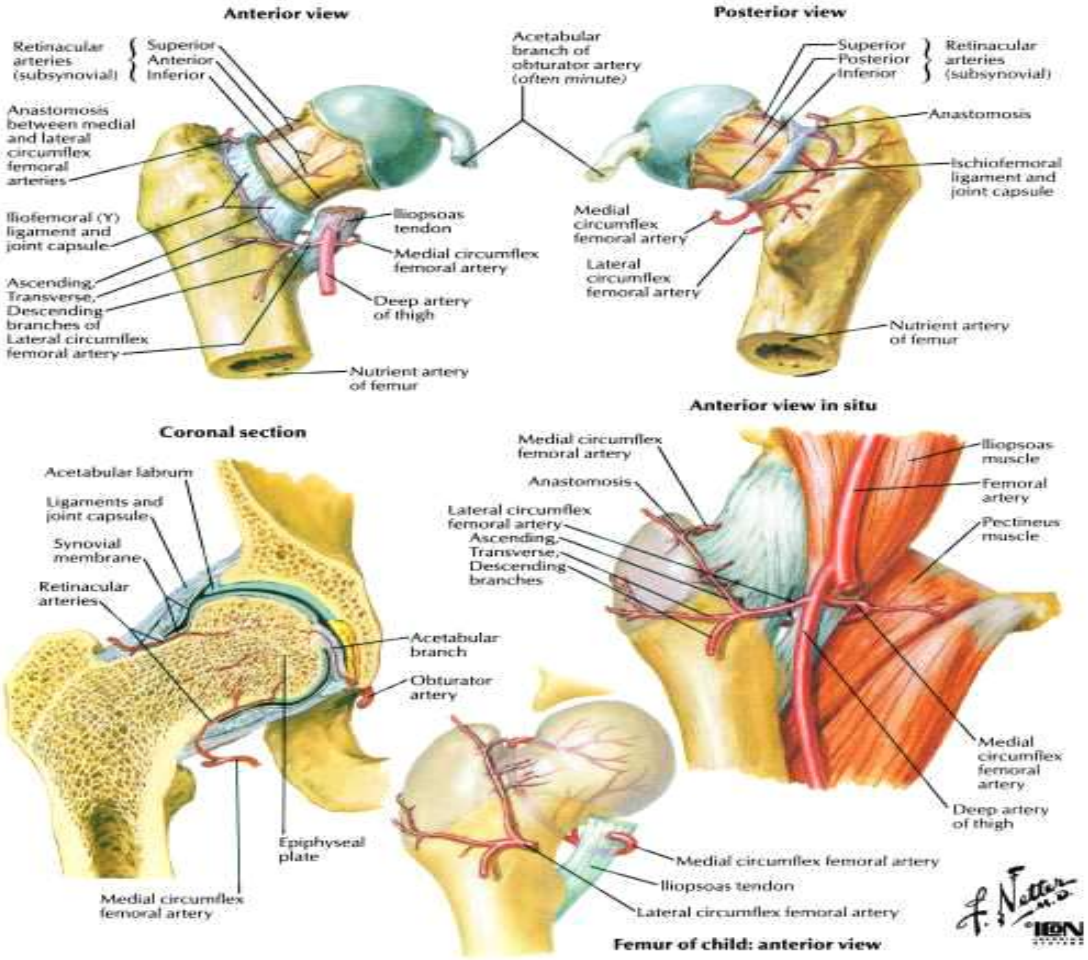

Figure1-5:- The Blood supply of the femoral head (From Netter's Concise Atlas of Orthopaedic Anatomy, 1st edition 2001)

Radiological Diagnosis:

1-Radiograph:

Become primary imaging modality at 3-months. after the femoral head begins to ossify.

A-hip dislocation:

1-Hilgenreiner's line - horizontal line through right and left triradiate cartilage (femoral head ossification should be below this line).

2-Perkin's line - line perpendicular line to Hilgenreiner's through point at lateral margin of acetabulum (femoral head ossification should be medial to this line).

3-Shenton's line - arc along inferior border of femoral neck and superior margin of obturator foramen.

Publisher: SARC Publisher

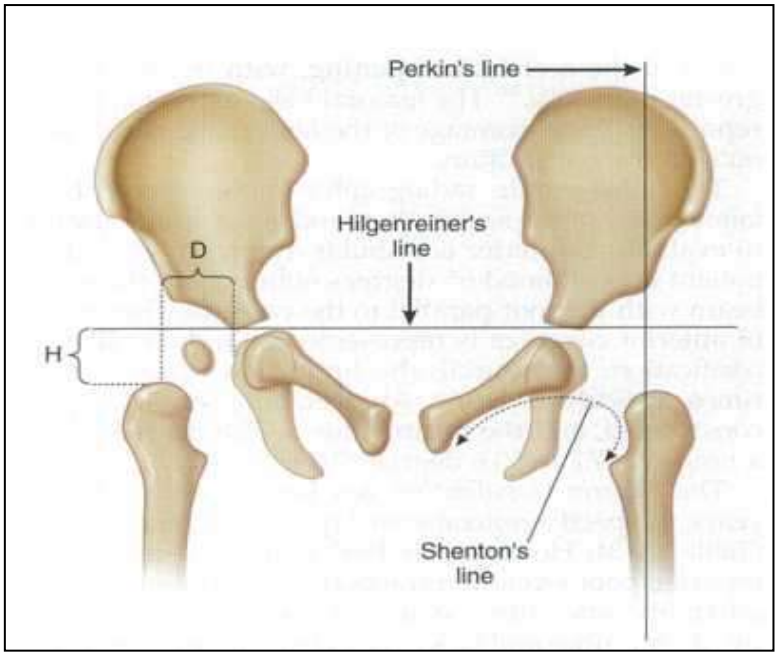

Figure 1-6:-

Radiographic measurements those are useful for evaluating developmental dysplasia of the hip. The Hilgenreiner's line is drawn through the triradiate cartilages. The Perkin line is drawn perpendicular to the Hilgenreiner's line at the margin of the bony acetabulum. The Shenton line curves along the femoral Metaphysis and connects smoothly to the inner margin of the pubis. Dimension H (height) is measured from the top of the ossified femur to the Hilgenreiner's line. Dimension D (distance) is measured from the inner border of the teardrop to the center of the upper tip of the ossified femur. Dimensions H and D are Measured to quantify proximal and lateral displacement of the hip and are most useful when the head is not ossified. From Tachdjian's pediatric orthopedics, 4thedition, 2008, Vo.l 1.P.659)

B-hip dysplasia:

1-Acetabular index - line drawn from point on triradiate cartilage to point on lateral margin of acetabulum (normal is < 30 degrees) decreasing with age.

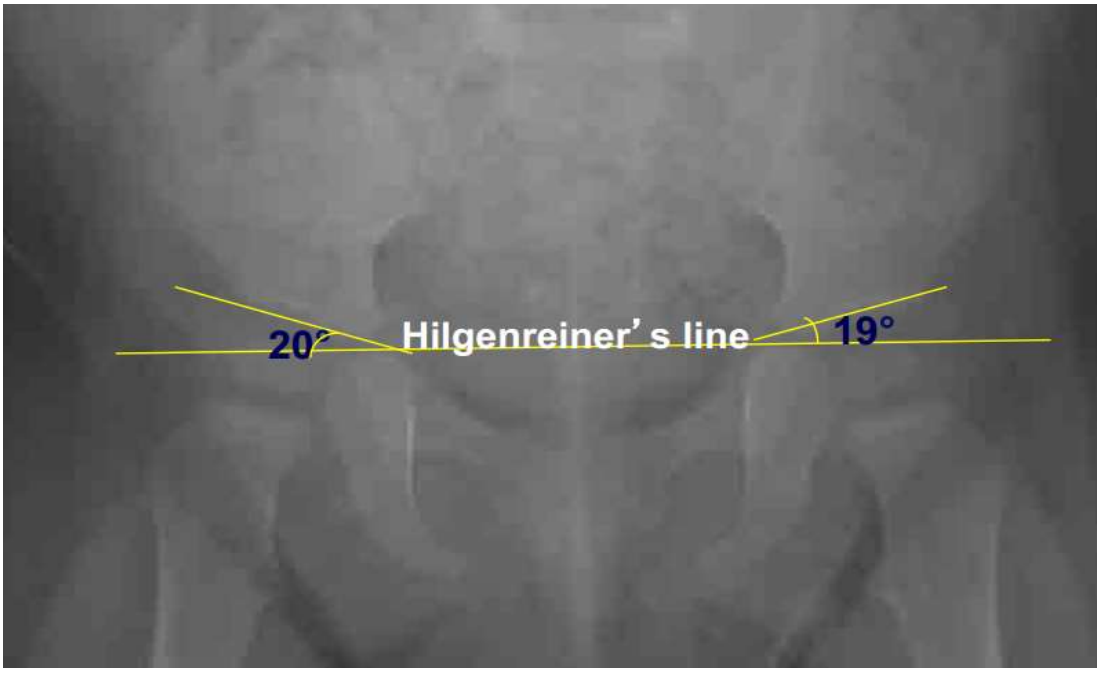

Figure 1-7: Normal values of acetabular index.

