EC PAEDIATRICS
Research Article

Long-Term Result After Operative Hung Zigzag Osteotomy Combined Fibular Allograft for Developmental Dysplasia of the Hip, and Coxa Magna in Children

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Abstract

Objective: Coxa magna (CM) is defined as a condition in which the transverse (transverse) diameter of the femoral head is larger on the affected side than on the intact side. CM can occur as a manifestation of avascular necrosis (AVN) after treatment for developmental dysplasia of the hip (DDH).

Methods: This study is a retrospective study on 158 cases of DDH after zigzag osteotomy combined with fibular allograft (ZOFA) and CM from October 2009 to December 2012. The patients were divided 3 Variations: Variation 1 (ZOFA), variation 2 (ZOFA with limbusectomy) and variation 3 (ZOFA with femoral shortening osteotomy).

Results: One hundred fifty-eight patients with unilateral side. There were 133 girls (84.2%) and 25 boys (15.2%). Mean age at surgery was 21.5 months (12 to 36) and mean age at last follow-up was 10 years 4 months (9 years 7 months - 13 years 4 months). Median follow-up was 11 years 6 months (10 years 8 months to 14 years 2 months). Surgery was performed on 72 patients in V1, 53 patients in V2, and 33 patients in V3. Having CM: 48 (30.4%); AVN: 55 (34.8%). Overall, excellent 65.2%, good 2: 20.3%, fair: 11.4%, poor: 3.1%. Coxa magna 48 (30.4%) and AVN: 55 (34.8%).

Conclusion: One of the most important causes of coxa magna is overexpansion of the acetabular capacity by limbus resection. Another cause is avascular necrosis of the hip after surgery. Coxa magna worsens long-term results. To prevent coxa magna, it is important to retain the limbus.

Keywords: *Coxa Magna; Legg-Calvé-Perthes Disease; Asymmetry; Femoral Head Enlargement; Avascular Necrosis*

INTRODUCTION

Congenital developmental dysplasia of the hip (DDH) has undergone a revolution during the past 120 years from Howorth's reported about this disease [1]. Prenatal, perinatal, and postnatal factors that contribute to dislocation have been identified and early diagnostic techniques have improved. Newborn screening programs and physician awareness have reduced the rate of untreated hip dislocations in older children. The focus of treatment has shifted from forceful manipulation and electrostatic infusion to gentle analgesia and dynamic splinting.

Fortunately, the incidence of serious treatment complications such as avascular necrosis has decreased. Many factors have contributed to this decline, including the use of dynamic splinting in infants, the use of preoperative traction [2], and the avoidance of excessive cast positions [3]. Despite these precautions, changes in the shape of the femoral head continue to be observed after surgical treatment of some hip dislocations. The purpose of this article is to explore one such change, that of Coxa Magna.

When discussing DDH, reference materials and standard textbooks only briefly mention CM [4]. They showed that CM often occurs after avascular necrosis. It is rarely mentioned that CM can occur in the absence of avascular necrosis, and no consistent quantitative definition of CM has been given. Furthermore, the incidence of CM remains unknown, the association with different treatment modalities has not been determined, and the effect of CM on the acetabulum is unclear. In this study, the incidence of CM and its association with treatment regimens were investigated. The relationship of the greater femoral head to the acetabulum was quantified to make predictions about future hip development.

Purpose of the Study

The purpose of this study is the long-term results after surgery for congenital developmental dysplasia of the hip using primary surgery with zigzag osteotomy combined with allograft grafting and coxa magna.

MATERIAL and METHODS

Blood supply to the proximal femur

There are three main sources of blood supply to the proximal femur: the extracapsular arterial ring; ascending cervical vessels (retinal branches); and round ligament artery [5] (Figure 1). The outer capsule is formed mainly by the medial and lateral femoral heads, which in turn give rise to the metaphyseal and epiphyseal branches.

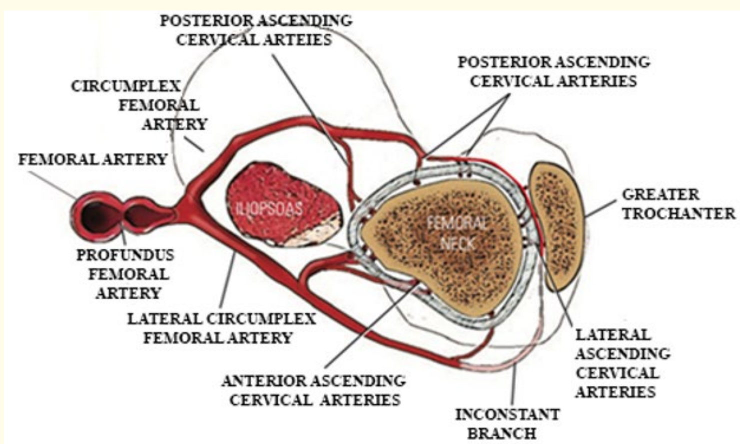


Figure 1: *Anatomy of arterial supply at the femoral head.*

The anterior part of the lateral capsule is formed mainly by the lateral femoral circumflex artery. The posterior, lateral, and medial aspects of the ring are formed by the medial femoral circumflex artery. Chung [5] found that the greatest amount of blood flow to the femoral head is through the lateral ascending cervical artery (the end of the medial femoral circumflex artery). This corresponds to the lateral epiphyseal artery described by Trueta [6] which passes through the capsule in the posterior transitional fossa (Figure 1). The extremely important lateral ascending cervical artery passes through this fossa, which is extremely narrow in children under 8 years of age, making it a possible cause of disruption of proximal femoral blood flow [5].

Before the appearance of the secondary ossification center of the proximal femur, branches of the ascending cervical artery penetrate the head and terminate in an expanding sinusoid that will eventually supply the ossification center(s) of the femur. proximal femur [5] (Figure 1). Trueta [6] and Chung [5] demonstrated that the anterior connecting network is much less extensive than the posterior connecting network, especially in specimens from patients aged 3 to 10 years. Ogden [7] reported the presence of blood vessels passing through the cartilage plate in some of his specimens, but Chung [5] disagreed, arguing instead that the blood vessels do not actually pass through the plate cartilage that passes through the peripheral perichondral fibrocartilage complex. The cartilaginous plate is an absolute barrier to blood flow between the epiphysis and the medulla with the epiphysis and medulla oblongata originating from the same ascending cervical branches. There is communication between these two circulations on the bone surface but no connection within the bone. The medulla oblongata is well supplied with blood by many small medullary arteries while the epiphysis lacks this extensive network, making it more susceptible to rupture [5]. Trueta and Amato [8] demonstrated experimentally that the epiphyseal circulation is responsible for nourishing the cartilage while the metaphyseal circulation is responsible for calcification of the cartilage matrix, removal of degenerative cells and matrix formation.

Anatomy and histological limbus

The margin is a pathological structure that occurs when abnormal pressure from the femoral head on the labrum causes fibrocartilage to hypertrophy and form surrounding fibrous tissue. The Limbus form results from secondary adaptive changes that occur with persistent hip subluxation or hip dislocation [9]. The limbus is reversible and everted, and is a mass capable of reducing the concentricity of the dysplastic hip (Figure 2).

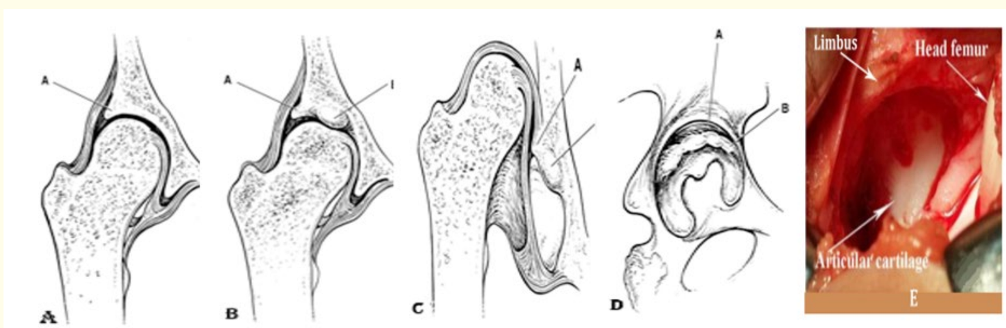


Figure 2A-2D: *A. In this normal hip, the labrum [A] is located at the periphery of the cartilaginous acetabulum. B. In the dysplastic reduced hip, note the hypertrophied labrum, now called the limbus [A]. The neolimbus [B], a hypertrophied ridge inside the cartilaginous acetabulum, is located at the periphery just beneath the limbus. C. In this dislocated dysplastic hip, note how the limbus [A] is a block to reduction, and could invert or evert while the neolimbus [B] is not a potential block to reduction and cannot invert or evert. D. Lateral view of the dysplastic acetabulum depicts the neolimbus [B] running from anterior to posterior beneath the limbus [A]. E. Intraoperative photo of the acetabulum.*

The acetabular cartilage of the hip joint is composed of hyaline cartilage while the acetabular cartilage is composed of fibrocartilage [10]. In 1946, Leveuf and Bertrand described the limbus as wide lips [11]. In 1976, Milgram and Tachdjian [12] proposed a mechanism for the pathological changes leading to limbus formation. They postulated that persistent hip dislocation mechanically irritates the labrum, leading to labial hypertrophy. This may also apply to abnormal forces caused by a subluxated hip. This hypertrophied labial tissue is produced by fibroblasts in the acetabular rim.

Many layers of this fibrous tissue stretch over the cartilage lip to form a new fibrous tissue lip. The junction between the fibrocartilage margin and the fibrocartilage lip is not a clear boundary. Although two distinct tissues comprise the margin, they fuse without a clear tissue plane [12]. The rim typically forms on the lateral aspect of the labrum, just as the neolimbus forms on the lateral aspect of the acetabulum.

After receiving approval from our institutional review board, we queried the surgical database at our center to identify all patients who had undergone revision surgery. open to treat DDH with zigzag osteotomy and combined fibrous allograft bone grafting (ZOFA) [13]. Patients with teratogenic dislocations, neuromuscular or connective tissue disorders, and those with a history of previous hip arthroplasty at another institution were excluded from the study. Patients with Tonnis grades I and II were excluded from this study. Only patients with grades III and IV were included in the study.

This study retrospectively evaluated the outcomes and CM after Operative ZOFA. This study group included patients diagnosed with DDH who had surgery between 2009 and 2012. The surgeries were performed by one surgeon (Author) and evaluated by two surgeons. independent orthopedic surgeon, not a member of the faculty.

All members have confirmed consensus. The study was approved by our Institute's Ethics Review Committee and was conducted in accordance with the tenets of the Declaration of Helsinki.

