GRAF METHOD ULTRASOUND SCREENING OF NEWBORNS FOR DEVELOPMENTAL DYSPLASIA OF HIP

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BAHRIA UNIVERSITY ISLAMABAD

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Dr. Nasim Marvi

06-113202-002

A thesis submitted in fulfillment of the requirements for the award of the degree of Master of Philosophy (Anatomy)

Department of Anatomy

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Dedicated to my caring husband, children, and my supervisor Prof. Dr. Aisha Qamar.

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ABSTRACT

Developmental dysplasia of the hip (DDH) is a multifactorial and predominant developmental malformation of the musculoskeletal system in newborns. It is now believed that the hip is not only dislocated at birth, but the process of dislocation progresses after birth. Hence the disorder previously known as congenital dislocation of the hip is now correctly termed as the developmental dysplasia of the hip which can develop even after birth. The term developmental dysplasia of the hip involves an assortment of abnormalities ranging from shallow acetabulum to complete dislocation of the head of femur. Timing of the initial hip ultrasound can make this disorder easily treatable. Graf method hip ultrasound is advisable for early recognition of DDH. Identifying usefulness of ultrasound in early detection of DDH is extremely important for best functional outcomes. Early detection and management are essential because conservative treatment is often successful, but delayed diagnosis may demand complex surgical treatment, as it is a preventable and treatable condition. Objectives of study include, to assess early identification of the DDH in newborns, to correlate association of Barlow's and Ortolani's tests with ultrasound, and to identify the risk factors associated with the occurrence of DDH. Subjects meeting inclusion criteria were considered after acquiring ethical approval from ethical review committee of the respective hospitals. Informed consent was obtained from parents of all participants. A detailed history was taken from parents. After inspection of both legs for length and thigh folds, a clinical examination by Barlow and Ortolani's maneuver was performed followed by Graf method ultrasound of both hip joints on all neonates referred from OPD, admitted and delivered in the National Institute of Child Health, Fazaia Ruth Pfau Medical College, Zubaida Medical Center, and Bantava Anis Hospitals. Both clinical and ultrasonographic examinations were performed by the investigator and counter-checked by the consultant neonatologists and radiologists. Information regarding family history, presentation of the baby at birth, birth weight, duration of gestation, presence of oligohydramnios, mode of delivery, parity, gender,

ethnic background, co-existing musculoskeletal deformities, lower-limb malformations and multiple pregnancies was recorded in the subject evaluation proforma.

Results of ultrasound examination, among the 230 hips that were assessed, 69.13 percent of the hips were found to be mature or immature but appropriate for age, whereas 30.86 percent of the hips were found to be pathological immature or pathological hips.

The newborn babies were examined clinically by Barlow's and Ortolani's test. The data showed that out of 115 subjects (230 hips), these maneuvers were positive only in 6 hips of pathological types (type-lll & type-lV). A significant correlation was observed in the newborn subjects with breech presentation, first born and ethnicity for DDH with the ultrasound results of a pathological. Conclusions: Current study demonstrated that universal screening enabled us to identify DDH in a number of children who had normal clinical examinations and without risk factors, suggesting that a universal screening is preferable to a selective screening.

KEYWORDS: Developmental dysplasia of the hip, Ultrasound hip, Barlow's and Ortolani's tests, Risk factors, Graf method ultrasound screening, Newborns.

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LIST OF ABBREVIATION

ABBREVIATION	FULL FORM
AI	Artificial Intelligence
AVN	Avascular Necrosis
CDA	Cervico-Diaphyseal Angle
CI	Confidence Interval
CS	Cesarean Section
DDH	Developmental Dysplasia of H
FAL	Femoral Axis Length
HAL	Hip Axis Length
ICC	Intraclass Correlation Coefficie
IQR	Interquartile Range
NVD	Normal Vaginal Delivery
OPD	Out Patient Department
OR	Odds Ratio
POCUS	Point-Of-Care Ultrasound
SHUS	Selective Hip Ultrasonogra Screening
UH US	Universal Hip Ultrasonogra Screening
US	Ultrasound

LIST OF ANNEXURES

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

1.1.1 Developmental dysplasia of the hip

Since orthopedic surgeons have learned to diagnose and treat hip dysplasia efficiently, millions of young people have been spared from crippling. The cause of "developmental dysplasia of the hip" is a developmental aberration that results in a defect in the hip that may range from laxity to complete dislocation (Chand et al., 2021).