Publisher: SARC Publisher

Normal value of acetabular indexes:
Age < 2 years= 17°-30°
Age >2 years=18° (±4°)

2-Tear drop sign: The pelvic tear drop (also known as U-figure) is a radiographic feature seen on pelvic x-rays and results from the end-on projection of a bony ridge running along the floor of the acetabular fossa. This was shown to be the case by demonstrating that sawing away this bony plate made the feature disappear. It has also been confirmed by Vare in 1952 by applying a thin "strip of lead foil applied to the acetabular fossa and curving round the inferior margin of this, up over the inner wall of the lesser pelvis as far as the ilio-pectineal eminence." This configuration outlines the shape of the medial wall of the acetabulum. Normally it is biconcave, while .In dysplasia with subluxation it is triangular, small, or may be absent. (Butler, P. *et al*., 1999)

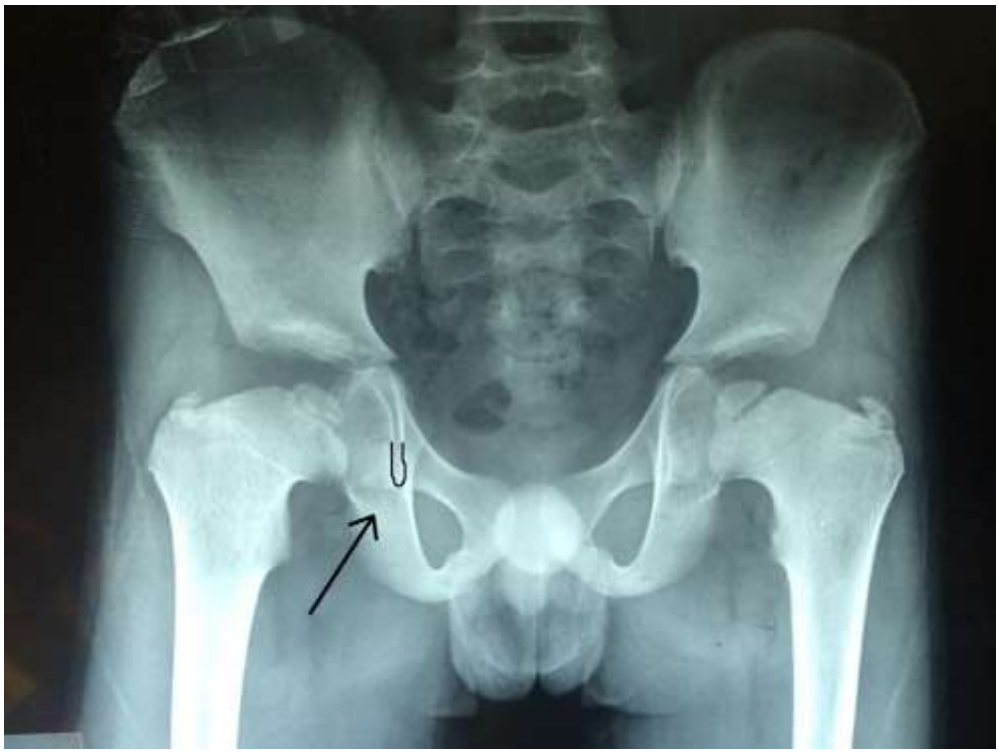

Figure (1-8): Tear drop configuration

Tonnis grading (1982): In which the center of the ossification nucleus of the femoral head is related to Perkins line and to the horizontal line at the level of the lateral margin of the acetabulum (Fig 1-9):

Grade 1: hip dysplasia with only mild subluxation.

Grade 2: the ossification center of the femoral head was migrated laterally but still inferior to the superolateral corner of the true acetabulum.

Grade 3: the ossification center at a level of superolateral corner of the true acetabulum.

Grade 4: the ossification center at a level superior to the superolateral corner of the true acetabulum (15).

Publisher: SARC Publisher

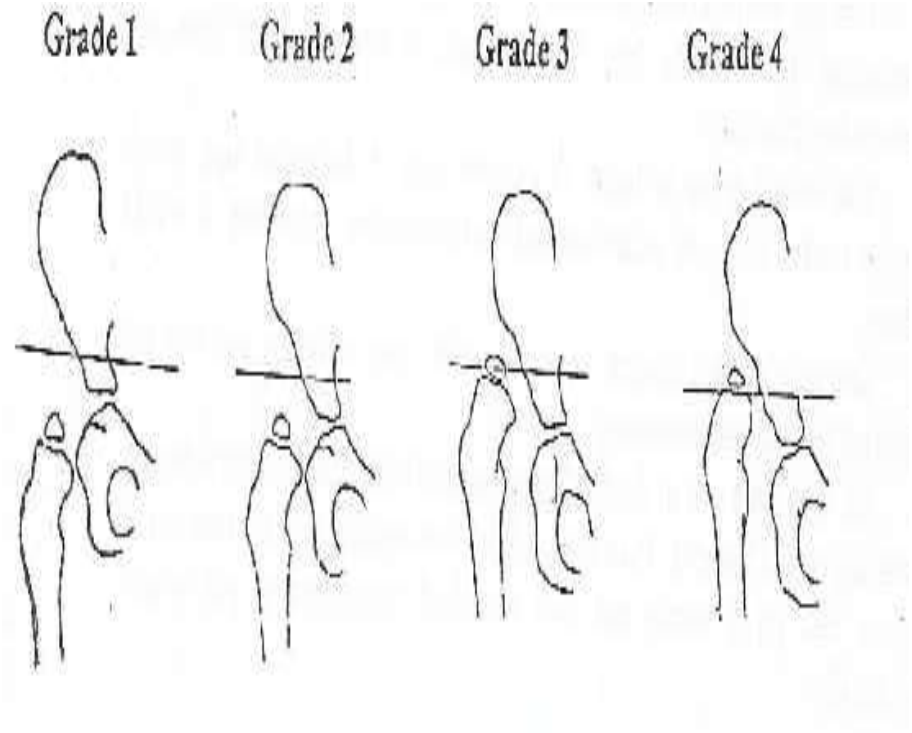

Figure (1-9): Tonnis grading (From Bennet G.C: pediatric hip disorder 1987 p. 64-113).

2-Ultrasound: Useful before femoral head ossification (< 5 months)

3-Arthrogram: It is invasive imaging based test using fluoroscopy to obtain series of pictures after contrast media (air,dye,water)or combination of these had been injected inside the hip joint under general anesthesia. Used to confirm reduction during closed reduction help identify an object that is blocking the reduction. Object that block reduction include

A-inverted labrum: Labrum enhances the depth of the acetabulum by 20% to 50% and contributes to the growth of the acetabular rim. In the older infant with DDH the labrum may be inverted and may mechanically block concentric reduction of the hip.

B-inverted limbus: Represents a pathologic response of the acetabulum to abnormal pressures caused by superior migration of the head, consists of fibrous tissue, transverse acetabular ligament, iliopsoas tendon and pulvinar.

TECHNIQUE: place the childe supine after general anesthesia given ,perform sterile preparation and draping of the hip. With gloved fingertip, locate the hip joint immediately inferior to the middle of inguinal ligament and one fingerbreadth Lateral to the pulsating femoral artery, medial and anterior to adductor musculature. Under fluoroscopy assistance,22 gauge spinal needle inserted ,to which is attached 5ml syringe filled with normal saline, until it enters the joint hip, resistance is met as needle passes through the joint capsule. After injecting normal saline, it is aspirated and syringe removed. (1) Again, fill the syringe with 5 ml of 25% strength hypaque solution and inject 1 to 3 ml through needle into joint .Rapidly remove the needle, and while hip still unreduced, have arthrogram made. Before developing it, gently reduce the hip joint into a stable position and have a second arthrogram made. Maintain reduction until both arthrogram have been developed and studied.

Publisher: SARC Publisher

Figure (1-10): Arthrographic technique

Publisher: SARC Publisher

Arthrographic features of normal hip: The lateral rim of the acetabulum is still largely undeveloped. The acetabular roof is represented by a thick layer of cartilage that is extended laterally by a projecting fibro- cartilaginous ring, the acetabular labrum. A good arthrogram will demonstrate the labrum as a complete ring encircling the head from the superior recess. This enables us to evaluate the extent of the cartilaginous coverage of the femoral head. Normally about two-thirds of the head should be covered

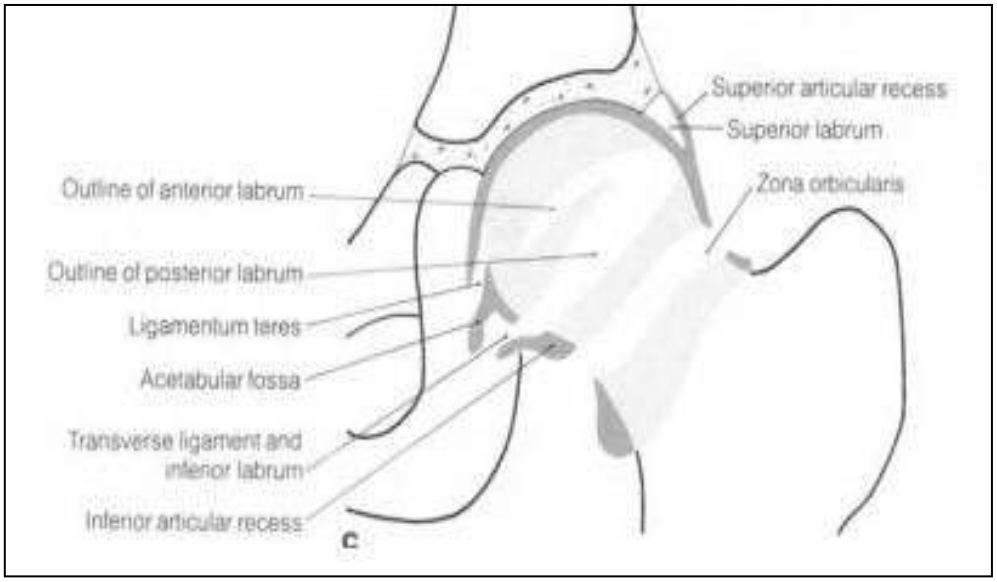

Figure (1-11): Normal hip arthrogram

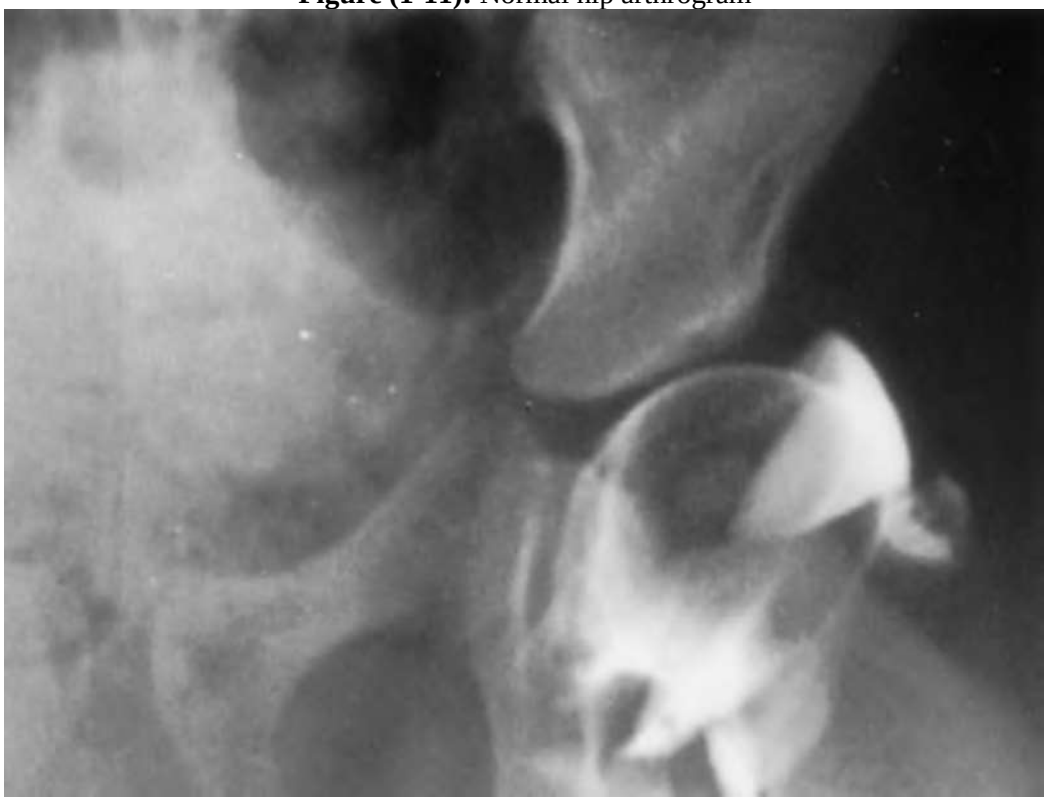

Figure (1-12):- Anteroposterior arthrogram of a normal hip in a neutral position. Note the sharp lateral acetabular margin (the "thorn") with a recess of joint capsule overlying it.