From August 2009 to December 2012, 133 girls (84.2%) and 25 boys (15.2%) with DDH received open reduction surgery and ZOFA [13]; In total only one side is used. There were no cases of preoperative skin or bone traction, nor was a varus or varus osteotomy required. Patients were performed at a median age of 21.5 months (12 to 36) and median age at last follow-up was 10 years 4 months (9 years 7 months - 13 years 4 months). Median follow-up was 11 years 6 months (10 years 8 months to 14 years 2 months).

Dislocations of the hip were graded using the Tönnis system [14].

Grade	Criteria
1	Capital femoral epiphysis medial to Perkins line
2	Capital femoral epiphysis lateral to Perkins line but below the level of the superior acetabular rim grade Criteria.
3	Capital femoral epiphysis at the level of the superior acetabular rim
4	Capital femoral epiphysis above the level of the superior acetabular rim

Table A

The acetabular index angle

The acetabular index was measured as the primary variable to evaluate correction of acetabular dysplasia and subsequent maintenance of acetabular dysplasia. The term acetabular index was introduced by Kleinberg and Lieberman in New York in 1936 to refer to a radiographic sign [15]. "The angle formed between the roof or iliac portion of the acetabulum and a horizontal line passing through three-ray cartilage".

AI was measured preoperatively, immediately postoperatively, and at 3 months, 6 months, 1 year, 2 years, and latest follow-up.

Femoral neck anteversion angle

The angle of torsion is called anteversion, anterior rotation or anterior torsion; similarly, if it is directed posteriorly (behind the transcondylar plane), it is called inversion, retroversion or posterior torsion [16].

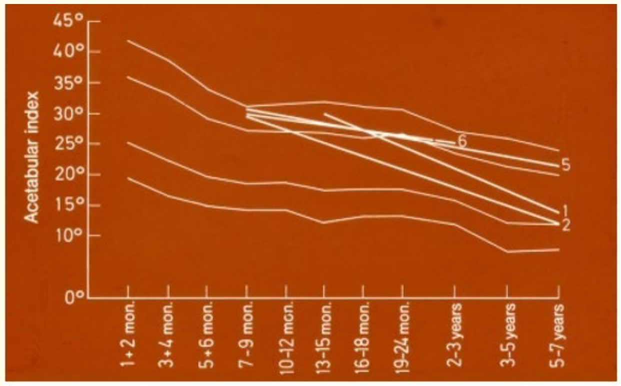


Figure 3: *Normal acetabular index.*

There are many imaging methods described and used to measure femoral displacement; we agree that Ruby's opinion favors the use of the Ryder-Crane technique [17].

Biplane method (Ryder-Crane) [17]: With this technique, all radiographs are taken with the patient lying supine. The X-ray tube is placed directly over the hip. One radiograph is taken with the limb in a neutral (extended) position and a second with the hip and knee flexed to 90 degrees and the thigh abducted to 30 degrees, a position maintained by a specially made box. special. Lines representing the cervical and femoral shafts were drawn from the first radiograph. This is the obvious twist angle. The true twist is determined by reference to a standard angle table derived from trigonometric considerations.

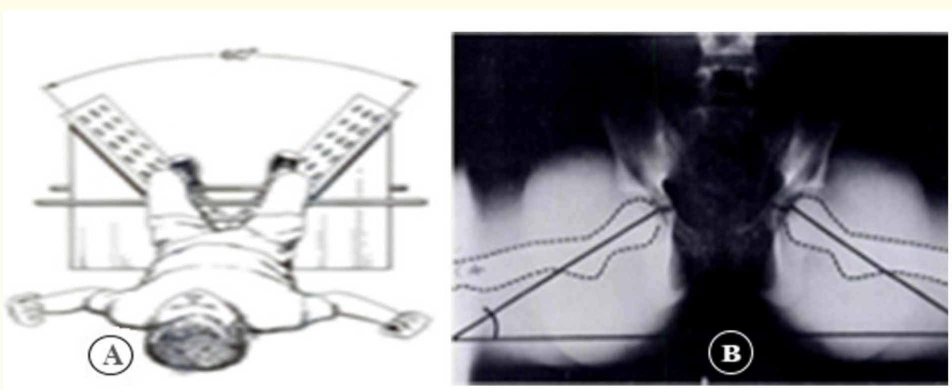


Figure 4A and 4B: *A. The limb in neutral position (extended) and a second with the hips and knees flexed to 90 degrees and with the thighs abducted to 30 degrees, the position being maintained by a specially constructed box. B. Lines representing the axis of the neck and the shaft of the femur are drawn of the first roentgenogram.*

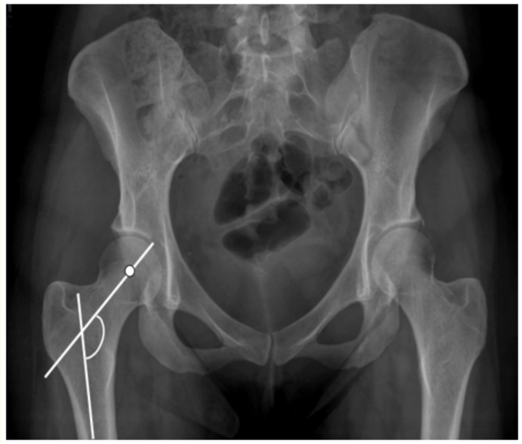


Figure 5: *Femoral shaft-neck angle.*

Femoral shaft-neck angle

Using the AP view of the hip, angle formed by axis of femoral shaft and line drawn along axis of femoral neck passing through center of head of femur.

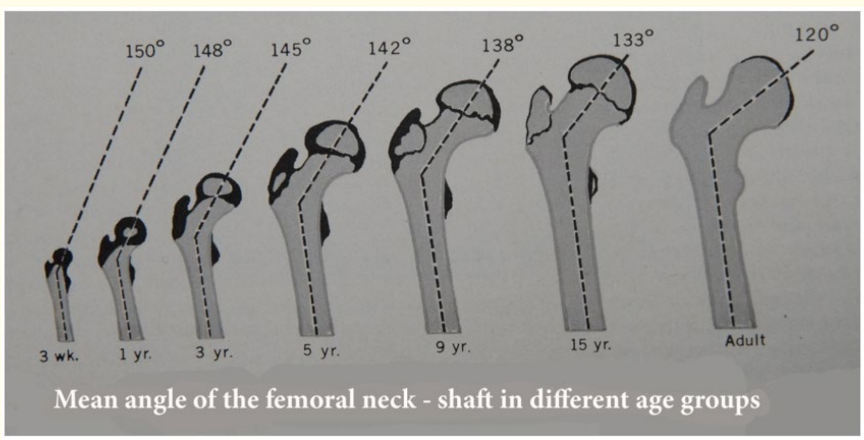


Figure 6: *Normal mean angle of femoral neck-shaft according to age [18].*

Acetabular anteversion angle

AAV was analyzed in the axial sections placed parallel to the pelvic obliquity showing both the triradiate cartilages. AAV was expressed as the angle between a line perpendicular to the trans-triradiate line and a line drawn across the margins of the acetabulum, from its posterior to anterior edge30 to 40 degrees is the normal range for the McKibbin instability index [19].

We elected not to use the central-edge angle of Weiberg (CE angle), as the femoral heads in the majority of hips were partially ossified. Assessment of avascular necrosis (AVN) of the femoral head was performed according to Kalamchi and MacEwen's classification [20].

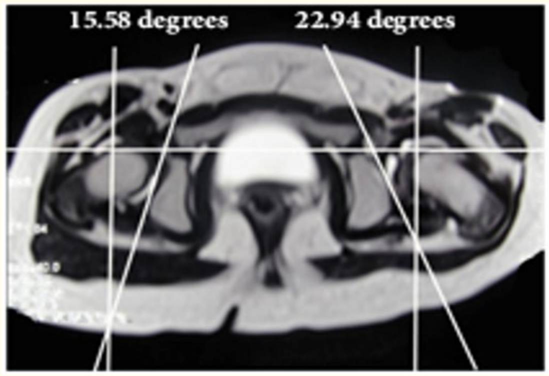


Figure 7: *Acetabular anteversion angle.*

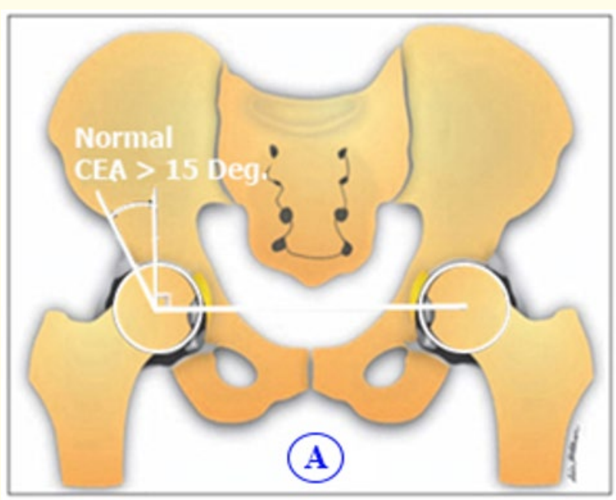
History of previous treatment of the studied cases (referred cases from other medical centers) included history of the application of Pavlik harness in 12 hips (11.3%), during the first year of life, which eventually failed, preoperative over-head traction (Brayant´s traction position) using adhesive skin traction kits in 8 hips (7,5%), whereas skeletal traction was used for two hips in a bilateral case (3.8%) from the distal femur. All those cases referred, they have been operated in this study.

We elected not to use the central-edge angle of Weiberg (CE angle), as the femoral heads in the majority of hips were partially ossified.

The center-edge angle (CE angle) was in children [21].

Age	Normal Mean Angle	Abnormal if
5 to 8	25°	< 20°
9 to 12	30°	< 25°
13 or older	35°	< 25°

Table B



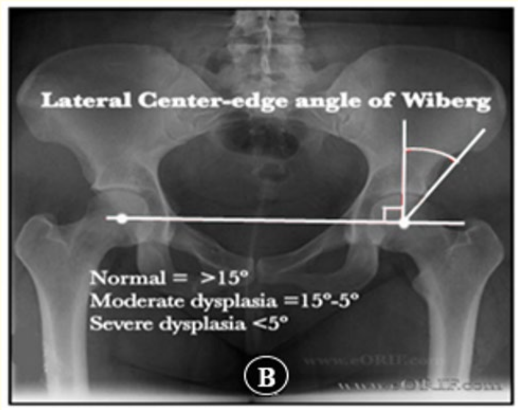


Figure 8A and 8B: *Measurement of center-edge angle. A. Drawing shows center-edge angle (CEA), which is measured by drawing line through center of both femoral heads on well-centered anteroposterior pelvis radiograph perpendicular line in femoral head of interest and line through lateral margin of acetabulum and femoral head. Angle formed between perpendicular and lateral margin of acetabulum is CEA. B. Anteroposterior pelvis radiograph in 38-year-old woman shows dysplastic left hip (CEA < 20°).*

-CE angle provides useful information after the age of 5 years (may be used in adults);

-Angle formed by a line drawn from the center of the femoral head to the outer edge of the acetabular roof, and a vertical line drawn thru the center of the femoral head; with angle greater than 25 deg are considered normal; less than 20 deg indicates severe dysplasia.