Developmental dysplasia of the hip (DDH) is the favored terminology to define this disorder in which the femoral head has an unusual relationship with the acetabulum. The femoral head moves in and out of the shallow socket, resulting in the defective formation of the femoral-acetabular relationship, leading to long-term deformities such as gait problems, degenerative lesions of the hip, and muscular atrophy (Fan et al., 2019). The joint capsule is highly flexible at birth, and the hip acetabulum and femur head are underdeveloped. Dislocation is always postnatal (Moore, Dalley, & Agure, 2014). Biomechanical stimulation of the fetal skeleton is produced by fetal kicking and movements, which is essential for embryonic musculoskeletal development, specifically joint morphology. The most common collective morphologic anomaly at birth is DDH (Moore et al., 2014).

The exact cause of this condition is unknown; however, it appears to be the result of multiple contributors, including genetic, mechanical, hormonal, and environmental factors. Several risk factors are linked to restricted fetal movement (Verbruggen et al., 2018). The term refers to the primary dysplasia with an undetermined cause. Secondary dysplasia can be caused by neuromuscular, connective tissue, or skeletal problems (Karnik et al., 2021).

DDH is an epidemiologic problem. It includes a comprehensive spectrum of anomalies that vary from a absolute firm dislocation at birth to acetabular dysplasia which is asymptomatic in the adult (Loder & Skopelja, 2011). Thus, it becomes necessary that the disorder is uncovered earlier because the possibility of normal development during remaining growth can be improved and achieved by early correction of the normal relationship between the femoral head and acetabulum (Akhter, Farhan, & Shami, 2015).

According to the available research, the incidence of DDH in infants significantly changes with geographical location, ranging from its lowest point in populations of Africans to its highest point in populations of Caucasians (Harsanyi et al., 2020). The reported incidence of DDH ranges from 1.5 to 20 per 1,000 live births (Kilsdonk et al., 2021). The incidence is comparatively higher when ultrasonography is employed in addition to clinical evaluation (Noordin et al., 2010).

In terms of risk factors, DDH is frequently seen with positive family history, female newborn, high birth weight and breech presentation but less frequently noticed with firstborn and vaginal delivery (Treiber et al., 2021). Other factors have also been observed, such as ethnic background, co-existing musculoskeletal or lower-limb malformations, oligohydramnios, and multiple pregnancies (Buonsenso et al., 2021). It is difficult to understand the pathophysiology of DDH, which may involve a number of factors, one of which is a genetic predisposition (Zhu et al., 2019). DDH is seven to nine times more frequent in female babies due to the effect of circulating maternal hormone relaxin, which results in increased ligamentous laxity. (Harsanyi et al., 2020). Due to fetal positions, the involvement of the left hip joint is more common, possibly resulting from leaning towards the mother's spine Bilateral involvement is frequent as well. Breech presentation is a significant risk factor consequential from prolonged strain on lower limbs during a breech delivery. Incidence of DDH rises twelve-fold with positive family history in first-degree relatives (Ömeroğlu, Akceylan & Köse, 2019).

Global epidemiological studies have confirmed that traditional swaddling techniques keep limbs in adducted position, which is a potential risk for DDH (Vaidya, Aroojis, & Mehta, 2020). Other factors such as primiparity, high birth weight, oligohydramnios, polyhydramnios and multiple pregnancies can also increase the risk of DDH due to limited fetal mobility

(Harsanyi et al., 2020). The developmental dysplasia of hip is prevalent in the population of Tibet due to living at high altitudes (Zhao et al., 2019).