Arthrographic Features of the Abnormal Hip**:**
There are four essential points, then, that must be checked on hip arthrogram, these are:

1) The relation of the femoral head to the acetabulum and its periphery;
2) The shape and position of the superior labrum;

Publisher: SARC Publisher

3) The shape and position of the inferior labrum and transverse ligament;
4) The size and extent of the medial dye pool to evaluate the acetabular cavity and the size of the acetabular opening for reduction of the head.

Accepted criteria for reduction were a concentrically reduced cartilaginous femoral head with less than 6mm of lateralization. Lateralization was measured on the arthrogram as the distance between the iliac bone and the surface of the cartilaginous femoral head on a line drawn from the inferior end of the Ilium to the centre of the cartilaginous femoral head, designated as T distance (Figure1-13 below).

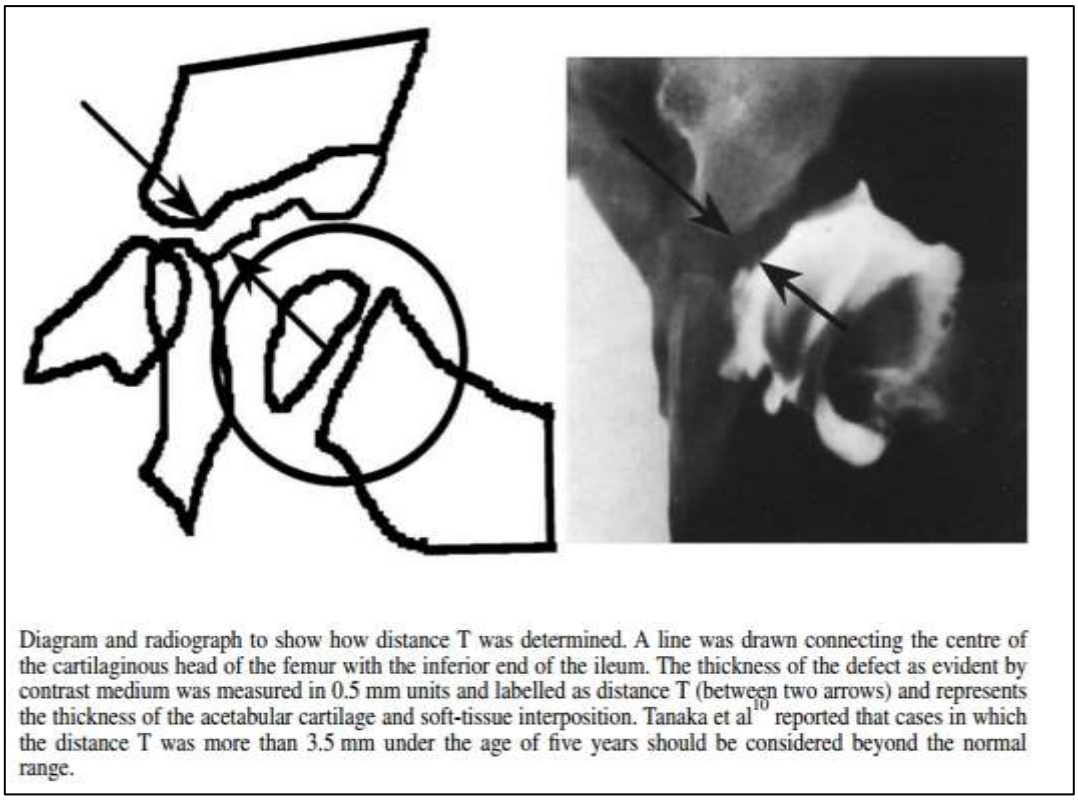

Diagram and radiograph to show how distance T was determined. A line was drawn connecting the centre of the cartilaginous head of the femur with the inferior end of the ileum. The thickness of the defect as evident by contrast medium was measured in 0.5 mm units and labelled as distance T (between two arrows) and represents the thickness of the acetabular cartilage and soft-tissue interposition. Tanaka et al[10] reported that cases in which the distance T was more than 3.5 mm under the age of five years should be considered beyond the normal range.

Figure 1-13: Abnormal hip arthrography showing T-distance

The other factors that determine acceptable reduction are the amount of dye pooling in the medial joint space (7mmor less)

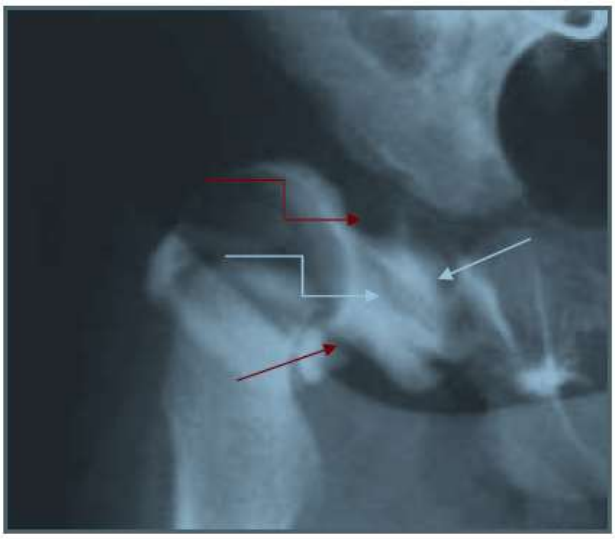

Figure (1-14): abnormal hip arthrography:

Publisher: SARC Publisher

Dislocated hip arthrogram shows abnormal inverted blunt labrum (zigzag red line), wide medial dye pool (straight white line), hypertrophied ligamentum teres (zigzag white line), hourglass deformity (straight redline). (Canale & Beaty: Campbell's Operative Orthopedics, 11th ed.2008).

Miyake's classification of the limbus:

We used Miyakes, (1967) classification which defines 6 types of limbus as follows; A-normal-everted which has a blunted and enfolded shape causing minimal block to the reduction-intermediated- inverted, which is enfolded and interposed between the femoral head and the acetabulum- blockaded which prevents the entrance of the dye into the true acetabulum, and has an ill-defined shape and- impossible which obviously prevent reduction. Miyake recommended that only the everted and intermediate types should be treated by closed methods

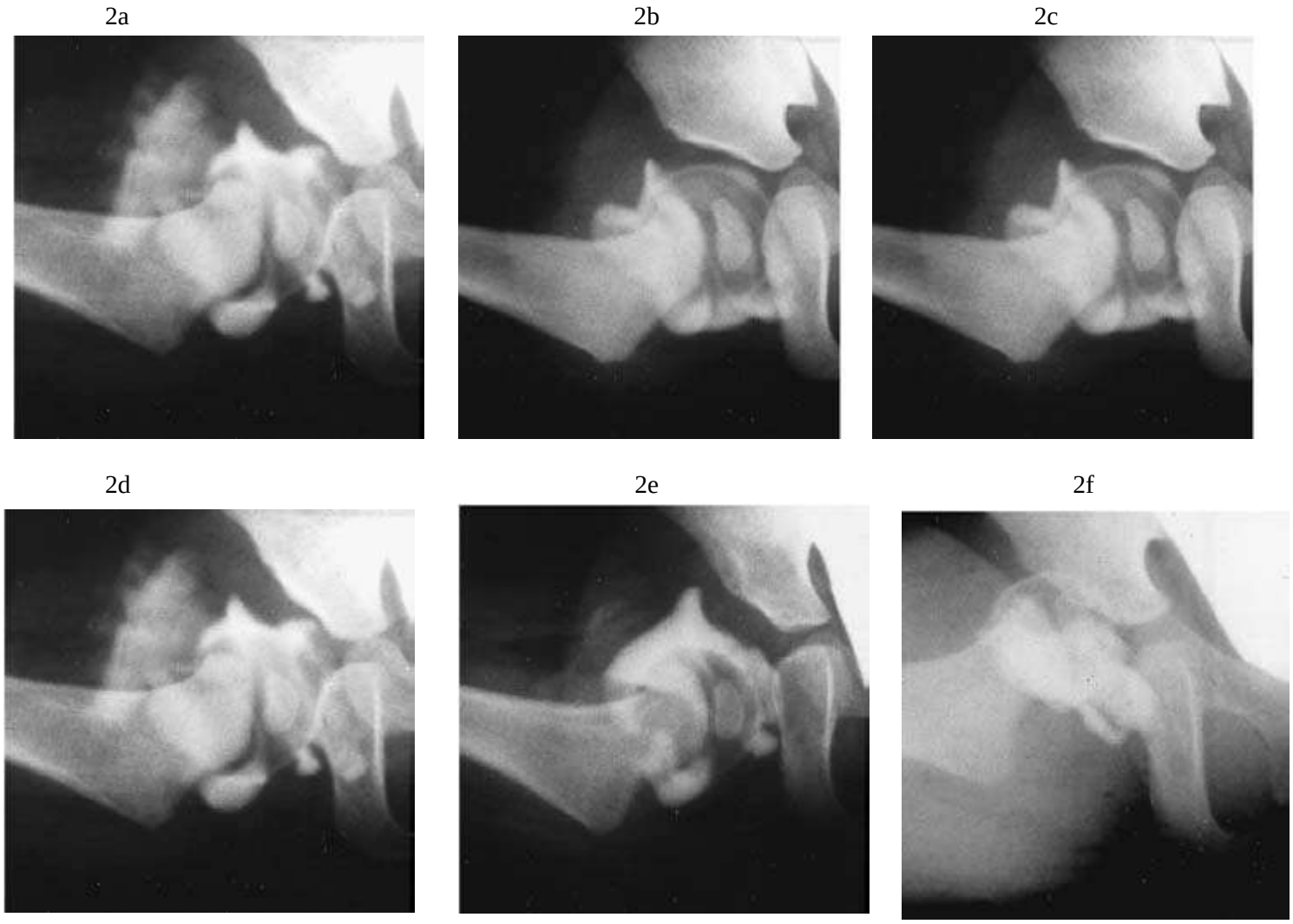

Figure (1-15): Types of limbus

SURGICAL OPTIONS IN TREATEMENT OF DDH:

The fundamental treatment goals in DDH are the same, regardless of the age of the patient. The first goal is to obtain reduction and maintain that reduction to provide an optimal environment for the development of the femoral head and acetabulum.