Surgical technique

No traction was applied to the hip before the operation. The patients are operated on in the supine position with a sandbag under the ipsilateral hip. An anterolateral approach is used. The bikini (modified ilioinguinal) anterior approach was used in all the studied cases [13], while the femoral osteotomy was performed through a separate direct lateral approach and incision to the proximal femur in indicated cases. The straight head of the rectus femoris is elevated from the anterior inferior iliac spine and the reflected head transected. The iliopsoas tendon is divided at the pelvic brim. When open reduction is necessary, a “T”- shaped capsulotomy is performed with the stem of the T horizontal rather than in line with the neck. Care is taken to extend the capsulotomy as medial as possible. The ligamentum teres and the transverse acetabular ligament are excised, removal of any fibrofatty tissue from the acetabulum, and plication of the capsule.

Carefully check the limbus, if it is thick and prevents concentric reduction of the femoral head, proceed with limbus removal (very cautiously).

Secondary to the zigzag of the osteotomy, line osteotomy is opened by using towel clips on both sides [13]. A fibular allograft with sides approximately 12 - 15 mm × 20-25 mm long, and is placed into the osteotomy perpendicular to the weight-bearing axis. The stability is tested in the mediolateral direction and by a push-pull test, pushing the ipsilateral hip upwards.

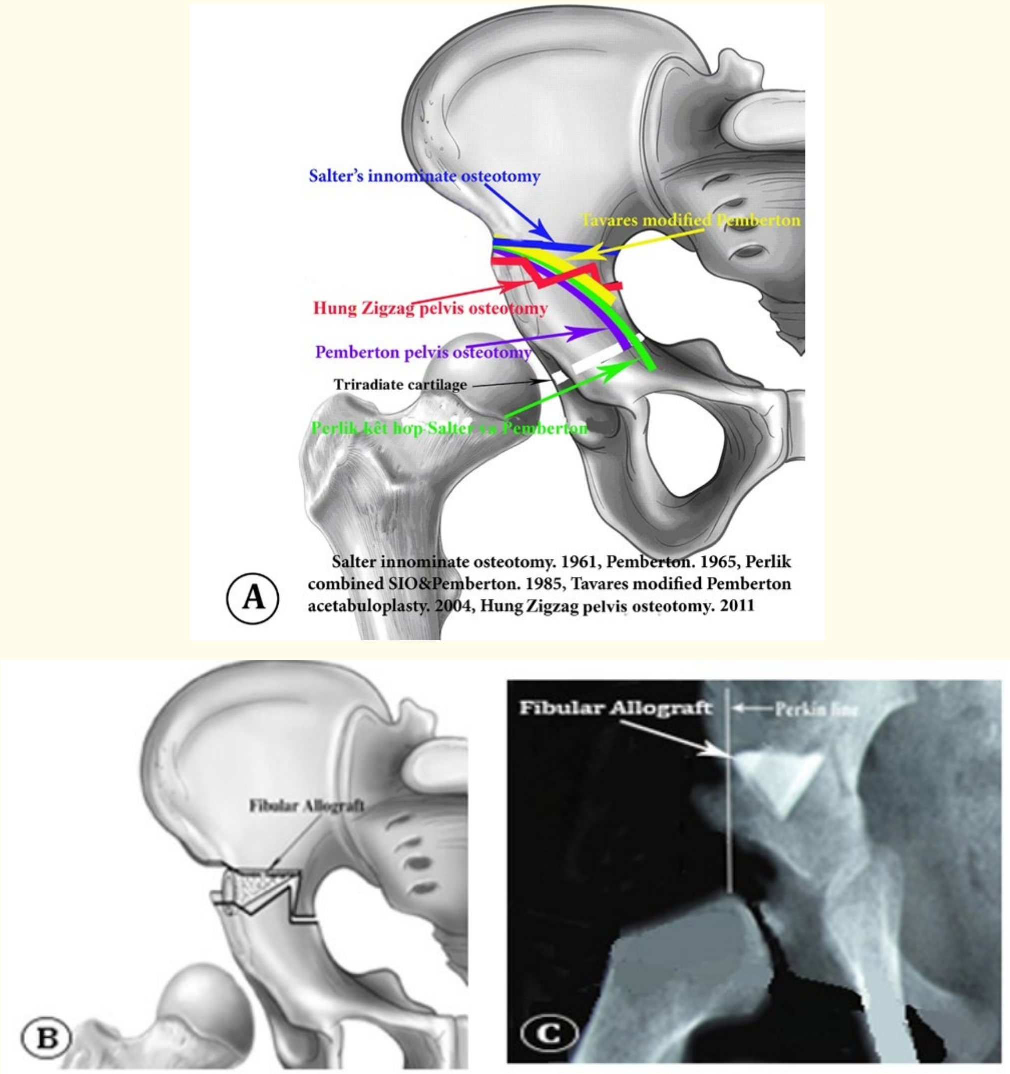


Figure 9A and 9B: *A. Hung Zigzag osteotomical line ilium. B. Illustration of osteotomy on ilium and fibular allograft. C. Post-operative roentgenography ilium.*

Before capsulorrhaphy, to maintain concentric reduction, the hip was applied in position with hip in 30 degrees of flexion, 50 degrees of abduction, and 20 degrees of internal rotation. The Kirschner wires was passed through the greater trochanter and into the ilium above the capsule after capsulorrhaphy and was retained seven days.

Femoral shortening

Femoral shortening should be performed 10 -12 weeks after ZOFA, Pre-Operation with high Dislocation and femoral neck-shaft angle more 150 degrees.

Through a separate lateral approach, the proximal end of the femur was exposed subperiosteally and a transverse osteotomy was made in the subtrochanteric region [13]. The two femoral fragments were allowed to overlap, and reduction was obtained quite easily. A segment of femur that was 1 to 1.5 centimeters long, sufficient to relieve the muscular tension across the hip joint, was then removed. If, at the time of the trial reduction of the hip, internal rotation of the femur seemed to contribute to stability of the joint, derotation was achieved by externally rotating the distal femoral fragment in relation to the proximal fragment before applying the plate. We believe that it is important to avoid excessive derotation of the femur, especially if an acetabular procedure is anticipated, as posterior instability may result. The osteotomy is then fixed rigidly with a pediatric blade-plate or a 3.5 dynamic-compression plate.

Figure 10A and 10B: *A. Shortening of the femur; B. Two steel wire loops both fragments.*

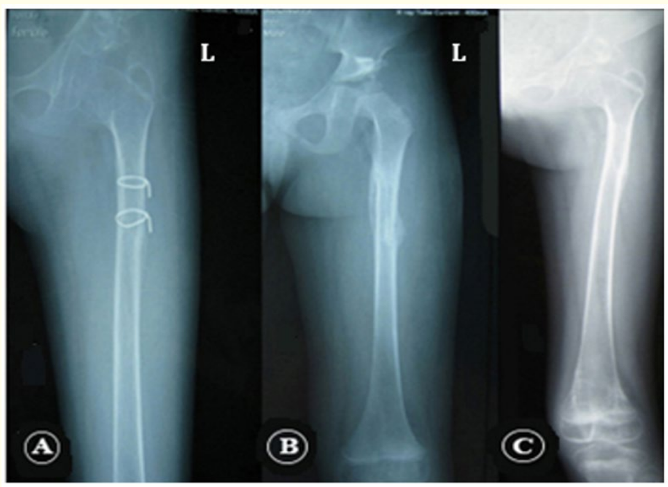


Figure 11A-11C: *A. The fragment are fixed by two wire loops wire; B. Post-operative 12 weeks; C. Post-operative 20 weeks.*

Postoperative care

The double spica cast was applied immediately after surgery, hip in 30 degrees of flexion, 50 degrees of abduction, and 20 degrees of internal rotation.

Three months after surgery, the entire cast is removed, and patients is gradually weaned haft spica cast it only at night and nap time until acetabular development is normal. The haft spica cast is usually worn for an average of 12 to 24 months after surgery. Weight bearing was not allowed until radiographic evidence of healing of the osteotomy site was obtained.

The allograft was considered to have been stable if the correction of the dysplastic acetabulum was maintained during the 2-year post-operative period and non extrusion of the graft had occurred from the osteotomy site. Fibular allograft incorporation into the ilium was considered to have taken place if complete union at the osteotomy site had occurred and confluence of the graft to the ilium was evident on the X-rays.

Measure femoral head and neck

Imaging software (http://nih.gov) was used to obtain measurements from each specimen. Measurements were performed by 2 investigators. Distance measurements from the original image are recorded in pixel units. Each image has a standard ruler at the level of the femur sample, allowing conversion of pixels to millimeters.

The following measurements were obtained from AP images: (1) femoral head diameter and (2) minimal neck diameter (Figure 1). Femoral head diameter was measured by fitting a perfect circle onto the femoral head and selecting the best-fitting circle without the femoral head extending > 1 mm beyond the contour of the circle according to the method described by Mose [22]. The minimum neck diameter is achieved by identifying and marking the axis of the femoral neck and then finding a line orthogonal to the axis that represents the shortest distance between the upper and lower parts of the neck. The absolute difference is obtained by subtracting the larger sample (left or right) from the larger sample. Percent asymmetry was determined using the following equation:

Percent asymmetry = (max - min)

(maximum and minimum average) x 100.

The mean and SD were determined for each measurement taken for the entire population and for different subpopulations based on demographics. The absolute degree of difference and the percentage of asymmetry between the left and right femurs were classified into different categories (Table 2).

Interobserver and interobserver reliability of the measurement procedure were determined by calculating the intraclass correlation coefficient (ICC). Interobserver reliability was calculated by both observers completing all femurs independently using the same method. Intraobserver reliability was calculated for both observers by repeating 50 randomly selected femurs (left and right femurs: minimum femur diameter and neck diameter) at intervals > 8 weeks apart.