In infants, DDH does not manifest any symptoms; however, as the youngster begins to walk, symptoms such as a limp, waddling gait, and discrepancy in leg length appear. These symptoms are typically painless. It is clinically irrelevant that the average age of walking lags behind by one month because there is a large range of walking ages and all of them are within the expected time. Pain and early osteoarthritis are among the late effects of undiscovered DDH, which frequently result in the need for premature hip replacement therapy. A restricted abduction of hip, a discrepancy in length of both legs, and an asymmetrical fold of buttock are examples of abnormalities that can be found during a physical examination (Kilsdonk et al., 2021).

The Ortolani technique is the clinical test that is the most sensitive to detect hip instability. In this test, an abducting force is applied to the hip of the infant, which results in repositioning of the displaced head of femur into the acetabulum with a perceptible clunking sound.

Diagnosis of DDH can be achieved by clinical/physical examination, and radiological examination. However, the clinical examination is regarded as insufficient for early detection as it can be clinically undetectable (Hareendranathan et al., 2021). Physical examination is recommended as the initial evaluation for each neonate and includes positive Galeazzi sign (difference in leg length) (Fig: 1.1 ‘A’) and, evidence of gluteal or thigh folds (Fig: 1.1 ‘B’). It has been observed that approximately half of the infants would be missed in the initial examination (Hareendranathan et al., 2021).

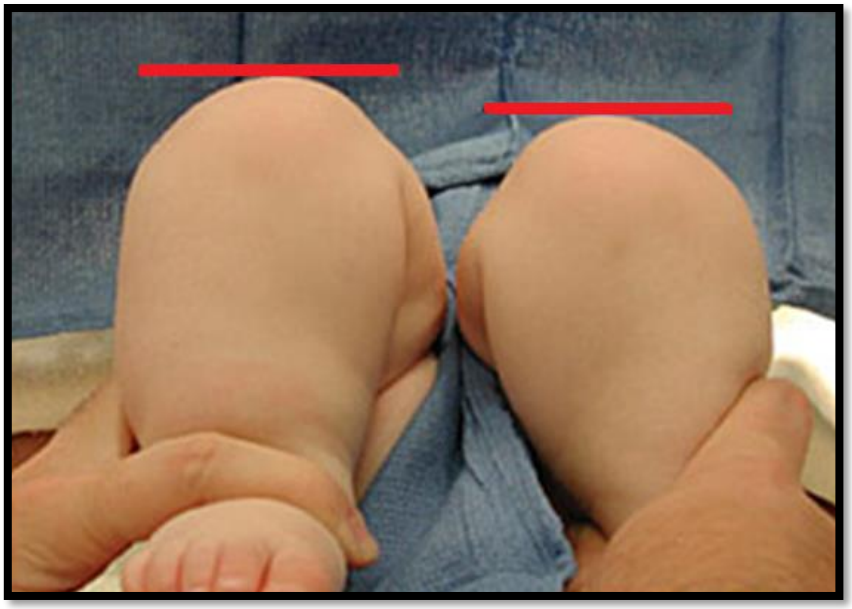

Figure-1.1: (A) Showing a positive Galeazzi sign in a seven-month-old girl with left hip dislocation. Left femoral shortening is observed (Storer & Skaggs, 2006).