1-The most commonly used surgical approach to open reduction is the anterolateral Smith-Petersen approach with a modified bikini incision, as described by Salter and Dubos, (1974). This is a standard approach to the hip joint and is familiar to most surgeons. In the late-diagnosed patient with DDH, any associated capsular laxity can be plicated through this approach. If the surgeon thinks that a secondary procedure, such as pelvic

Publisher: SARC Publisher

osteotomy, is necessary, it also can be accomplished through the same surgical approach (Salter, R. B, 1961; Salter, R. B, 1966; Salter, R. B, 1974; Salter, R. B. *et al*., 2004). One of the advantages of the anterior Smith-Petersen approach is that the hip is immobilized in a functional position, with minimal hip flexion and some degree of Abduction. If this approach is used in conjunction with a capsular plication, the postoperative immobilization period is usually 6 to 8 weeks. The disadvantages may include greater blood loss than with the various medial and anteromedial approaches, possible damage to the iliac crest apophysis and the hip abductors, and postoperative stiffness. If this approach is used in bilateral cases, the procedures are usually staged at 2- to 6-week intervals.

2-The medial approach described by Ferguson (posteromedial approach) is in the plane between the adductor brevis and the adductor Magnus (Ferguson, A. B. Jr, 1982; Vedantam, R. C. *et al*., 1998). Advocates of this approach claim that its advantages include minimal soft tissue dissection, direct access to the medial joint capsule and the iliopsoas tendon, avoidance of damage to the iliac apophysis and abductor muscles, minimal blood loss, and excellent Cosmesis. However, it is a less familiar. Approach to most surgeons, and visualization is somewhat impaired. Capsular repair cannot be accomplished through this approach. The stability of the reduction is maintained only by the postoperative cast. This approach is somewhat difficult to use in older patients, and no concomitant surgical procedures can be performed through the same incision. Concern has also been expressed about a possible higher incidence of proximal femoral growth disturbance after use of this approach (Simons, G. W, 1980).

3- A third approach to open reduction in this age group is the anteromedial approach originally described by Ludloff and modified by Weinstein and Ponseti(Aiwa approach) (Weinstein, S. L. *et al*., 1979-Sosna, A. *et al*., 1990)

Surgical technique: We used the interval between the pectineus and iliopsoas, anterior to the pectineus, using the Weinstein-Ponseti approach. A 3-4 cm transverse Incision was made parallel to and just distal to the crease in the groin. The tendon of the adductor longus was isolated, sectioned at its origin, and allowed to retract. The tissue plane between the pectineus (medially) and femoral sheath (laterally) was developed with blunt dissection. The iliopsoas tendon was visualized, isolated, And divided transversely on the lesser trochanteric. We attempted to preserve the branch of the medial femoral circumflex artery that crosses over the antero-medial Capsule of the hip joint. The articular capsule was performed axially as the minimal incision from the outer edge of the acetabulum. Then, an additional cut parallel to the acetabular margin and perpendicular to the first cut was made if the capsule was still tight. The ligamentum teres seemed to block reduction because of hypertrophy and was resected. The transverse acetabular ligament was divided to allow a stable reduction, but the limbus was left intact in all cases. The hypertrophic fibrous fatty tissue of the pulvinar was removed with pituitary rongeurs. An intraoperative radiograph was obtained to check the reduction. The surgeon who decides that capsular plication should be performed cannot do it through this approach. The medial femoral circumflex vessels (the primary blood supply to the proximal femur) are in the operative field. Moreover, visualization is claimed by some to be poor, and the approach is associated with a noticeable incidence of aseptic necrosis (Simons, G. W, 1980; Fisher, E. H. I. *et al*., 1991) which is well in line with the results of other series of open reductions (Morcuende, J. A. *et al*., 1997; Morcuende, J.M. *et al*., 1997). Capsular plication appears to be unnecessary in this age group, because in a successful closed reduction the capsule tightens and the scar induced by the surgical procedure helps to provide capsular stability. This approach, however, depends on the placement of a well-molded cast. The approach to casting after reduction is the same as that described earlier for closed reduction. A certain degree of capsular stability is gained through the prolonged postoperative immobilization that is necessary. No residual stiffness has been reported.

4- The medial approach for open reduction of developmental dislocation of the hip (DDH) was introduced by Ludloff, (1913) Ludloff's method has been described as a simple method requiring minimal dissection and tissue destruction; it allows correction of the anteroinferior tightness by releasing the tight iliopsoas tendon and the constricted antero-inferior part of the capsular ligament. Although results of this procedure have been described in many reports, the outcome remains controversial (Castillo, R, 1990; Konigsberg, D.E, 2003) Open reduction is sometimes required when the dislocation is detected after the patient has started to walk. In

Publisher: SARC Publisher

such cases, patients show adhesion of the postero-superior part of the capsular ligament and short external rotators because of the posterior dislocated position, and its association with weight-bearing compression.

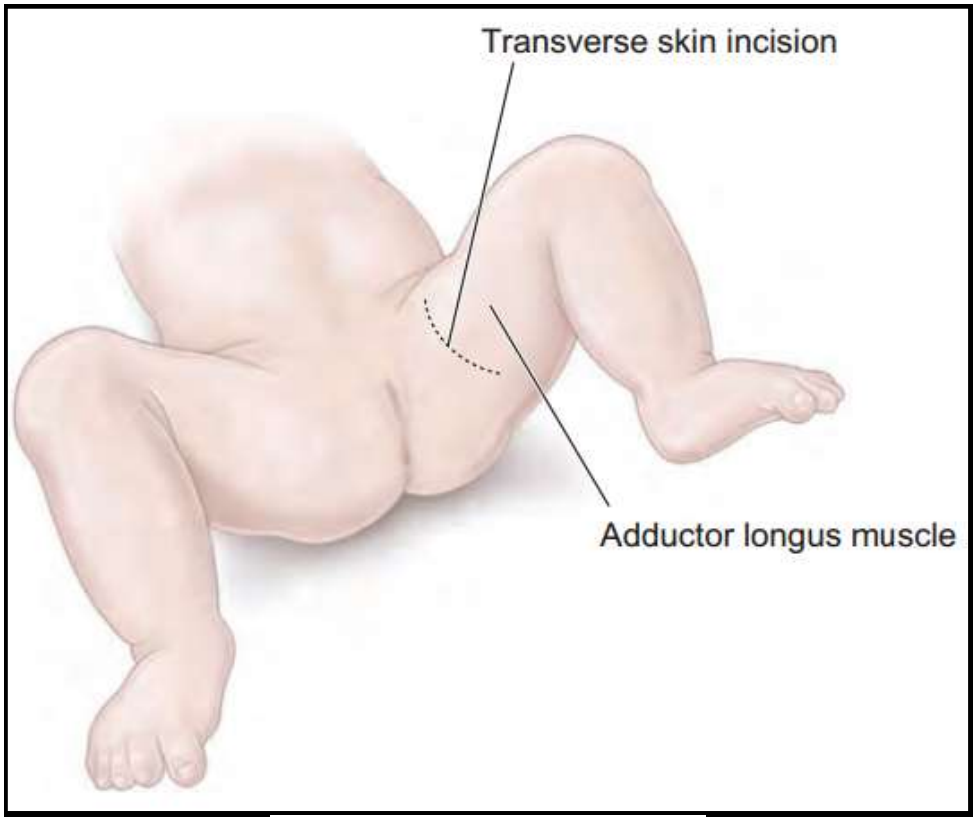

Figure (1-16): the Ludloff's incision

Advantages

- Easy access to blocks to reduction.
- Especially psoas / inferior capsule.
- Reduced blood loss.
- -Less operative time.

Disadvantages

- Risk of AVN via MCA damage.
- Only < 1 year as no access to periacetabular region.
- No capsulorraphy is done.

Position: Patient is supine with the affected hip in a flexed, abducted, and externally rotated position.

Approach:

Incision: Transverse incision over the adductor longus Begin incision 3 cm below the pubic tubercle, Length of incision is determined by the amount of femur that needs to be exposed.

Superficial dissection: Develop plane between gracilis and adductor longus muscles.

Deep dissection: Develop plane between adductor brevis and adductor Magnus until you feel lesser trochanter on the floor of the wound. Protect posterior division of the obturator nerve.