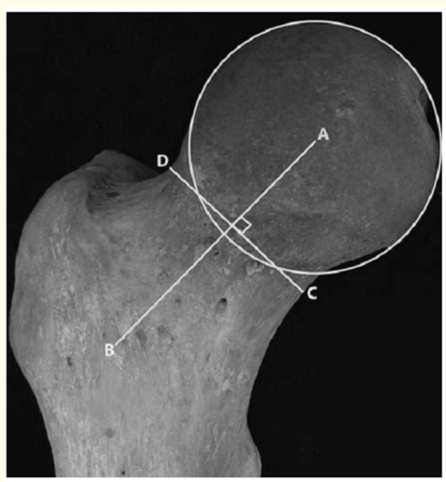


Figure 12: *Anteroposterior view of femoral specimen. Best fit circle shown around the femoral head. The minimal neck diameter was defined as the minimal distance about the neck perpendicular to the neck axis. Line CD represents the minimal neck diameter (in this specimen). Line AB represents the neck axis [22].*

Parameters

Femoral head measurements were performed at the greatest diameter using the Hilgenreiner line as the horizontal reference line. Coxa magna was defined as a safe tip with a horizontal diameter at least 15% larger than the symmetrical position on the contralateral side. A difference of 15% was chosen because this number is large enough to eliminate false positive results when determining coxa magna. Femoral neck and acetabular floor thickness were not recorded due to difficulties in standardizing these measurements. Subjectively, all coxa magna cases were noted to have a thicker femoral neck.

The center of the femoral head was determined from the best-fit sphere using Moseoverlays [22]. Central edge angle (CE) was measured as described by Wiberg [30]. The acetabular index was measured as described by Harris [23]. A modification of the criteria of Salter., *et al*. [24] was used to determine the presence of avascular necrosis. Avas necrosis appears if the following conditions are met: (a) Aggregates are not present? 1 year after reduction. (b) Existing fossil cores do not develop after 1 year of reduction. (c) The tip of a woman's mouth has increased radiographic density and is fragmented. (d) Development of Coxa plana, coxa breva or other obvious growth deformities, except coxa magna.

Evaluating result

Patients were scheduled to return to the outpatient clinic every three months during the first day after surgery and at 3 months, 6 months, 1 year, and 2 years after surgery and then annually. Patients were clinically evaluated at each visit for range of motion of the affected hip, gait quality, Trendelenburg testing, and the presence of any pain. Radiographs of each hip were performed to evaluate the quality of reduction, acetabular index, and the presence or absence of avascular necrosis. Each patient's preoperative radiographs were evaluated to determine the index and acetabular location of the affected hip.

Evaluation of avascular necrosis of the femoral head (AVN) was performed according to the classification of Kalamchi and MacEwen [20]: Grade 1: Changes affecting the nucleus pulposus; Grade 2: Lateral physical injury; Grade 3: Damage to the center of the body; Grade 4: Damage to the entire head and body.

X-ray details according to Severin [20] were used to evaluate radiographic results after surgery: Gade 1: Normal; Grade 2: Moderate deformity of the head, femoral neck or acetabulum; Grade 3: Mild dysplasia; Grade 4: Subluxed; Grade 5: The head articulates with the secondary acetabulum above the primary acetabulum; Grade 6: Dislocation; Grade 7: Arthritis.

Barrett's modified McKay criteria [25] were used to clinically evaluate postoperative results: Excellent results: Hip is stable, no pain, no lameness, negative Trendelenburg sign, completely normal movement. Google results: Stable hip, no pain, slight limp, mild range of motion. Moderate results: The hip is stable, painless, lame, has a positive Trendelenburg sign and limited range of motion or a combination of these symptoms. Poor results: The hip is unstable or painful, or both; Trendelenburg sign is positive.

RESULT

Between August 2009 to December 2012, there were 181 patients who underwent ZOFA surgery, 23 patients were excluded from the study due to bilateral DDH. There remained 158 patients with unilateral DDH in this study. 133 girls (84.2%) and 25 boys (15.2%) with DDH underwent open reduction and zigzag osteotomy combined with fibular allograft (ZOFA) [13]; Patients were divided into 3 Variant: Variant 1 included 72 patients (72 Hips, 45.6%) surgical ZOFA; variant 2 included 53 patients (53 Hips, 33,5%) surgical ZOFA and limbusectomy; variant 3 included 33 patient (33 hips, 20.9%) surgical ZOFA and shortening osteotomy femur.

None had preoperative skin or skeletal traction, nor derotational varus or valgus osteotomies or shortening procedures for operation initially, and second operation with femoral osteotomy after initial ZOFA on 3 months in 33 Hips (Variant 3).

Tönnis system type 3 in 117 hips (74.1%) and type 4 in 41 hips (25.9%).

The anterior approach was used to expose inner table of the ilium and ZOFA in all cases.

The Kirschner wires (KW) did not use to fix the fibular allograft at the pelvic osteotomy site.

All of the fibular allografts were completely incorporated mean 14 weeks (range, 12 weeks - 17 weeks) post-surgery. Without graft was related infections.

The average operative time was 95 min (range 80 - 105 min). Radiographs were made preoperatively, and immediately postoperatively.

The blood loss from this procedure is acceptable. Post-operative blood transfusion was no required.

Acetabular Index	Preope*. AI	Immediate postope. AI*	Postope*. AI 3 months	Postope. AI 6 months	Postope. AI 12 months	Postope. AI 24 months	AI latest follow-up
Mean	42.95°	24.56°	22.91°	21.70°	20.54°	19.45°	17.26°
SD	4.404	2.5452	2.0702	2.280	1.798	1.7308	1.6033
Range	36.17° - 51.56°	18.92° - 30.52°	18.36° - 28.10°	16.64° - 26.35°	15.26° - 25.38°	16.14° - 23.43°	14.08°- 19.35°

Table 1: *Comparision of acetabular index preoperative and latest fellow-up.*

**Preope: Preoperative; *Postope: Postoperative; *AI: Acetabular Index.*

The preoperative acetabular indices, mean was 42.957º, ranged from 36.17º to 51.56º (SD = 4.4046). Compared AI preoperation and AI Immediate postoperation with Pvaluate is 0.0000001; AI immediate postoperation and AI postoperative 3 months with Pvaluate is 0.0000001. Postoperative 3 months and AI postoperative 6 months with Pvaluate is 0.000000. Postoperative 6 months and AI postoperative 12 months with Pvaluate is 0.0000001. Postoperative 12 months and AI postoperative 24 months with Pvaluate is 0.0000001.

There was no significant difference between the AI results after 24 months and the AI latest results (Pvaluate is 0.202263).

Procedures	Primary Operation	Limbusectomy	Femoral Osteotomy
Number Patients	72	53	33
Adductor tenotomy (AT)	68 (94.4%)	48 (90.6%)	30 (90.9%)
Psoas tendon (PS)	57 (93.1%)	57 (93.1%)	32 (96.9%)
Ligamentum teres (LT)	58 (80.6%)	49 (92.5%)	28 (84.8%)
Transverse ligament present (TL)	59 (81.9%)	46 (86.8%)	27 (81.8%)
Pulvinar present (PV)	61 (84.7%)	47 (88.7%)	26 (8.8%)
Capsulorrhaphy (CR)	72 (100%)	33 (100%)	33 (100%)
Kirschner wire (KW)	72 (100%)	33 (100%)	33 (100%)

Table 2: *Details of primary operation and ZOFA.*

AT: Adductor Tenotomy; LT: Ligamentum Teres Present; PS: Psoas Tendon; TL: Transverse Ligament Present; PV: Pulvinar Present; CR: Capsulorrhaphy; KW: Kirschner Wire was Passed through the Greater Trochanter and into the Ilium.

In ZOFA: Adductor tenotomy: 68 (94.2%); Poas tendon: 57 (93.1%); Ligamentum teres: 58 (80.6%); Transverse acetabular ligament: 59 (81.9%); Capsulorraphy: 72 (100.0%); Kirschner: 72 (100.0%).

In ZOFA and Limbusectomy: Adductor tenotomy: 48 (90.6%); Poas tendon: 50 (94.3%); Ligamentum teres: 49 (92.5%); Transverse acetabular ligament: 46 (86.8%); Capsulorraphy: 53 (100.0%); Kirschner: 53 (100.0%).

In ZOFA and femoral shortening osteotomy performed after initially operation 3 months. Adductor tenotomy: 30 (90.9%); Poas tendon: 32 (96.9%); Ligamentum teres: 38 (84.8%); Transverse acetabular ligament: 27 (81.8%); Capsulorraphy: 33 (100.0%); Kirschner: 33 (100.0%).

Procedures	With CM	Without CM
ZOFA	22.2% (16)	77.9% (56)
ZOFA and Limbusectomy	39.6% (21)	60.4% (32)
ZOFA and Femoral Osteotomy	33.3% (11)	66.7% (22)

Table 3: *Procedures on hips with and without coxa magna.*

Total CM: 48 (30.4%).

In table 5 results are expressed as percentages and numbers of hips (in parentheses) that had the various procedures and the mean age at operation 21.5 and follow-up 11.6.

Significant at Pvaluate= 0.021753. Therefore, latest results to have the highest rate in ZOFA and limbusectomy, ZOFA and femoral osteotomy, and ZOFA.

Procedures	With AVN	Without AVN
ZOFA	33.3% (24)	66.7% (48)
ZOFA and Limbusectomy	30.2% (16)	69/8% (37)
ZOFA and Femoral Osteotomy	45.5% (15)	54.5% (18)

Table 4: *Procedures on hips with and without avascular necrosis.*

Total AVN: 55 (34.8%).

Results are expressed as percentages and numbers of hips (in parentheses) having each procedure and as the mean age at operation and follow-up. The three Variant have no statistically significant differences.

Significant at Pvaluate= 0.021805. Therefore, latest results to have the highest rate in ZOFA and femoral osteotomy, ZOFA, ZOFA and limbusectomy.

Procedures	No. Hip AVN (%)	Classification according to Kalamchi			
		I	II	III	IV
ZOFA (n = 72)	24 (33.3%)	4 (16.7%)	17 (70.8%)	2 (8.3%)	1 (4.2%)
ZOFA and Limbusectomy (n = 53)	16 (30.2%)	3 (18.7%)	9 (56.3%)	4 (25.0%)	
ZOFA and Femoral Shortening (n = 42)	15 (35.7%)	1 (6.7%)	12 (80.0%)	2 (13.3%)	
Total 158 Hips	55 (34.8%)	8 (14.5%)	38 (69.2%)	8 (14.5%)	1 (1.8%)

Table 5: *Avascular necrosis according to Kalamchi [19].*

In the table 5 there were 55 head femur were avascular necrosis. Classification according to the Kalamchi with grade I: 8 (14.5%), grade II: 38 (69.2%), grade III: 8 (14.5%), grade IV: 1 (1.8%). In this study with avascular necrosis: 55 (34.8%). AVN in open reeduction 24 Hips (33.3%), AVN in femoral shortening 15 hips (35,7%), and limbusectomy 16 (30.2%).