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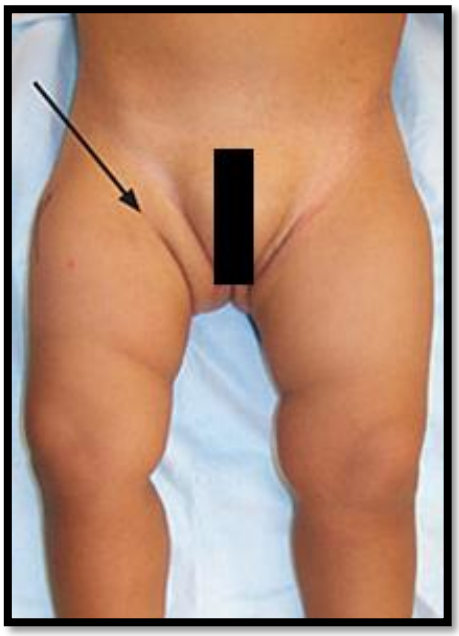

Figure: 1.1 (B) A 21–month-old child with right hip dislocation. Asymmetric extra skin fold in the upper thigh is visible (Storer & Skaggs, 2006).

Postnatal clinical routine screening of the hip can be obtained by Barlow and Ortolani maneuver. The sensitivity of both these tests varies with the experience of the examiner. 50% of proven cases of DDH are skipped by clinical examination alone, as reported in the literature (Buonsenso et al., 2021). The head of the femur is almost a cartilaginous structure and commencement of ossification occurs during 4 to 7 months of age. Therefore, assessment with a plain radiograph of the hip joint during the first few months is not an investigation of choice (Mureşan et al., 2019).

Despite the significant advancements in imaging technology in recent years, ultrasonography (US) is a suitable and reliable screening method for the monitoring and treatment of a number of musculoskeletal disorders in children. In addition to the known benefits of this investigation modality, such as non-exposure to radiation, economic cost, and widespread accessibility, ultrasound is also beneficial due to constitutional characteristics of musculoskeletal system of children, such as ability to observe vascular and cartilaginous structures, enabling dynamic imaging, and facilitating rapid contralateral comparison. Small children offer an early window of opportunity to evaluate these regions by ultrasound since they have soft tissues which are thin, and bones are mostly made up of cartilage. High quality images are obtained by high-frequency (10–15 MHz), high-resolution probes for studying the pediatric musculoskeletal system thus, US is the first-line investigation for developmental dysplasia in neonates (Barbuto et al., 2018).

Ultrasound examination is now employed in most centers for early detection of DDH. In 1980s, the ultrasound was introduced for the first time as a technique to assess the development of hip of an infant (Tan et al., 2019). But later, popularity was gained by the Graf classification of hip growth due to its enhanced early detection (Mureşan et al., 2019). The condition of the hip joint is assessed as explained in Graf method by looking at alpha and beta angles and analyzing the hip type and is classified accordingly. There is a solid consensus that hip screening of the neonates by ultrasound should be done as early as possible, before six weeks of life, as during this period the hip is still maturing and it will allow a more successful level of outcome (Treiber et al., 2021).

Possible options of treatment are conservative and surgical procedures depending on the time of diagnosis. If diagnosed early than condition can be treated conservatively such as use of wide diapering, Frejka's Pillow, Pavlik Harness and counselling the parents regarding

swaddling method as swaddling is the one of most common postnatal and acquired risk factor (Fig:1.2). Swaddling keeps the legs in adducted position which prevents normal frog leg posture of babies. It is very important to educate the parents regarding babies' posture while sleeping (Fig: 1.3 A & B). Surgical options include closed reduction and fixation with spica cast, **o**pen reduction and reconstruction of hip (Kotlarsky et al., 2015). If diagnosed early, it can be successfully treated conservatively, as outlined in the most recent clinical practice guideline by the American Academy of Pediatrics (Jejurikar et al., 2021).