Publisher: SARC Publisher

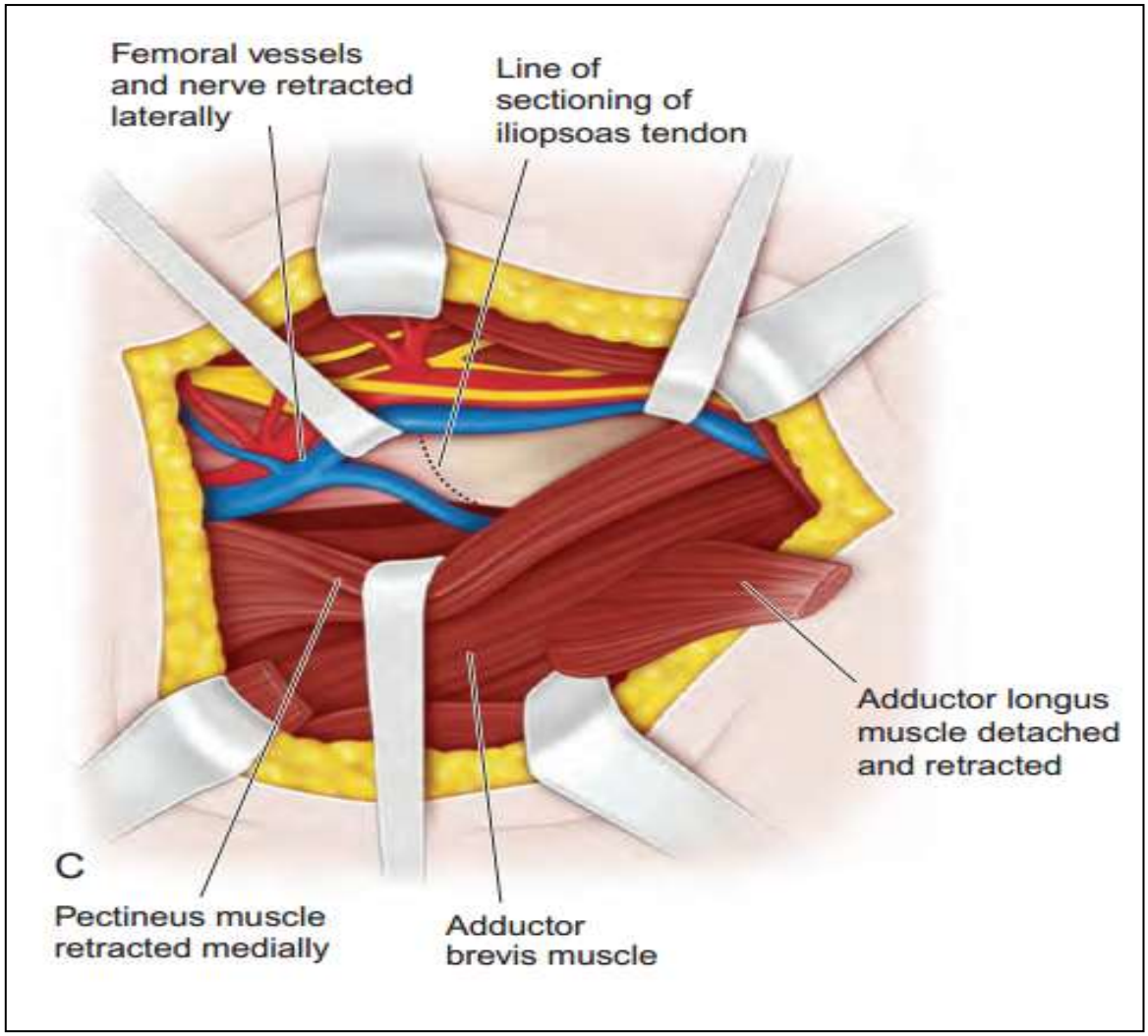

Figure (1-17): the Ludloff's approach, the deep dissection

PATIENTS AND METHOD:

This is a prospective study started from November 2012 to November 2014, done on 90 children (25 boys, 65 girls) with (110) developmentally dysplastic hips below age of 16 months in AL Basra General Hospital, all of them were evaluated preoperatively excluding the teratological and neuromuscular causes. Management started by closed reduction with or without adductor tenotomy followed by immediate intraoperative hip arthrogram to assess the outcome in reference to the concentric profile of reduction and its stability in the accepted safe zone. Twenty five patients (29 hips) out of the 90 patients (7 boys, 18 girls) have failed closed reduction as proved by the intraoperative arthrogram and were subjected to immediate open reduction utilizing the medial approach (Ludloff's, 1913)

Preoperative Evaluation

1- History:- History was taken from every parent including: Name, gender, date and type of delivery, perinatal history, and developmental mile stones to exclude neuromuscular disorders.

2- Clinical examination: Including general examination to exclude any associated anomalies of the spine and other joints. Hip examination also done to exclude any previous scar and for range of movement.

3- Radiography: All patients sent for X-Ray study of the pelvis include both hips, also send for chest X-ray as part of preoperative assessment.

4- Anesthetic assessment: Every child was sent for pre-operative anesthetic assessment with routine laboratory investigations, with preparation of one pint of blood.

5- Consent: the family also informed about the procedure and the possibility of go further to open reduction and for any complications that might happened.

Surgical technique: The child was placed supine after a general anesthesia. We examined the hip and checked whether it is reducible or not by performing Ortolani's and Barlow's maneuver.

Publisher: SARC Publisher

Then Performed sterile preparation and draping of the hip. Percutaneous tenotomy for adductor longus muscle was done through a small 2 to 3 millimeters incision over the tendon of adductor longus, and then check for stability. Reduction is considered stable if the hip can be adducted 20 to 30 degrees from maximum abduction and extended to below 90 degrees without re dislocation. Arthrogram under C-arm control was done for suspicious cases to assess the concentric reduction and for any obstacles, and closed reduction was considered failed for those cases with medial dye pool more than 7 millimeters and the T-distance, which is an indicator of the thickness of the soft-tissue interposition at the acetabular floor and it equal to 3.5 millimeters as the accepted normal value. Medial approach was done for those cases with failed closed reduction. A 4–5 cm transverse skin incision centered over the anterior margin of the adductor longus, parallel and 1 cm inferior to the inguinal crease was performed. The adductor fascia was divided longitudinally and the adductor longus which was already divided percutaneously and retracted distally. The interval between the adductor brevis and the pectineus was developed taking care to avoid damage to the branches of the medial circumflex artery. The iliopsoas tendon was identified, its sheath opened, and the tendon sharply divided and allowed to retracted proximally. The hip capsule was identified and divided. The transverse acetabular ligament divided. The ligamentum teres was divided off the femoral head and acetabulum sharply. A rongeur was used to remove the pulvinar fat. At this point, the hip was easily reduced. Stability was checked. The wound was irrigated with saline and the hemostasis was achieved. The subcutaneous tissue was closed with vicryl 3-0 and the skin with Nylon 3-0. Postoperatively, a bilateral hips pica cast using fiber glass was applied for all patients in 90–100 degrees of flexion and 45-55 degrees of abduction on the operated side, with 10-20 degrees of internal rotaton.this spica kept for 8 weeks then changed to above knee spica for another 6 weeks, then after that complete removal of spica and started physiotherapy. Post-operative 3rd generation cephalosporin (ceftriaxone) was used for 5 days in a dose 50mg per Kg intravenously. X-ray for pelvis and both hips was taken in the 1st day post operatively, then repeated every month during the period of follow up. The operative time duration (average from 20 – 30 minutes for each hip) and the surgical steps with the postoperative notes was documented in the patient's medical records. All patients were followed up clinically according to the Modified McKay criteria. (McKay, D.W., 1974)

Table (2-1): Modified McKay criteria (McKay, D.W, 1974)

Modified McKay criteria	
Excellent	Stable, painless hip, no limp, negative Trendelenburg sign, and a full range of movement
Good	Stable, painless hip, slight limp, negative Trendelenburg sign, and a slight decrease in range of movement
Fair	Stable, painless hip, limp, positive Trendelenburg sign, and limitation of movement
Poor	Unstable or painful hip, or both; positive Trendelenburg sign

Publisher: SARC Publisher

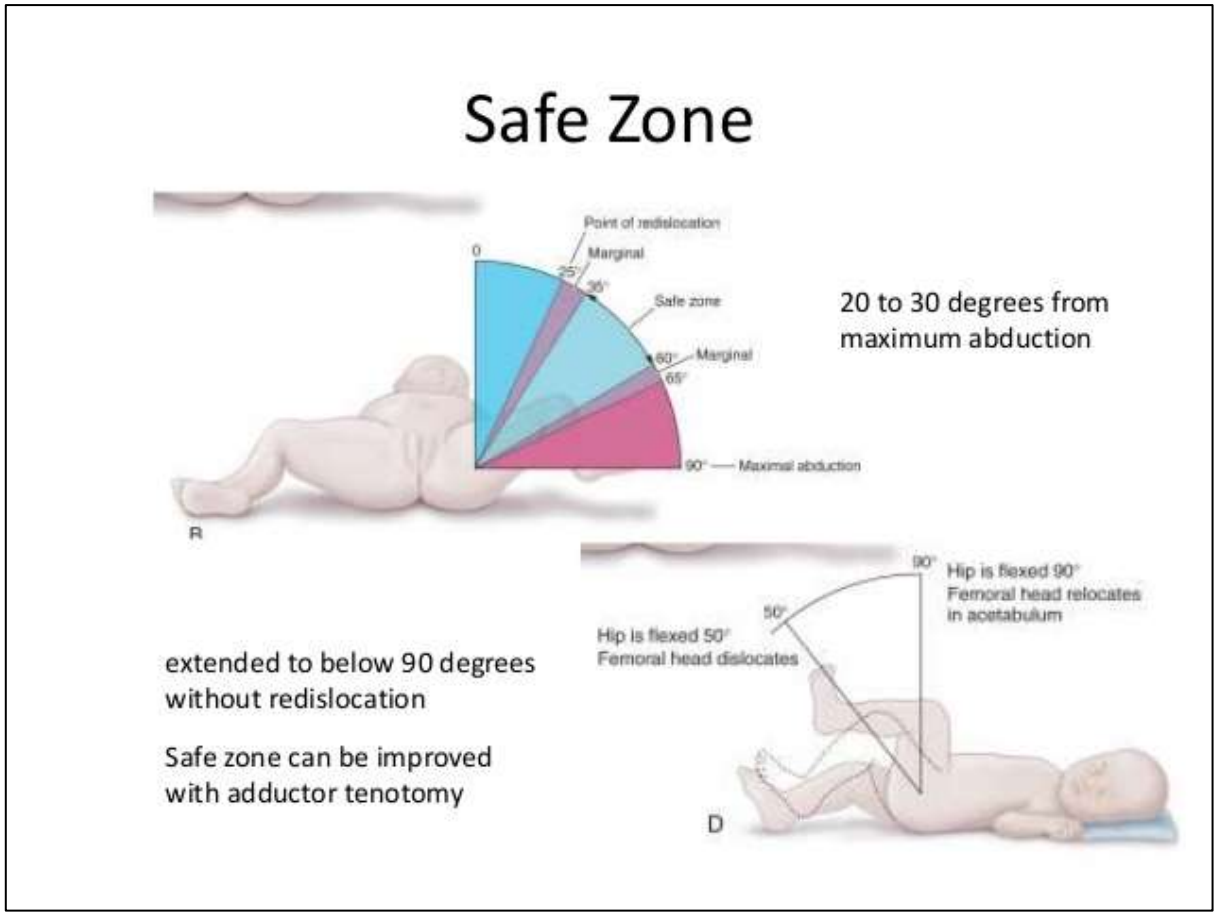

Fig (2-1): Safe zone of Ramsey

RESULTS

In our study, the 25 patients, seven males (28%) and eighteen females (72%) with DDH, twenty one patients (84% unilateral) and (four patients, 16% Bilateral) whom were subjected to open reduction via the Ludloff's medial hip approach had a mean age of 11.9 months, (range from 7 – 16 months) at time of surgery, our follow-up period was ranged from (4-23 months, with a mean of (14.8 months).The patients with an age of one year and below comprised 60% (sixteen patients) of the operated group. The mean of the acetabular Index readings pre-operatively was (31.4°) ranged from (28° - 38°) and post-operative AI mean was (23.84°) ranged from (20°-29°), a mean reduction of AI post-operatively from the pre-operative readings equal to **(**7.56°**)** was observed during our follow-up, the figure (2-2) below show this reduction in plotted graphs.