Procedures	Number Hip	Modified McKay criteria for clinical evaluation			
		Excellent (%)	Good (%)	Fair (%)	Poor (%)
ZOFA	72	43 (59.7)	16 (22.2)	10 (13.9)	3 (4.2)
Accepted		59 (81.9%)			
ZOFA and Limbusectomy	53	36 (67.9)	10 (18.9)	6 (11.3)	1 (1.9)
Accepted		46 (86.8%)			
ZOFA and Femoral Shortening	33	24 (72.7)	6 (18.2)	2 (6.1)	1 (3.0)
Accepted		30 (90.9%)			
Total	158	103 (65.2)	32 (20.3)	18 (11.4)	5 (3.1)

Table 6: *Clinical evaluation according to modified McKay criteria [25].*

Excellent 103 (65.2%), good 32 (20.3%), fair 18 (11.4%), poor: 5 (3.1%). Satisfy results (Excellent and good) 103+32 = 135 (85.4%). Accepted result (103+32) 85.4%.

Significant at Pvaluate= 0.022166. Therefore, latest results to have the highest rate in femoral osteotomy, limbusectomy, and primary operation.

The results are accepted: In primary operation (V1): 59 (81.9%); limbusectomy (V2): 46 (86.8%); femoral shortening (V3): 30 (90.9%)

Complications:

1. Redislocation: 4 Hips (3.4%)
2. Avascular necrosis: 55 (34.8%)
3. Coxa magna: 48 (30.4%)
4. Infection: 0
5. Fracture: 1 Hips (1.1%)
6. Sciatic nerve damage: 0.

We performed ZOFA, did not use Kirschner wires to fix the fibular allograft at the pelvic osteotomy site, so don't have some complications such as: K-wire migration, K-wire luxation/breakage, implant loss, graft problems, medial displacement of the distal fragment.

DISCUSSION

Bone grafting is widely used in pediatric orthopedic surgery. Autologous bone grafts remain the "gold standard" in reconstructive surgery because of their osteogenic, osteoconductive, and nonimmunogenic properties. The iliac crest is the most popular donor site because of ease of access and acquisition and the availability of large quantities of both cortical and trabecular bone.

Trevor DLJ and Fixen JA. 1975 [26] performed ilioplasty in the treatment of congenital hip dislocation using rib grafting. Kessler., *et al*. 2001 [27] used an allograft in a Pemberton osteotomy with a wedge patellofemoral graft, allowing good correction of acetabular dysplasia with immediate graft stability. Grudziak and Ward 2001 [28] with the graft height being able to be increased using freeze-dried fiber allografts cut into trapezoidal sections in a Dega osteotomy. Wade 2010 [29], used iliac crest allograft for pericapsular acetabuloplasty in the treatment of developing hip dislocation. In this study, we only used monofilament allografts.

Radiological evaluation demonstrated that ZOFA produced similar results to primary osteotomy [13]. The acetabular index was restored to normal limits in the immediate postoperative period and continued to improve thereafter. Bohm and Brzuske [30] reported an average correction of 11.9˚ using the Salter osteotomy. Ito., *et al*. [31] reported a mean improvement of 16.4˚ in acetabular index. The average correction of 17.26˚ in this series is comparable to reports in the literature. Rab [32] estimates that the Salter anonymous osteotomy provides approximately 15 degrees of lateral coverage and 25 degrees of anterior coverage, although many clinicians believe that more lateral coverage can be achieved. In this study, comparisons can be made with reports in the literature.

In the literature, graft migration rates range from 0% to 17% [25]. In ZOFA, the graft migration rate was 0%. The postoperative outcome of the graft may be a result of care taken to verify the stability of the graft using this technique. An increased initial acetabular index reflects the absence of the normally located femoral head and its irritation within the acetabulum. This may indicate that this complication is a true failure of the previous open and closed reduction, rather than redistribution, as some acetabular improvement should appear in the index values acetabulum. In this study, the mean correction was 17.26˚ (range, 14.08˚ - 19.35˚) (See table 1), we demonstrated that the acetabular index continued to improve.

Coxa Magan was first described in 1935 by Ferguson and Howorth [33] when they reported on 13 patients with the disease. They state: When there is a circulatory disorder not severe enough to produce coxa plana. The femoral head and neck may enlarge without other noticeable changes. These cases have the clinical features of coxa plana but are characterized by visual enlargement of the femoral head and neck rather than flattening and irregular ossification of the head. This condition is designated CM. Therefore, CM is defined as circumferential widening without flattening or irregularity of the femoral head. In their first series out of 13 cases. Ferguson and Howorth [33] list patients with juvenile rheumatoid arthritis, septic arthritis, congenital hip dislocation, and pelvic tuberculosis.

The most widely used classification of Proximal Femoral Growth Disorder (PFGD) is that of Salter., *et al* [24]. The inclusion of coxa magna as a sign of Proximal Femoral Growth Disorder (PFGD) in this classification is questionable, because coxa magna is often seen after open reduction due to stimulation of blood flow to the head on the femur [55,58]. As noted above, it is also often difficult to determine whether some residual deformity after treatment is secondary to disorders that existed before correction or is the result of other complications related to correction. fix. One of the most common deformities is flattening of the medial aspect of the proximal femur, possibly due to the pressure of the femoral head on the pelvis before realignment.

Class	Features
1	Failure of the appearance of the ossific nucleus of the femoral head within 1 year after reduction
2	Failure of growth of an existing ossific nucleus within 1 year after reduction
3	Broadening of the femoral neck withing 1 year after reduction
4	Increased radiographic bone density, followed by fragmentation of the femoral head
5	Residual deformity of the femoral head and neck when reossification is complete; these deformities include coxa magna, coxa plana, coxa vara, and a short, broad femoral neck

Table 7: *Salter classification of proximal femoral growth disturbance (PFGD) [34].*

In 1963, Pearson [35] reported 15 patients with CM. All of these patients followed a fairly characteristic clinical course. They initially presented with a limp and signs suggestive of synovitis, and many were thought to have tuberculosis. Enrollment radiographs were abnormal or early demineralization suggested hypertension; Subsequent films show remineralization, followed by recovery of the bone to normal density, followed by widening of the femoral head and bulbar features of the coxa magna. The time interval from the initial stages of synovitis to the development of CM ranges from 6 to 24 months.

Neuhauser and Wittenborg [36], in an article on the radiographic findings of hip synovitis, divided these findings into four stages. The first stage includes signs of inflammation around the pelvis, characterized by bulging of the abductor fat lines toward the top, bulging of the psoas and adductor brevis muscles inferiorly and distention of the obturator internus muscle. During the second phase, the joint space widens with lateral displacement of the femoral head due to increased thickness of the femur. articular cartilage. Third stage radiographs show more pronounced bone demineralization in the femoral head than in the acetabulum. The fourth stage shows bone overgrowth with an increase in the size of the femoral head and metaphysis.

McMurray [37] presented six cases of CM and also described the sequence of synovitis, demineralization, recalcification, and hypertrophy of the femoral head and neck. He discovered that the spherical epiphysis expanded and that the acetabulum often failed to accommodate this expansion; This mismatch results in lateral displacement of the femoral head.

Edgren [38] in 1965 and Schiller and Axer [39] in 1972 presented the only quantitative evidence of head hypertrophy after Legg-Calve-Perthes syndrome. Histological analysis of synovial tissues in hips that will develop CM shows thickening of the synovial membrane and bursa, systemic congestion, and venous congestion.

Rigal [40] using tritiated thymidine, showed that the epiphysis has three main growth zones: one at the epiphyseal line, one on the articular side of the secondary ossification center, and a third surrounding the epiphyseal line. Rigal also showed that this third growth zone becomes increasingly less active as the epithelium matures; However, when the growth cartilage of the epiphyseal line is damaged, often due to blockage of blood supply, these peripheral areas are stimulated to produce more cartilage, which then becomes ossified leading to the femur and the medulla oblongata bone is enlarged. Margins of the epiphyseal line Additional cartilaginous columns will become hyperplastic and hypertrophic, further increasing the circumference of the central epiphyseal line and thereby increasing the volume of the epiphysis and, to a lesser extent, the metaphysis. This is especially true when the central column is ischemic.

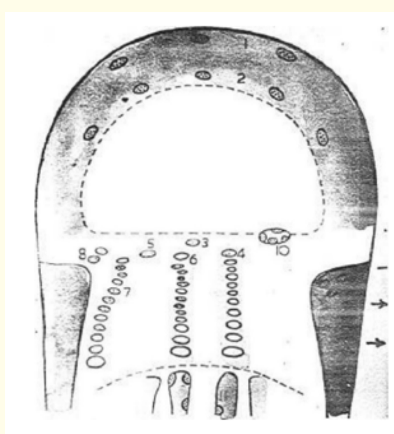


Figure 13: *Drawing by Rigal from Trueta [32] showing the three areas of the epiphyseal group especially in reference to the area surrounding the epiphysis which we believe contributes to CM.*

Trueta [41] has shown that the blood supply to the femoral head goes through several stages. From birth to about 2 years of age, the blood supply is carried by transperiosteal vessels. With epiphyseal fusion, 80% of the blood supply is delivered to the femoral head by the lateral epiphyseal vascular group. This continues until the patient is about 8 years old. During this period, from 2 to 8 years of age, CM occurs.

Therefore, the development of CM appears to be due to an initial hyperemic reaction in the hip of the femoral head. With hyperplasia and hypertrophy of marginal cartilage. Secondary ischemia that often develops in Legg-Calvé-Perthes syndrome is either absent or minimal. Thus, the overgrowth, hyperplasia of the cartilage columns, and subsequent hypertrophy of the head occur without the collapse and malformation commonly seen in ischemia. This explains the occurrence of coxa magna in unusual conditions such as pelvic tuberculosis and juvenile rheumatoid arthritis.

On X-ray, hypertension can be suspected when there are signs of synovitis. Expansion of the joint space represents proliferation of peripheral cartilage; Demineralization would be secondary to hypertension, and the gradual appearance of coxa magna would represent calcification of this proliferative cartilage although some degree of relative ischemia may have developed in the later stages of the process.