Figure-1.2: Image above showing the position of hip joint during swaddling.

https://res.cloudinary.com/babylist/image/upload/f_auto,q_auto:best,c_scale,w_768/v1510945103/best_swaddles_thumb_zoabko.jpg

Figure-1.3: Photograph A is showing correct method of swaddling. Photograph B is showing frog leg position of baby.

https://cdn2.momjunction.com/wp-content/uploads/2014/09/Sleeping-Positions-For-Babies-What-Is-Safe-And-What-Is-Not-5-624x702.jpg

1.2 EMBRYOLOGY OF HIP JOINT

1.2.1 Prenatal Development of the Hip

By the end of the third week after fertilization, the embryo will already have the initial stages of primitive limb buds which are initially filled with mesenchyme. Primitive limb buds over time, develop to create all the components of joint components except nerves and blood vessels (Zaghloul & Mohamed, 2018). The length of the 6-week embryo is 12 millimeters. The ischium, ilium, pubis, and shaft of femur are all outlined by areas of the mesenchyme that have condensed and become thicker. The next step is rapid differentiation. An inter-zone develops between head of femur and acetabulum by seventh week when the length of embryo is 17 mm. This occurs somewhat later than the appearance of the femoral shaft. This inter-zone gives rise to the development of three distinct layers, which, along with the synovial membrane, culminate in the formation of the perichondrium of the head of femur and acetabulum (Moore, Persaud, & Torchia, 2018).

At eight weeks, the embryo has reached a length of 30 millimeters, and blood vessels have begun to form inside the ligamentum teres. The femoral neck begins to form an angle on the femoral shaft, eventually becoming more pronounced. Apoptosis causes the fissure that announces the actual joint cavity to begin developing. At the same time, the acetabular labrum becomes distinguishable as a distinct structure. At 11 weeks, the embryo measures 50 millimeters in length. The diameter of the femoral head, which is spherical, is 2 millimeters. Its development is independent to that of the acetabulum (Hartog et al; 2019; Zaghloul & Mohamed, 2018).

Femoral anteversion between 5 and 10 degrees can be identified, and blood vessels of the hip have been formed. The length of the fetus at 16 weeks is 120 mm. The fetus can kick and move because the hip muscles have matured to a point where they can be identified separately. There is evidence of early ossification inside the cartilage anlage of the femoral shaft. However, the cartilaginous state of the femoral head and trochanters persists for a significant time after birth. In utero, fetal hip is frequently flexed, abducted, and rotated externally, with the left hip commonly being the hip more rotated than the right. The epiphyseal and metaphyseal arteries are the primary sources of blood flow to the head of the femur (Moore et al., 2018).

At this point in development, the blood arteries in the ligamentum teres play a relatively little part in the supply of blood to the head of the femur. However, this changes later in the pregnancy. The hip joint expands and develops during the last 20 weeks of fetal development within the mother's womb (Sadler, 2018; Zaghloul & Mohamed, 2018).

12.2: Postnatal Development of the Hip

The process of acetabular development continues after birth. The triradiate cartilage is responsible for 70 percent of the expansion, which occurs in both diameter and depth. There is a structure called the twin growth plates where the bones of pelvis meet the triradiate cartilage. These twin growth plates permit the circumferential expansion of the cavity, which is necessary to provide room for the expanding femoral head. Additionally, growth plates may be seen extending beyond the articular surface of each pelvic bone (Girsh, 2021; Heimkes et al., 2019). The acetabular ring epiphysis accounts for nearly a third of the acetabular depth, which is the tissue that encircles and supports the acetabular edge. Between the ages of 11 and 14 days, the ring epiphysis shows signs of ossification in the form of small centers. During the middle years of adolescence, it will often fuse to the acetabular edge (Heimkes et al., 2019).

Around 11 years of age the triradiate cartilage finally closes in girls, but it takes another year in boys. The development of the proximal femoral epiphysis is the most difficult among the growth zones of appendicular skeleton (Schoenwolf et al., 2020).

The progression of the proximal femur through its many phases of development is shown in (Fig- 1.4). The two most essential characteristics are the continuity of epiphyseal and physeal cartilage along the posterosuperior part of the neck during development after birth and the intracapsular route of the arteries to the head of femur (Sadler, 2018; Zaghloul & Mohamed, 2018). The beginning of secondary ossification in the head of femur occurs between 4 and 6 months after birth (range 2–10 months). The procedure involves a centrally located sphere of ossification which extends centrifugally, finally resulting in the hemispheric shape of the articular surface and by this time the child is between the ages of 6- and 8-year-old and forming a distinct subchondral plate that follows the contour of the physeal surface of head of femur (Moore et al., 2018).