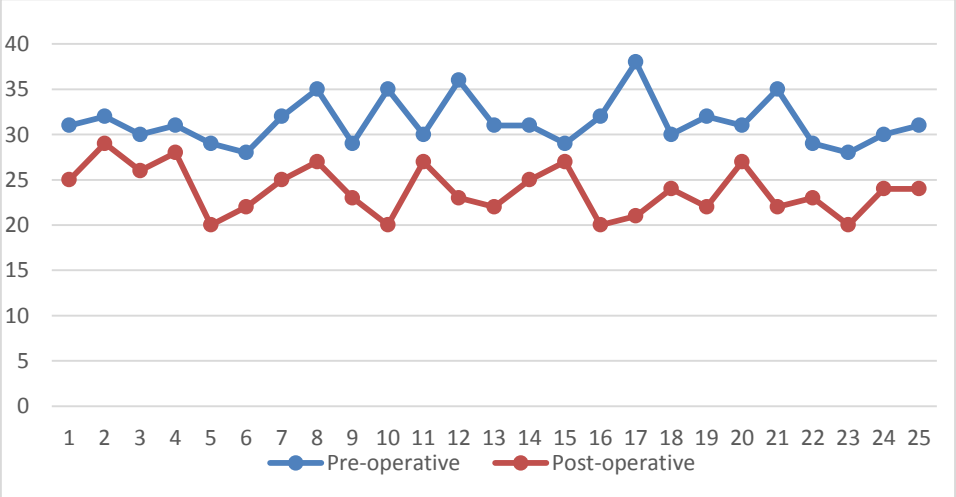

Figure (2-2): Pre- and Post-operative Acetabular Index values in the Patients

Publisher: SARC Publisher

There were 6 patients with post-operative avascular necrosis of the femoral head; they comprise a percentage of 24% from the remaining patients group whom undergo a medial hip approach for reduction, as shown in the table (2-2) below.

Table (2-2): The AVN grades according to kalamchi criteria (Kalamchi, A. *et al*., 1980) occurring postoperatively

AVN Grade	Number of Cases	Percent %	Total % of post-operative AVN
No AVN	19	76.0	76.0 %
Grade 1	3	12.0	24.0 %
Grade 2	2	8.0	
Grade 3	1	4.0	
Total	25	100.0	100.0 %

Figure (2-3): a 14 months old female with postoperative AVN of right femoral head.

Publisher: SARC Publisher

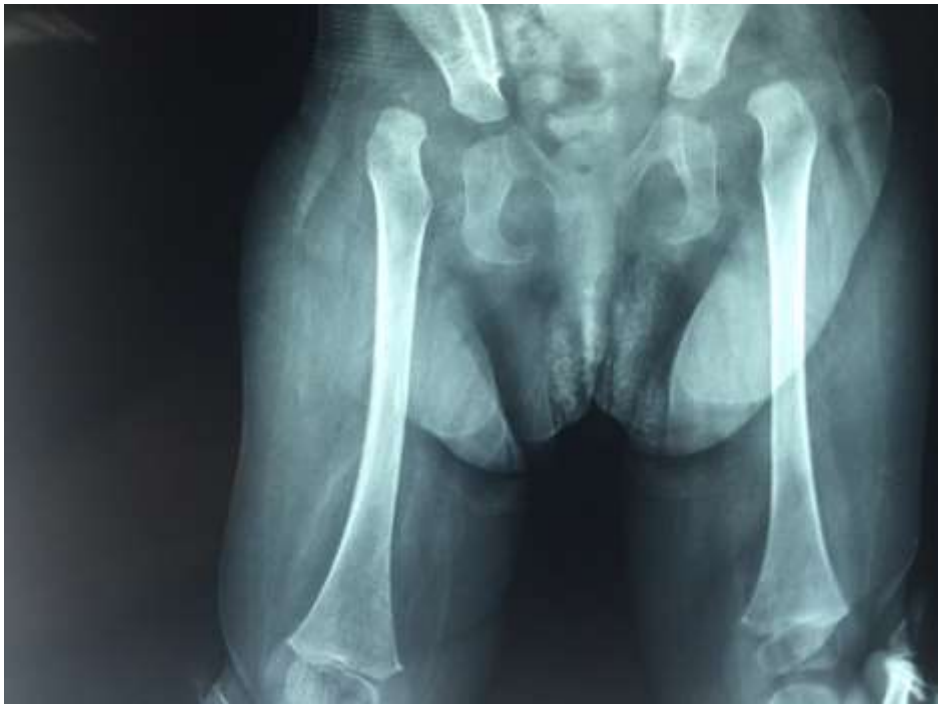

Figure (2-4): an 8 months old female with postoperative AVN of right femoral head.

Figure (2-5): an 8 months old female with postoperative AVN of right femoral head.

There were no other significant postoperative complications as shown in the table (2-3); in addition there were no patient need blood transfusions after surgery.

Table (2-3): the postoperative complications after Ludloff's hip approach In all the 25 patients

Complication	Number of cases	Percentage	P value
Postoperative Infection	0	0	0.00
Postoperative AVN	6	24%	0.00
Postoperative stiffness	2	8%	0.009
Postoperative Re-dislocation	0	0	0.00
Major neurovascular complications	0	0	0.00

Publisher: SARC Publisher

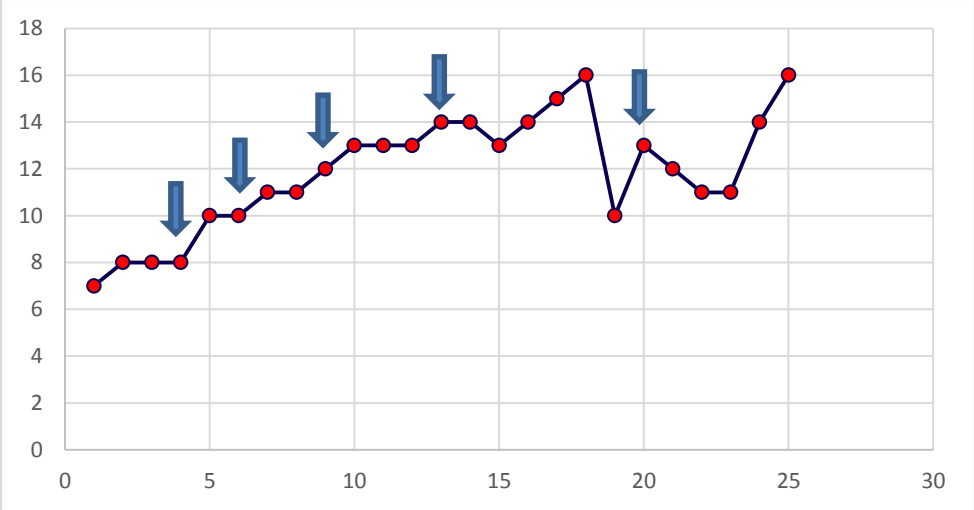

Fig (2-6): occurrence of AVN according to age in the postoperative sample

The above figure shows the ages at which the AVN occurs in the patients' sample.

The table (2-4) summarizes the overall patients' data as attached in the appendix.

In our study, a satisfactory result after medial approach reduction in 25 patients was 88% at a mean of age equal to 25.5 months. We define the satisfactory outcome as any patient with no major post-operative complication or with a mild AVN (goes with Grade 1 in Kalamchi-MacEwen System), the unsatisfactory results was defined as any case with a major or important post-operative complication; infection, major neurovascular injury, redislocation, and moderate to severe AVN (goes with Grade 2, 3 and 4 in Kalamchi-MacEwen System). No need for further surgery was present in all the 25 patients till the present time of writing this our research.

DISCUSSION:

DDH is still one of the major pediatric affections of the general well-being of both the individual and his/her community in term of adulthood hip arthritis and its sequels not to mention the stigma that it holds for the young female in our evolving community. This needs an early and prompt management; either conservative or surgical, this depend on so many parameters to respect and to be followed in our management in order to obtain an effective, safe and durable reduction in an early age as possible and with the minimum rate of complications as less as we can. The conservative management of DDH in the newly born or during the first 6 months of life represent the safest and the most effective treatment policy present for this disorder. Unfortunately this can't be the rule in all our beloved patients, many of them; for a particular reason or another, failed to be diagnosed in this early golden period and will be presented to us in the late stages with more dysplasia, fibrosis and bony deformity, necessitating a more aggressive, invasive type of management to end into our main aims of treatment: a concentric, congruent and stable reduction in a safe zone at the earliest possible age. (Okano, K. *et al*., 2009) Many ways of surgical approaches can be utilized to obtain these goals mentioned above, it depend on many factors for patients selection for a specific approach, namely the age of presentation (probably the most important one), the need for dealing with the obstacles for reduction, the need for bony corrective or reconstructive procedure in line with the primary surgery, and the presence of fibrosis and adhesions as a consequence of a previous surgery. The surgical approach used in open reduction remains a contentious issue. Avascular necrosis (AVN) of the femoral head and damage to the physis are The main complications following such surgery, with a variable reported incidence, ranging from 0 to 67% ([39] Kiely, N. *et al*., 2004). Numerous other possible complications can occur, including redislocation, stiffness of the hip, infection, blood loss, and, possibly the most devastating with the avascular necrosis of the femoral head. The rate of femoral head necrosis varies substantially; depending on the study, it may be anywhere from 0% to 73%.[1] Fogarty, E. E. *et al*., 1981[1] Numerous studies demonstrate that extreme abduction, especially when combined with extension and internal rotation, results in a higher rate of avascular necrosis.[1] Schoenecker, P. L. *et al*., 1978; Tiderius, C. *et al*., 2009) The medial approach to the hip was first described in 1908 by Ludloff who explored the interval between the adductor longus and the pectineus