If the hip is not immobilized for a long time during the acute phase of the disease and the large femoral head maintains a smooth spherical surface, the function of the hip joint remains good or nearly normal. If there is a severe mismatch in the ratio between the femur and the acetabulum, secondary changes in the joint may then develop. None of our patients demonstrated significant dysfunction and pain was not a factor after several years, but we expected to see the development of secondary traumatic arthritis. developed when our patients were four, five, and six years old.

Pathological limbus

In 1990, Tachdjian [42] described the margin as "a pathological response to eccentric pressure" and "hypertrophic fibrous tissue with overgrowth of cartilaginous elements from the labrum household". This text also reports mechanical irritation due to femoral head dislocation. to the formation of fibrous tissue on the labrum produced by fibroblasts in the acetabular rim [42].

The contour may be inverted and prevent concentric contraction of the hip joint. Inverted margins may insert themselves between the femoral head and the acetabular surface, thereby preventing the femoral head from positioning itself properly within the acetabulum. In 1948, Leveuf described the limbus as a "lesion" that only becomes an obstacle to correction if it is "pushed down into the joint" [43]. In 1978, Ponseti described the limbus as a "hypertrophied labrum" that may or may not be reversible depending on whether the hip is truly dislocated or only mildly dislocated [44]. Due to the spherical nature of the femoral head and the proximal direction of the joint reaction forces, the inverted labrum can only exist when the hip is dislocated.

Some authors debate whether the limbus is partly composed of the joint capsule. In 1962, Scaglietti and Calandriello [45] described the theory of limbus formation. They believed that the dislocated femoral head had inverted the acetabular labrum and retained a fragment of the joint capsule between the acetabular labrum and the pelvic surface. They feel the labia and capsule then fuse together and together become what is called the limbus. However, in 1976, Milgram and Tachdjian [46] reported that the limbus did not appear to be formed because the flexor joint capsule was submerged in water. Due to the spherical nature of the femoral head and the proximal direction of the joint reaction forces, the inverted labrum can only exist when the hip is dislocated.

Some authors debate whether the limbus is partly composed of the joint capsule. They feel the labia and capsule then fuse together and together become what is called the limbus. However, in 1976, Milgram and Tachdjian [46] reported that the limbus did not appear to form because the flexor joint capsule was carefully excised without disturbing the acetabular cartilage responsible for development. Others have reported that the procedure is risky and difficult to perform reliably in practice. In 2005, a report by Angliss., *et al*. [47]

reviewed the long-term follow-up of nearly 150 patients who had previously received prolonged treatment for DDH. This article attempts to identify early signs that help predict postoperative outcomes. They reported a worse outcome associated with limbusectomy. In this study, although histological examination of the resected specimen showed only marginal fibrocartilage tissue, they believed that the medial cartilage of the acetabular rim was likely damaged by marginal resection. This potential damage to the epiphyseal cartilage may lead to abnormal acetabular development, thereby leading to poorer outcomes [47].

Limbusectomy can also be detrimental because the limb is important not only for the normal development of the acetabulum but also for the stability of the hip joint. A study in dogs demonstrated that inversion of the acetabular labrum causes acetabular dysplasia [48]. Therefore, since the labrum is important in the normal development of the hip joint, it is likely that the labrum is also important in deepening the hip socket, improving stability and therefore has developmental potential normal acetabulum. Radial separation of the limbus has been proposed as an alternative that may avoid damage to the acetabular epiphysis cartilage [47,48].

In 1997. Tumer., *et al*. [49] studied 56 developmental hip dislocations in 37 children with a mean age of approximately 11 months who had undergone open hip reduction. They found that limbusectomy was not necessary to achieve concentric reduction and that such limbusectomy could lead to the development of osteoarthritis in later years.

Incidence of coxa magna

In this study, the incidence of coxa magna was 30.4% at latest follow-up. The incidence of CM after open surgery varies widely in the literature from 33 to 96% [50]. The reason for this discrepancy appears to be not only differences in patients and surgical approaches but also in the definition and measurement methods of the extended tip. In this study, there were CM: 48 (30.4%) (Table 3).

Author	Pathology	Age at Follow-up	Coxa Magna Definition
De Valderrama., *et al*. [51]	Transient synovitis	21	> 10% diameter difference
Nachemson and Scheller [52]	Transient synovitis	25	> 1 mm diameter difference
Stylberg., *et al*. [53]	LCDP	47.3	> 10% diameter difference
McAndrew and Weinstein [54]	LCDP	55.5	Femoral head ratio < 0.9
Gamgle., *et al*. [55]	DDH	5.7	> 15% diameter difference
Kallio [56]	Transient synovitis	5.6	> 2 mm diameter difference
Leitch., *et al*. [57]	LCDP	15.7	> 3 mm radius difference
Imatani., *et al*. [58]	DDH	14	REF > 120%
Shigeno and Evans [59]	LCDP	14.7-18.5	> 10% diameter difference
Luhman., *et al*. [60]	DDH	8	> 15% diameter difference
Rowe., *et al*. [61]	LCDP	14.4	> 10% diameter difference
Larson., *et al*. [62]	LCDP	20.4	Femoral head ratio < 0.9
Sakamaki., *et al*. [63]	DDH	10	> 15% diameter difference
Game., *et al*. [64]	DDH	15.6-35.8	> 15% diameter difference
Topak., *et al*. [65]	DDH	15.4	> 15% diameter difference
Young., *et al*. [66]	DDH	31.2	> 10% diameter difference
Hung., *et al*. in this study	DDH	21.5	> 15% diameter difference

Table 8: *The femoral head/neck ratio defines coxa magna according to the author.*

There are 17 authors reporting the etiology of CM in this table 8: there are 3 transient synovitis, 6 LCPD and 8 DDH.

According to the documents we have, due to different diseases causing CM, the measurement methods are different, determining the circumference of the head and neck of the femur is also different, so the ratio of CM is also different.

Etiology of coxa magna

In the etiology of coxa magna reported by Gamble., *et al*. [64] and Sakamaki [63], macrocephaly is caused by abnormal mechanical stress associated with acetabular dysplasia or hip subluxation. Iwasaki., *et al*. [67], O'Brien., *et al*. [68], Sosna and Rejholec [69] stated that coxa magna exhibits increased vascularity in response to hip synovitis due to decreased opening.

Even in our subjects who demonstrated excellent concentric reduction of the femoral head within the acetabulum immediately after surgery, the CM rate remained high (34.0%). The femoral head cartilage area quickly enlarged in all patients within just a few months after treatment open surgery. Some experimental and clinical reports show that invasive open joint surgery and postoperative hip synovitis can cause obstruction, local venous congestion, and head edema. on the femur, and thus they create activation. articular cartilage cells as well as thickening of articular cartilage. Therefore, we believe that invasive surgery itself including open surgery is one of the causes of CM.

According to the association between marginal resection and the incidence of CM, Ando [70], Hatanaka [71] and Sakamaki [53] showed that marginal resection directly reduces the likelihood of acetabular development and subsequent acetabular dysplasia, accordingly, causes CM. But our results show that in the amputation group, the femoral head and neck cartilage quickly enlarged compared to the other group at a very early stage after open amputation. It appears that in addition to the effects of invasive surgery, overexpansion of acetabular capacity by marginal resection also encourages more noticeable development of the cartilaginous femoral head and neck at a very early stage. Next, CM may precede cartilage hypertrophy with subsequent and gradual ossification of this cartilage. Therefore, to prevent coxa magna, it is important to restrain the limb carefully and perform surgery to avoid injury.

Effects of coxa magna on long-term results

Several reports [72] have described the association between coxa magna and short-term outcomes, but there have not been any reports on the effect of macrocephaly on long-term outcomes. In this study, there was a negative correlation between REF and CEA, and CEA in patients with CM was significantly lower than in patients without coxa magna. According to the Severin classification, the mean REF in patients classified as unsatisfactory was significantly higher than in patients classified as satisfactory. 62.5% of patients receiving coxa magna were classified as unsatisfactory. In contrast, in patients without CM, 77.4% were classified as satisfactory. This demonstrates that CM worsens long-term outcomes.

There was a positive correlation between REF and acute angle, and acetabular development was poorer in patients with CM than in patients without CM. In this study, we could not demonstrate which was the main cause, the occurrence of acetabular dysplasia or coxa magna. But it was found that hypertrophy of the cartilaginous cap before expansion of the bony cap occurs rapidly within a few months after expansion. Therefore, we propose that acetabular dysplasia is due to mechanical deformation of the femoral head-acetabular relationship due to rapid enlargement of the femoral head due to marginal resection.

Necrotic femoral head avascular

Avascular necrosis (AVN), also known as osteonecrosis, bone infarction, aseptic necrosis and ischemic osteonecrosis, is the phenomenon of cell death (necrosis) of bone components caused by cockroaches. cause. blood supply section. Without blood, bone tissue dies and bones break. If avascular necrosis involves bones and joints, destruction of the joint surface often results. In this study there were AVN: 55 (34.8%) (Table 4).

Factors associated with avascular necrosis

Osteonecrosis is a major complication after DDH surgery, hindering further development of the hip joint. The presence of early signs of osteonecrosis was considered the independent variable. Factors that may be associated with the occurrence of osteonecrosis include the patient's age at the time of surgery and gender. Unfortunately, AVN of the femoral head and physical damage after treatment of congenital hip dislocation is a serious complication and hinders the desired long-term outcome [73]. The reported incidence of AVN ranges from 0 to 73% [73]. The actual incidence of AVN is difficult, if not impossible, to assess due to the variety of treatments available for congenital hip dislocation. In addition, criteria for determining the presence of AVN also vary significantly in each patient group. The most feared complication in the treatment of progressive hip dysplasia is avascular necrosis. Diagnosis can be difficult and requires a series of radiographs taken over a significant period of time.

In earlier stages, it is defined as apophysitis. Subsequently, vascular damage progresses to the proximal femur and acetabulum. Kalamchi and MacEwen classified these vascular changes. Kalamchi reported AVN frequencies ranging from 0 to 73%. [20]. Barrett reported an AVN frequency of 6% [25]. Hajdar reported an AVN of 8.1% [74]. Regarding the cause of AVN, there are 2 factors: extracapsular embolism due to fixation and mechanical pressure.

In this study, Kalamchi classified AVN grade I: 8 (14.5%), grade II: 38 (69.2%), grade III: 8 (14.5%); grade IV: 1 (1.8%); avascular necrosis: 55 (34.78%) (Table 3 and 4). Latest has the highest rate of femoral osteotomy, ZOFA, limbusectomy (Pvaluate = 0.021805).

Overall, in this study, clinical assessment according to the modified McKay criteria: Excellent 103 (65.2%), good 32 (20.3%), fair 18 (11.4%), poor: 5 (3.1%). Satisfactory results (Excellent and good) 103+32 = 135 (85.4%). Acceptable results (103+32) 85.4% (Table 6).