Publisher: SARC Publisher

(Ludloff, K, 1908). This approach is advantageous in that it gives direct access to the structures that prevent concentric reduction, i.e. the stricture of the caudal capsule and the Iliopsoas tendon. The disadvantages are the risk of damaging the medial circumflex femoral artery (MCFA) and the inaccessibility of other parts of the joint. (Kiely, N. *et al*., 2004) Ludloff's method has been described as a simple method requiring minimal dissection and tissue destruction; it allows correction of the antero-inferior tightness by releasing the tight Iliopsoas tendon and the constricted antero-inferior part of the capsular ligament. Although results of this procedure have been described in many reports, the outcome remains controversial [Kiely, N. *et al*., 2004; Koizumi, W. *et al*., 1996; Konigsberg, D. E. *et al*., 2003; Sosna, A. *et al*., 1992; Ucar, D. H. *et al*., 2004] No matter which operative approach is used, there is still a considerable incidence for the need of revision surgery. Following a medial approach, revision surgery via a lateral approach is considerably easier through fresh tissue planes. (Di Mascio, L. *et al*., 2008) The advantage of the medial approach over the lateral approach is that there is considerably less dissection involved, Operative time is less, blood loss is less, thus potentially enabling simultaneous bilateral procedures to be performed. The medial approach also avoids damage to the iliac apophasis and the scar is more cosmetically acceptable. The medial approach has been criticized owing to two main potential problems: the first is the inability to improve the stability of the hip after reduction due to lack of access to the lateral hip capsule and limbus (Simons, G. W, 1980). The second is the potential risk of damage to the medial circumflex femoral artery and resultant increased risk in the development of avascular necrosis (Tumer, Y. *et al*., 1997) In our study, a satisfactory result after medial approach reduction in 25 patients was 88% at a mean of age equal to 25.5 months. Koizumi, *et al*., [1996] reported satisfactory results in 23%, at age of 19 years (range, 14–23 years) follow-up, Matsushita, *et al*., [1999] in 34%, at 16 (range, 11–21) years follow-up and Ucar, *et al*., [2004] in 59% at 19.8 (range, 13–28) years follow-up. We think that this difference is related directly to the length of follow-up period, which was the shortest in our study comparing to the others. This may mask any future complication or unsatisfactory results that could occur in our patients group. It needs a further follow-up study for a prolong period of time. The rate of AVN development in our study was 24% (6 patients from 25). WATARU KOIZUMI, *et al* (1996) in his study of 33 patients with DDH treated by medial approach found a postoperative AVN rate equal to 42.9%. The reported incidence of avascular necrosis varies considerably from 4% in the series of Mau, *et al*., (1971) and 15% in that of Castillo and Sherman, (1990), to 35.5% in that of Sosna and Rejholec, (1992). The frequency of vascular disturbances to the head of the femur can be explained by the terminal nature of the sub-synovial branches of the MCA (Gautier, E. *et al*., 2000). Mascio, *et al*., (2008) (Di Mascio, L. *et al*., 2008) believe that by performing the capsulotomy at its insertion superiorly into the acetabular rim the risk of damage to these vessels is minimized. The MCA is potentially at risk when performing a medial approach, but similarly when performing a release of the Iliopsoas tendon via any approach. (Di Mascio, L. *et al*., 2008) The position of the Spica has also been shown to be critical in preventing the incidence of AVN (Salter, R. B. *et al*., 1969). Performing bilateral adductor tenotomies increases this relative position of safety and reduces the risk of developing AVN in the unaffected side during the period of Spica immobilization (Di Mascio, L. *et al*., 2008) Another factor is the age of the patients at the time of the operation. The mean age of patients in our study was (11.36 months) at time of surgery, 60% of our patients with an age of one year and below. There are some reports that patients younger than one year have good results [Castillo, R. *et al*., 1990; Mankey, M. G. *et al*., 1993; Mergen, E. *et al*., 1991].In Kunihiko Okano, *et al*., (2009) study, the mean age at surgery was 14.0 months (range, 6–31 months), and 14 patients (31%) who were treated at more than 18 months were included. Merge, *et al*., [1991] reported that patients between seven and 18 months of age at the time of operation had good results. Castillo, *et al*., [1990] reported that patients between five and 14 months of age at the time of operation also had good results. Mankey, *et al*., [1993] also reported that this procedure was effective in infants who were less than 24 months old. However, all studies were conducted at less than ten years average time for follow-up. On the other hand, Isiklar, *et al*., [2006] compared the radiological results for children aged 12– 18 months and under 12 months at the time of surgery in a 19.6-year (range, 13–28) follow-up and reported that, although additional bone surgery is needed in a higher incidence in children 12–18 months of age, the radiological outcome is not significantly different for patients younger than 12 months. In our study, all of the patients treated at more than 17 months of age had

Publisher: SARC Publisher

poor results when followed-up until skeletal maturity. However, improved results could be obtained by selecting patients less than 17 months of age for this approach. Kunihiko Okano, *et al*., (2009) identified AVN in 13 (29%) of 45 hips after operation. An AVN rate of 0–67% has been reported after open reduction through a medial approach [Castillo, R. *et al*., 1990; Gautier, E. *et al*., 2000- Mankey, M. G. *et al*., 1993], and some describe the relationship between age at open reduction and presence of AVN at follow-up. Mergen, *et al*., [1991] reported that AVN was only observed at less than seven months and over 18 months. Castillo, *et al*., [1990] and Mankey, *et al*., [1993] reported that AVN correlated positively with increased age at surgery. In our study, age at operation was significantly higher in the patients with AVN than the patients without AVN at follow-up, and all three hips classified as Kalamchi types III and IV were operated upon at more than 13 months of age. Kunihiko Okano, *et al*., (2009) also stated that the mean age at surgery was significantly older in the patients with AVN than without AVN (20.0 and 11.6 months, respectively, P<0.001). Another approach, such as the wide exposure method, should be selected for DDH with increased age at operation. Kunihiko Okano, *et al*., (2009) concluded that at more than ten years follow-up poor radiological results and prevalence of AVN correlated positively with increased age at open reduction by the medial approach for DDH. All the patients treated by medial approach for DDH at more than 17 months of age had unacceptable results. Another approach such as the wide exposure method should be selected for DDH in these patients. Livio DI MASCIO, *et al*., (2008) shows that there is a low incidence of lateral subluxation in these cases and a re-operation rate of only 8%. A revision rate of 19 % (Tumer, Y. *et al*., 1997) to 27 % (Castillo, R. *et al*., 1990) has been described with the Ferguson procedure,(posteromedial approach). Similar outcomes as in our study have been found by other authors using the medial approach for open reduction (Kiely, N. *et al*., 2004). In previous studies, however, the medial approach had been reserved for patients older that six months after which the femoral capital epiphysis is present. This is thought to reduce the incidence of a vascular necrosis (Kiely, N. *et al*., 2004).

CONCLUSION AND RECOMMENDATIONS:

Medial Ludloff's approach is a good hip approach to be utilized in the open reduction of congenital hip dislocation in the patients younger than one year of age, this represented in the dramatically less operative time comparing to other approaches, with less blood loss, less postoperative pain during hip movements resulted in early improved range of movement, no scarring in the anterolateral region to the hip making it easily to be operated on in the future if required, less risks for postoperative infection, redislocation, and major neurovascular injury. It also have a favorite technical operative advantage in that it create a direct path with the shortest way to attach dealing with a major obstacle of reduction, namely the Iliopsoas tendon. The main drawback is the risk of injuring the Medial circumflex femoral artery with a weighted opportunity for postoperative avascular necrosis of the femoral head. This can be decreased by a careful surgical dissection and manipulation, the operating surgeon must keep the MCFA in his mind all the time, or else its injury could invite a painful failure to both the surgeon and his patient. We recommend more studies to compare between both of the 2 approaches (anterolateral and medial) with a big sample and for a long period of follow-up till beyond bone maturity to assess more confidently the pro and cons of each in dealing with those difficult cases of DDH who require an open reduction for their remedy.

REFERENCES:

1. Canale & Beaty: Campbell's Operative Orthopaedics, 11th ed. (2008).
2. Orthopedic knowledge update 9, Alexander R. Vaccaro, MD.
3. Tachdjian's pediatric orthopaedics,4th edition 1 (2008): 637-674
4. Jensen, B. A., Reimann, I. & Fredensborg, N. "Collagen type III predominance in newborns with congenital dislocation of the hip." *Acta Orthop Scand*, 57.3 (1986): 362.
5. Andren, L. "Pelvic instability in newborns with special reference to congenital dislocation of the hip and hormonal factors: A roentgenologic study." *Acta Radiol, Suppl* 212 (1962): 1.
6. Muller, G. M. & Seddon, H. J. "Late results of treatment of congenital dislocation of the hip." *J Bone Joint Surg Br*, 35 (1953): 342.
7. Suzuki, S. & Yamamuro, T. "Correlation of fetal posture and congenital dislocation of the hip." *Acta Orthop Scand*, 57 (1986): 81.
8. Dunn, P. M. "The anatomy and pathology of congenital dislocation of the hip." *Clin Orthop Relat Res*, 119 (1976): 23.