Femoral shortening osteotomy

Femoral shortening as an adjunct to the long-term treatment of hip dislocation was first described by Ombrédanne in 1923 [75], and interest in this treatment modality was evident. in some articles. Recent reports consistently demonstrate that femoral shortening is useful in facilitating femoral shortening. Congenital hip dislocation in children gives better results than the traction method [76]. The next stage in treatment is to correct the hyperluxation of the femur as they believe that the contracture can be stabilized by this manipulation. The belief that rotational osteotomy provides stability is based on the assumption that a deep and precisely centered femoral head stimulates normal growth of the dysplastic acetabulum. Indeed, Harris., *et al*. [77] suggested that, after uniform reduction, 95% of the acetabulum will develop normally in children up to four years of age. Essentially, our current long-term review tests that belief. The high incidence of hips at follow-up being shown to have acetabular dysplasia or acetabular subluxation should again reset this assumption. The pre-existing flattening of the posterior portion of the femoral head, which articulates with the lateral wall of the pelvis, contributes to the oval deformity of the head. With rotation and abduction, the thickened anterior cartilage is placed into the acetabulum, and it is not uncommon to see a second nucleus pulposus present in this area. Furthermore, due to the asymmetry of the femoral head, rotation may not allow the center to center directly on the acetabulum. Failure to center the femoral head leads to progressive and persistent anterolateral dislocation.

Klisic and Jancovic [78] reported good results with femoral shortening in a series of patients over 5 years of age, while Galpin., *et al*. [79] performed femoral shortening in all children over 5 years of age. 2 years old. Wenger., *et al*. [80] even advocate shortening the femur in some children under 2 years of age.

Massie and Howorth [81], as well as Durham [82], recommend that femurs with tilts above +45 degrees should be corrected by osteotomy; Sankar., *et al*. in 2011 [83] predicted that the femur will rotate if the femur tilts more than 50 degrees. While Warndorf [84] only performed orthopedic osteotomy if the angle was +60 degrees or more, and Badgley in 1943 [85] with femoral anterior rotation exceeding 60 degrees determined at the time of reduction open is considered an indication for femoral osteotomy. This is done before or after reduction. Hibbs, in 1915 [86], also advocated osteotomy, usually before osteotomy; however, Farrell, von Lackum and Smith, in 1926 [87], from the Hibbs Clinic, wrote that osteotomy should not normally be performed until the hip has been reduced. Others, such as Lorenz [88], Bradford [89], Soutter [90], and Fairbank [91], have argued that osteotomy is unnecessary.

The results are good and the resistance level will usually correct itself. Lorenz, in 1905 [88], went further to say that inversion correction could lead to posterior subluxation. Bradford, 1923 [89] wrote that, if the correction is complete and stable, joint motion and function will become normal although femoral torsion tends to correct itself after correction. adjust. Soutter and Lovett, in 1924 [90], stated that, in their experience, congenital dislocations due to excessive torsion improved markedly after two or three years of weight bearing. Fairbank, in 1930 [91], stated that, if the hip is reduced before the fourth year, a rotational osteotomy is rarely required to correct anterior rotation of the hip. We support the author's opinion and should not cancel femoral osteotomy to correct malalignment. In this study, femoral osteotomy with Coxa Magna 30.4% (Table 3), and AVN 34.8% (Table 4).

We performed femoral osteotomy 12 weeks after the first surgery when the femoral neck-shaft angle was greater than 150° and the dislocation was high at only level IV according to Tönnis's classification (See table 3). We agree with the view of Kumar., *et al*. [92] that shortening the femur may prolong surgical time, increase blood loss, or speed up deformed bone formation.

Conclusion

One of the most important causes of coxa magna is to overwide the acetabular capacity by excising the limbus; another cause is avascular necrosis of the Hip after operation. CM worsens the long-term results. To prevent CM, it is important to retain the limbus.

Limitations of the Study

The results of this study have some limitations. First, the study is a retrospective study. Second, there are no data to compare results. Third, there are no preventive measures, only recommendations. Fourth, there is no specific treatment for CM.

Bibliography

1. Howorth BA. "Lifetime experience with congenital displacement of the hip". *Orthop Rei·* 11 (1982): 33-45.
2. Buchanan JR., *et al*. "Management strategy for prevention of avascular necrosis during treatment of congenital dislocation of the hip". *Journal of Bone and Joint Surgery American Volume* 63-A.1 (1981): 140-146.
3. Westin GW., *et al*. "Total avascular necrosis of the capital femoral epiphysis in congenital dislocated hips". *Clinical Orthopaedics and Related Research* 119 (1976): 93-97.
4. Coleman SS. "Treatment of congenital dislocation of the hip in the infant". *Journal of Bone and Joint Surgery American Volume* 47-A.3 (1965): 590-601.
5. Chung SM. "The arterial supply of the developing proximal end of the human femur". *Journal of Bone and Joint Surgery American Volume* 58-A.7 (1976): 961-970.
6. Trueta J. "The normal vascular anatomy of the human femoral head during growth". *Journal of Bone and Joint Surgery British Volume* 39-B.2 (1957): 358-394.
7. Ogden JA. "Changing patterns of proximal femoral vascularity". *Journal of Bone and Joint Surgery* 56-A.5 (1974): 941-950.
8. Trueta J and Amato VP. "The vascular contribution to osteogenesis. III. Changes in the growth cartilage caused by experimentally induced ischaemia". *Journal of Bone and Joint Surgery* 42-B (1960): 571-587.

9. Guille JT., *et al*. "Development dysplasia of the hip from birth to six months". *Journal of the American Academy of Orthopaedic Surgeons* 8.4 (2000): 232-242.

10. Tönnis D., *et al*. "Congenital dysplasia and dislocation of the hip in children and adults". Berlin, Germany, and New York, NY: Springer-Verlag (1987): 6,14.

11. Leveuf J and Bertrand P. "Luxations et subluxations congenitales de la hanche". Leur traitement base sur l'arthrographie. Paris, France: Doin (1946).

12. Milgram JW and Tachdjian MO. "Pathology of the limbus in untreated teratologic congenital dislocation of the hip. A case report of a ten-month-old infant". *Clinical Orthopaedics and Related Research* 119 (1976): 107-111.

13. Hung NN. Chapter 4. Zigzag Osteotomy combined Fibular Allograft (Hung Zigzag Pelvic osteotomy). Editor Nguyen Ngoc Hung. Overview and Hung Zigzag Pelvic Osteotomy. Developmental Dysplasia of the Hip in Children. LAP LAMBERT Academic Publishing. Germany. 2018.

14. Tönnis D. "Review of the literature on open reduction of the hip in congenital dysplasia and dislocation of the hip in children and adults". Springer, Berlin Heidelberg New York (1987): 332.

15. Kleinberg S and Lieberman HS. "The acetabular index in infants in relation to congenital dislocation of the hip". *Archives of Surgery* 32.6 (1936): 1049-1054.

16. Napoli MMM., *et al*. "Anteversão dos colos femorais: estudo radiológico". *Rev Imagem* 7 (1985): 111-116.

17. Ryder CT and Crane L. "Measuring femoral anteversion: the problem and a method". *Journal of Bone and Joint Surgery American Volume* 35.2 (1953): 321-328.

18. Mootha AK., *et al*. "MRI Evaluation of femoral and acetabular anteversion in developmental dysplasia of the hip: a study in an early walking age group". *Acta Orthopaedica Belgica* 76.2 (2010): 174-180.

19. McKibbin B. "Anatomical factors in the stability of the hip joint in the newborn". *The Journal of Bone and Joint Surgery British Volume* 52-B.1 (1970): 148-159.

20. Kalamchi A and MacEwen GD. "Avascular necrosis following treatment of congenital dislocation of the hip". *Journal of Bone and Joint Surgery American Volume* 62.6 (1980): 876-888.

21. Farrell BP., *et al*. "Congenital dislocation of the hip. A report of three hundred and ten cases treated at the network orthopaedic dispensary and hospital". *Journal of Bone and Joint Surgery* 24 (1926): 551-561.

22. Mose K. "Legg-Calve-Perthes disease [Thesis]". Aarhus, Denmark: University of Aarhus (1964).

23. Harris NH. "Acetabular growth potential in congenital dislocation of the hip and some factors upon which it may depend". *Clinical Orthopaedics and Related Research* 119 (1976): 99-106.

24. Salter RB., *et al*. "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". *Canadian Journal of Surgery* 12.1 (1969): 44-61.

25. Barrett WP., *et al*. "The effectiveness of the Salter innominate osteotomy in the treatment of congenital dislocation of the hip". *Journal of Bone and Joint Surgery American Volume* 68.1 (1986): 79-87.

26. Trevor DLJ and Fixen JA. "Acetabuloplasty in the treatment of congenital dislocation of the hip". *Journal Bone and Joint* 57.2 (1975):

167-174.

27. Kessler JK., *et al*. "Use of allografts in Pemberton osteotomies". *Journal of Pediatric Orthopaedics* 21.4 (2001): 468-473.
28. Grudziak JS and Ward WT. "Dega osteotomy for the treatment of congenital dysplasia of the hip". *Journal of Bone and Joint Surgery* 83A.6 (2001): 845-854.
29. Wade WJ., *et al*. "Contoured iliac crest allograft interposition for pericapsular acetabuloplasty in developmental dislocation of the hip: technique and short-term results". *Journal of Children's Orthopaedics* 4.5 (2010): 429-438.
30. Bohm P and Brzuske A. "Salter innominate osteotomy for the treatment of developmental dysplasia of the hip in children: results of seventy-three consecutive osteotomies after twenty-six to thirty-five years of followup". *Journal of Bone and Joint Surgery* 84.2 (2002): 178-186.
31. Ito H., *et al*. "Middle-term results of salter innominate osteotomy". *Clinical Orthopaedics and Related Research* 387 (2001): 156-164.
32. Rab GT. "Biomechanical aspects of salter osteotomy". *Clinical Orthopaedics and Related Research* 132 (1978): 82-87.
33. Ferguson AB. "Howorth M B: Coxa magna". *Journal of the American Medical Association* 104.10 (1935): 808-812.
34. Weinstein SL. "Developmental hip dysplasia and dislocation". In: Weinstein SL, Flynn JJ, eds. Lovell and Winter's Pediatric Orthopaedics. Volume 2. Seventh edition. Philadelphia: Lippincott Williams & Wilkins (2014): 983-1111.
35. Pearson JR. "Idiopathic coxa magna". *Lancet* 1.7295 (1963): 1350-1351.
36. Neuhauser EB and Wittenborg MH. "Synovitis of the hips in infancy and childhood". *Radiologic Clinics of North America* 1 (1963): 13-16.
37. McMurrav B. "A report or six cases or co-xa magna following synovitis of the hip joint". *British Journal of Radiology* 20.239 (1947): 477-481.
38. Edgren W. "Coxa plana". *Acta Orthopaedica Scandinavica* 84 (1965): 1-129.
39. Schiller Axer A. "Hypertrophy of the femoral head in Legg-Calve Perches syndrome". *Acta Orthopaedica Scandinavica* 43.1 (1972): 45-55.
40. Rigal WM. "As quoted by Iructa J: Studies of the development and decay of the human fracture". Philadelphia, W. B. Saunders Co (1968): 85.
41. Trueta J. "Studies of the development and decay of the human frame". Philadelphia. W.B. Saunders Co., (1968).
42. Tachdjian MO. "Congenital dysplasia of the hip". Pediatric Orthopedics. 2nd edition. Philadelphia, PA: WB Saunders (1990): 297-312.
43. Leveuf J. "Results of open reduction of "true" congenital luxation of the hip". *Journal of Bone and Joint Surgery American Volume* 30A.4 (1948): 875-882.
44. Ponseti IV. "Morphology of the acetabulum in congenital dislocation of the hip. Gross, histological and roentgenographic studies". *Journal of Bone and Joint Surgery American Volume* 60.5 (1978): 586-599.
45. Scaglietti O and Calandriello B. "Open reduction of congenital dislocation of the hip". *Journal of Bone and Joint Surgery British Volume* 44 (1962): 257-283.

46. Milgram JW and Tachdjian MO. "Pathology of the limbus in untreated teratologic congenital dislocation of the hip. A case report of a ten-month-old infant". *Clinical Orthopaedics and Related Research* 119 (1976): 107-111.

47. Angliss R., *et al*. "Surgical treatment of late developmental displacement of the hip: results after 33 years". *Journal of Bone and Joint Surgery British Volume* 87.3 (2005): 384-394.

48. Kim YH. "Acetabular dysplasia and osteoarthritis developed by an eversion of the acetabular labrum". *Clinical Orthopaedics and Related Research* 215 (1987): 289-295.

49. Tumer Y., *et al*. "Medial open reduction in the treatment of developmental dislocation of the hip". *Journal of Pediatric Orthopaedics* 17.2 (1997): 176-180.

50. Berkeley ME., *et al*. "Surgical therapy for congenital dislocation of the hip in patients who are twelve to thirty-six months old". *Journal of Bone and Joint Surgery American Volume* 66.3 (1984): 412-420.

51. De Valderrama JA. "The "observation hip" syndrome and its late sequelae". *Journal of Bone and Joint Surgery British Volume* 45 (1963): 462-470.

52. Nachemson A and Scheller S. "A clinical and radiological follow-study of transient synovitis of the hip". *Acta Orthopaedica Scandinavica* 40.4 (1969): 479-500.

53. Stulberg SD., *et al*. "The natural history of Legg-Calve-Perthes disease". *Journal of Bone and Joint Surgery American Volume* 63.7 (1981): 1095-1108.

54. McAndrew MP and Weinstein SL. "A long-term follow-up of Legg-Calve-Perthes disease". *Journal of Bone and Joint Surgery American Volume* 66.6 (1984): 860-869.

55. Gamble JG., *et al*. "Coxa magna following surgical treatment of congenital hip dislocation". *Journal of Pediatric Orthopaedics* 5.5 (1985): 528-533.

56. Kallio PE. "Coxa magna following transient synovitis of the hip". *Clinical Orthopaedics and Related Research* 228 (1988): 49-56.

57. Leitch JM., *et al*. "Growth disturbance in Legg-Calve-Perthes disease and the consequences of surgical treatment". *Clinical Orthopaedics and Related Research* 262 (1991): 178-184.

58. Matani J., *et al*. "Coxa magna after open reduction for developmental dislocation of the hip". *Journal of Pediatric Orthopaedics* 15.3 (1995): 337-341.

59. Shigeno Y and Evans GA. "Quantitative correlation between the initial and final femoral head deformity in Perthes' disease". *Journal of Pediatric Orthopaedics B* 5.1 (1996): 48-54.

60. Luhmann SJ., *et al*. "The prognostic importance of the ossific nucleus in the treatment of congenital dysplasia of the hip". *Journal of Bone and Joint Surgery American Volume* 80.12 (1998): 1719-1727.

61. Rowe SM., *et al*. "The correlation between coxa magna and final outcome in Legg-Calve-Perthes disease". *Journal of Pediatric Orthopaedics* 25.1 (2005): 22-27.

62. Larson AN., *et al*. "A prospective multicenter study of Legg-Calve´-Perthes disease: functional and radiographic outcomes of nonoperative treatment at a mean follow-up of twenty years". *Journal of Bone and Joint Surgery American Volume* 94.7 (2012): 584-592.

63. Sakamaki T. "Clinical study on coxa magna during the treatment in congenital dislocation in the hip". *Nihon Seikeigeka Gakkai Zasshi* 53.5 (1979): 491-504.

64. Gamble JG., *et al*. "Coxa magna following surgical treatment of congenital hip dislocation". *Journal of Pediatric Orthopaedics* 5.5 (1985): 528-533.

65. Topak D., *et al*. "Coxa magna following treatment of developmental dysplasia of the hip: investigation for associated potential factors". *Journal of Pediatric Orthopaedics B* 33.1 (2023): 21-28.

66. Young EY., *et al*. "Femoral head asymmetry and coxa magna: anatomic study". *Journal of Pediatric Orthopaedics B* 34.4 (2014): 415-420.

67. Iwasaki K., *et al*. "Coxa magna occurs after open reduction for congenital hip dislocation [in Japanese]". *Rinsho Seikei Geka* 13 (1978): 20-21.

68. O'Brien T and Salter RB. "Femoral head size in congenital dislocation of the hip". *Journal of Pediatric Orthopaedics* 5.3 (1985): 299-301.

69. Sosna A and Rejholec M. "Ludloff's open reduction of the hip: long-term results". *Journal of Pediatric Orthopaedics* 12.5 (1992): 603-606.

70. Ando K. "Experimental study on hypertrophy of the femoral head—with special reference to the effects of the surgical procedure to the hip joint [in Japanese]". *Japanese Orthopaedic Association* 59.4 (1985): 443-445.

71. Hatanaka T. "An experimental study on the influence of surgical procedures for hip joints in young rabbits [in Japanese]". *Japanese Orthopaedic Association* 51 (1977): 42-49.

72. Papavasiliou VA and Piggott H. "Acetabular floor thickening and femoral head enlargement in congenital dislocation of the hip: lateral displacement of the femoral head". *Journal of Pediatric Orthopaedics* 3.1 (1983): 22-27.

73. Tönnis D and Heinecke A. "Acetabular and femoral anteversion: relationship with osteoarthritis of the hip". *Journal of Bone and Joint Surgery* 81-A.12 (1999): 1747-1770.

74. Haidar RK., *et al*. "Simultaneous open reduction and Salter innominate osteotomy for developmental dysplasia of the hip". *Journal of Bone and Joint Surgery British Volume* 78.3 (1996): 471-476.

75. Ombredanne L. "Precis Clinique et Operatoire de Chirurgie Infantile". Paris: Masson (1923).

76. Predrag K and Ljubisa J. "Combined procedure of open reduction and shortening of the femur in treatment of congenital dislocation of the hips in older children". *Clinical Orthopaedics and Related Research* 119 (1976): 60-69.

77. Harris NH., *et al*. "Acetabular development in congenital dislocation of the hip: with special reference to the medications for acetabuloplasty and pelvic or femoral realignment osteotomy". *Journal of Bone and Joint Surgery* 57-B.1 (1975): 46-52.

78. Klisic P and Jancovic L. "Combined procedure of open reduction and shortening of the femur in treatment of congenital dislocation of the hip in older children". *Clinical Orthopaedics and Related Research* 119 (1976): 60-69.

79. Galpin RD., *et al*. "One-stage treatment of congenital dislocation of the hip in older children, including femoral shortening". *Journal of Bone and Joint Surgery American Volume* 71.5 (1989): 734-741.

80. Wenger DR., *et al*. "Derotational femoral shortening for developmental dislocation of the hip: special indications and results in the child younger than 2 years". *Journal of Pediatric Orthopaedics* 15.6 (1995): 768-779.

81. Massie WK and Howorth MB. "Congenital dislocation of the hip. Part II. Results of open reduction as seen in early adult period". *Journal of Bone and Joint Surgery American Volume* 33-A (1951): 171-190.

82. Durham HA. "Anteversion of the femoral neck in the normal femur and its relation to congenital dislocation of the hip". *Journal of the American Medical Association* 65.3 (1915): 223-224.

83. Sankar WN., *et al*. "Risk factors for failure after open reduction for DDH: A matched cohort analysis". *Journal of Pediatric Orthopaedics* 31.3 (2011): 232-239.

84. Warndorf R. "The pathology amid therapy of congenital dislocations of the hip". *American Journal of Orthopedic Surgery* 10 (1912): 241-261.

85. Badgley CE. "Correlation of clinical and anatomical facts leading to a conception of etiology of congenital hip dysplasia". *Journal of Bone and Joint Surgery* 25.3 (1943): 503-523.

86. Hibbs RA. "Anteversion of the neck of the femur in connection with congenital dislocation of the hip". *Journal of the American Medical Association* 65.21 (1915): 1801-1802.

87. Farrell BP., *et al*. "Congenital dislocation of the hip. A report of three hundred and ten cases treated at the nework orthopaedic dispensary and hospital". *Journal of Bone and Joint Surgery* 1926; 24: 551-561.

88. Lorenz A. "Some remarks on the treatment and after-treatment of congenital dislocation of the hip". *American Journal of Orthopedic Surgery* 2 (1926): 219-233.

89. Bradford EH. "The treatment of congenital dislocation of the hip". *Journal of Bone and Joint Surgery* 5 (1923): 76-98.

90. Soutter R and Lovett RW. "Congenital dislocation of the hip. A study of two hundred and twenty-seven dislocations". *Journal of the American Medical Association* 82.3 (1924): 171-177.

91. Fairbank HAT. "Congenital dislocation of the hip: with special reference to the anatomy". *British Journal of Surgery* 17.67 (1930): 380-416.

92. Kumar S and Jain AK. "Open reduction of late unreduced traumatic posterior hip dislocation in children". *Acta Orthopaedica Scandinavica* 70.6 (1999): 599-602.

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