Publisher: SARC Publisher

9. Ferguson, A. L. & Bert, J. R. "Orthopedic surgery in infancy and childhood." chapter 4, 4th edition (1975): 166-214.
10. Bennett, G. C. "Pediatric hip disorders." (1987): 64-113.
11. Landa, J., Benke, M. & Feldman, D. S. "The Limbus and the Neolimbus in Developmental Dysplasia of the Hip." *Clin Orthop Relat Res*, 466.4 (2008): 776–781.
12. Hernandez, R. J. "Concentric reduction of the dislocated hip: computed-tomographic evaluation." *Radiology*, 150 (1984): 266.
13. Hensinger, R. N. "Clinical symposia on CDH." *CIBA* 31.1 (1974).
14. Butler, P., Mitchell, A. & Healy, J. C. "Applied Radiological Anatomy." *2nd Edition, chapter 16, lower limbs, Cambridge University Press* (1999): 323
15. Orthopaedia Review. In: Orthopaedia - Collaborative Orthopaedic Knowledgebase. 19 (2010):26. Last modified Jul 22, 2011 14:37 ver.8. Retrieved 2011-08-04, http://www.orthopaedia.com/x/R4HRA.
16. Miyake, Y. "Evaluation of arthrogram of congenital dislocation of the hip: especially for the strangulation of ligamentum transversum acetabuli." *Cent Jpn J Orthop Traumat* 10 (1967):467.
17. Hernandez, R. J. "Concentric reduction of the dislocated hip: computed-tomographic evaluation." *Radiology* 150 (1984):266.
18. Salter, R. B. "Innominate osteotomy in treatment of congenital dislocation of the hip." *J Bone Joint Surg Br* 43 (1961):72.
19. Salter, R. B. "Role of innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip in the older child." *J Bone Joint Surg Am* 48 (1966):1413.
20. Salter, R. B. & Dubos, J-P. "The first fifteen years' personal experience with innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip." *Clin Orthop* 98 (1974):72.
21. Salter, R. B., Hansson, G. & Thompson, G. A. "Innominate osteotomy in the management of residual congenital subluxation of the hip in young adults." Clin Orthop 182 (1984):53.
22. Ferguson, A. B. Jr. "Treatment of congenital dislocation of the hip in infancy using the medial approach." *In: Tachdjian MO, ed. Congenital dislocation of the hip. New York: Churchill Livingstone*, (1982):283.
23. Vedantam, R. C., Capelli, A. M. & Schoenecker, P. L. "Pemberton osteotomy for the treatment of developmental dysplasia of the hip in older children." *J Pediatr Orthop* 18 (1998):254.
24. Simons, G. W. "A comparative evaluation of the current methods for open reduction of the congenitally displaced hip." *Orthop Clin North Am* 11 (1980):161.
25. Weinstein, S. L. & Ponseti, I. V. "Congenital dislocation of the hip." *J Bone Joint Surg Am* 61 (1979):119.
26. Weinstein, S. L. "The medial approach in congenital dislocation of the hip." *Isr J Med Sci* 16 (1980):272.
27. Weinstein, S. L. "Closed versus open reduction of congenital hip dislocation in patients under 2 years of age." *Orthopedics* 13 (1990):221.
28. Ludloff, K. "The open reduction of the congenital hip dislocation by an anterior incision." *Am J Orthop Surg* 10 (1913):438.
29. Fabry, G. "Open reduction by the Ludloff approach to congenital dislocation of the hip under the age of two." *Acta Orthop Belg* 56 (1990):233.
30. Castillo, R. & Sherman, FC. "Medial adductor open reduction for congenital dislocation of the hip." *J Pediatr Orthop* 10 (1990):335.
31. Cech, O., Sosna, A. & Vavra, J. "Indications and surgical technique for open reposition of congenital dislocation of the hip after Ludloff [author's translation]." *Acta Chir Orthop Traumatol Cech* 43 (1976):233.
32. Scapinelli, R. & Ortolani, M. Jr. "Open reduction (Ludloff approach) of congenital dislocation of the hip before the age of two years." *Isr J Med Sci* 16 (1980):276.
33. Sosna, A., Rejholec, M., Rybka, V, *et al*. "Long-term results of Ludloffs repositioning method." *Acta Chir Orthop Traumatol Cech* 57 (1990):213.
34. Fisher, E. H. I., Beck, P. A. & Hoffer, M.M. "Necrosis of the capital femoral epiphysis and medial approaches to the hip in piglets." *J Orthop Res* 9 (1991):203.
35. Morcuende, J. A., Weinstein, S.L., Dolan, L, *et al*. "DDH: results of treatment after reduction by an anteromedial surgical approach at a minimum four-year follow-up." *J Bone Joint Surg* 79A (1997):810.
36. Morcuende, J.M., Dolan, L.A., Weinstein, S.L, *et al*. "Long term outcome after open reduction through an anteromedial approach for congenital dislocation of the hip." *J Bone Joint Surg Am* 79 (1997):810.
37. Ludloff, K. "The open reduction of the congenital hip dislocation by an anterior

Publisher: SARC Publisher

incision." *Am J Orthop Surg* 10(1913):438–454.
38. Castillo, R. & Sherman, F.C. "Medial adductor open reduction for congenital dislocation of the hip." *J Pediatr Orthop* 10(1990):335–340.
39. Konigsberg, D.E., Karol, L.A., Colby, S. & O'Brien, S. "Results of medial open reduction of the hip in infants with developmental dislocation of the hip." *J Pediatr Orthop* 23(2003):1–9.
40. Okano, K, *et al*. "Long-term outcome of Ludloff's medial approach for open reduction of developmental dislocation of the hip in relation to the age at operation." *International Orthopaedics* (SICOT 33 (2009):1391–1396.
41. Ferguson, A. B. Jr. "Primary open reduction of congenital dislocation of the hip using a median adductor approach." *J Bone Joint Surg* 55-A (1973):671-689.
42. Kalmachi, A., Schmidt, T. L. & MacEwan, G. D. "Congenital dislocation of the hip. Open reduction via the medial approach." *Clin Orthop* 169 (1982):127-132.
43. Ludloff, K. "Zur blutigen Einrenkung der angeborenen Huftluxation." *Z. Orthop. Chir*. 22 (1908):272-276.
44. Kiely, N., Younis, U., Day, J. B. & Meadows, T. M. "The Ferguson medial approach for open reduction of developmental dysplasia of the hip. A clinical and radiological review of 49 hips." *J Bone Joint Surg Br* 86 (2004):430–433.
45. Koizumi, W, *et al*. "Ludloff's medial approach for open reduction of congenital dislocation of the hip. A 20-year follow-up." *J Bone Joint Surg Br* 78 (1996):924–929.
46. Konigsberg, D. E., Karol, L. A., Colby, S. & O'Brien, S. "Results of medial open reduction of the hip in infants with developmental dislocation of the hip." *J Pediatr Orthop* 23 (2003):1–9.
47. Sosna, A. & Rejholec, M. "Ludloff's open reduction of the hip: long-term results." *J Pediatr Orthop* 12 (1992):603–606.
48. Ucar, D. H, *et al*. "Open reduction through a medial approach in developmental dislocation of the hip: a follow-up study to skeletal maturity." *J Pediatr Orthop* 24 (2004):493–500.
49. Di Mascio, L., Carey-Smith, R. & Tucker, K. "Open reduction of developmental hip dysplasia using a medial approach: A review of 24 hips." *Acta Orthop. Belg*. 74 (2008):343-348.
50. Simons, G. W. "A comparative evaluation of the current methods for open reduction of the congenitally displaced hip." *Orthop Clin North Am* 11 (1980):161-181.
51. Tumer, Y., Ward, W. T. & Grudziak, J. "Medial open reduction in the treatment of developmental dislocation of the hip." *J Pediatr Orthop* 17 (1997):176-180.
52. Matsushita, T, *et al*. "Open reduction for congenital dislocation of the hip: comparison of the long-term results of the wide exposure method and Ludloff's method." *J Orthop* Sci 4 (1999):333–341.
53. Mau, H., D¨orr, W. M., Henkel, L. & Lutsche, J. "Open reduction of congenital dislocation of the hip by Ludloff's method." *J Bone Joint Surg [Am]* 53-A (1971):1281-8.
54. Castillo, R. & Sherman, F. C. "Medial adductor open reduction for congenital dislocation of the hip." *J Pediatr Orthop* 10 (1990):335-40.
55. Gautier, E., Ganz, K., Krugel, N., Gill, T. & Ganz, R. "Anatomy of the medial femoral circumflex artery and its surgical implications." *J Bone Joint Surg* 82-B (2000):679-683.
56. Salter, R. B., Kostuik, J. & Dallas, S. "Avascular necrosis of the femoral head as a complication of treatment for congenital dislocation of the hip in young children. A clinical and experimental investigation." *Can J Surg* 12 (1969):44-61.
57. Mankey, M. G., Arntz, G. T. & Staheli, L. T. "Open reduction through a medial approach for congenital dislocation of the hip. A critical review of the Ludloff approach in sixty-six hips." *J Bone Joint Surg Am* 75 (1993):1334–1345.
58. Mergen, E., Adyaman, S., Omeroglu, H. & Erdemli, B. "Medial approach open reduction for congenital dislocation of the hip using the Ferguson procedure. A review of 31 hips." *Arch Orthop Trauma Surg* 110 (1991):169–172.
59. Okano, K, *et al*. "Long-term outcome of Ludloff's medial approach for open reduction of developmental dislocation of the hip in relation to the age at operation." International Orthopaedics (SICOT 33 (2009):1391–1396.
60. Isiklar, Z. U., Kandemir, U., Ucar, D. H. & Tumer, Y. "Is concomitant bone surgery necessary at the time of open reduction in developmental dislocation of the hip in children 12–18 months old? Comparison of open reduction in patients younger than 12

Publisher: SARC Publisher

months old and those 12–18 months old." *J Pediatr Orthop* B 15 (2006):23–27.
61. Tumer, Y., Ward, W. T. & Grudziak, J. "Medial open reduction in the treatment of developmental dislocation of the hip." *J Pediatr Orthop* 17 (1997):176-180.
62. Kiely, N., Younis, U., Day, J. B. & Meadows, T. M. "The Ferguson medial approach for open reduction of developmental dysplasia of the hip. A clinical and radiological review of 49 hips." *J Bone Joint Surg* 86-B (2004):430-433.
63. Fogarty, E. E. & Accardo, N. J. Jr. "Incidence of avascular necrosis of the femoral head in congenital hip dislocation related to the degree of abduction during preliminary traction." *J Pediatr Orthop* 1.3 (1981):307-11.
64. Schoenecker, P. L., Bitz, M. & Witeside, L. A. "The acute effect of position of immobilization on capital femoral epiphyseal blood flow. A quantitative study using the hydrogen washout technique." *J Bone Joint Surg Am* 60.7(1978):899-904.
65. Tiderius, C, *et al*. "Post-closed reduction perfusion magnetic resonance imaging as a predictor of avascular necrosis in developmental hip dysplasia: a preliminary report." *J Pediatr Orthop* 29.1 (2009):14-20.
66. Kalamchi, A. & MacEwen, G. D. "Avascular necrosis following treatment of congenital dislocation of the hip." *J Bone Joint Surg* 62-A (1980):876-888.
67. McKay, D. W. "A comparison of the innominate and the per capsular osteotomy in the treatment of congenital dislocation of the hip." *Clin Orthop Relat Res* 98 (1974):124-132.

Source of support: Nil;
Conflict of interest: Nil.

Cite this article as:
Majeed, H.R. and Hameed, A.H. "LUDLLOF'S (Medial) Approach Open Reduction of Developmental Dysplasia of the Hip in Children below 16 months of age." *Sarcouncil Journal of Medical Series* 3.5 (2024): pp 30-55.

Publisher: SARC Publisher