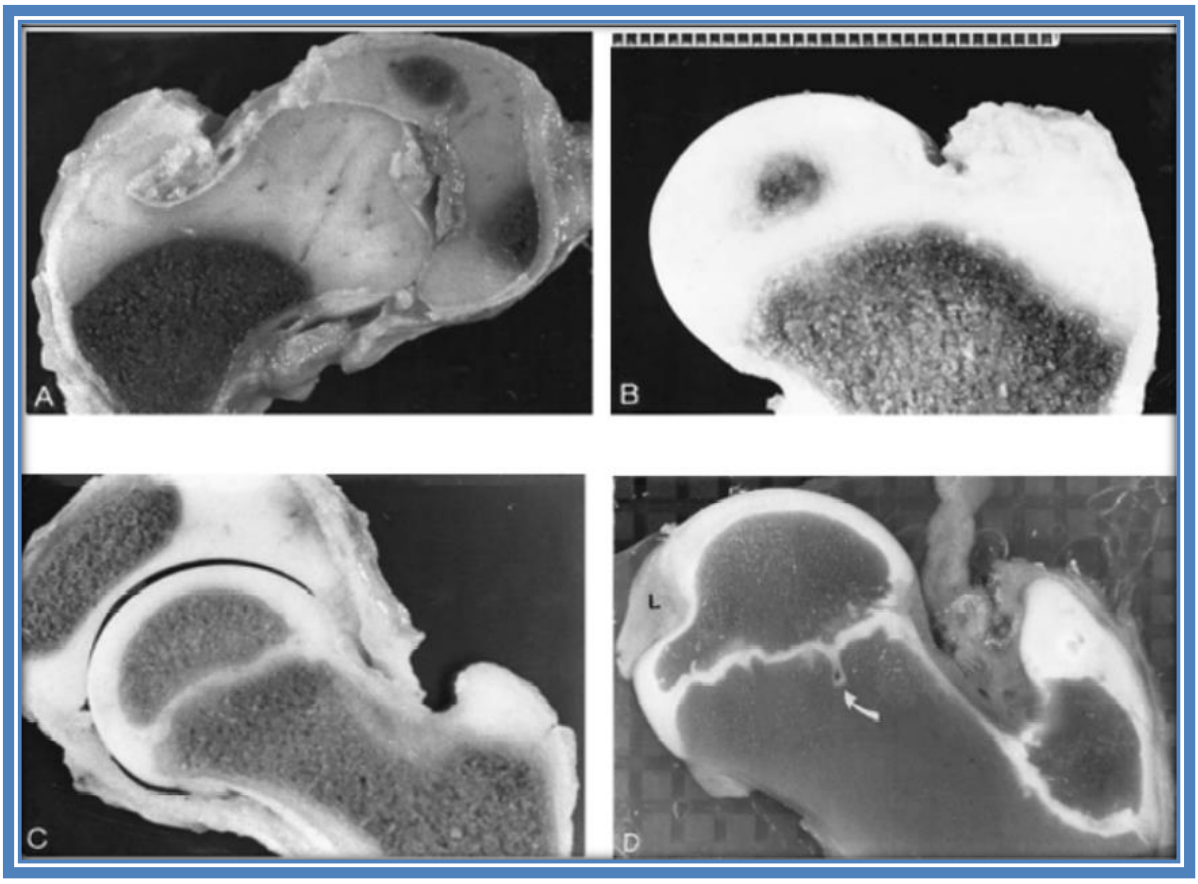

Figure.1.4: Slab sections (proximal femoral development). A) At 2 months, the capital femur and greater trochanter are continuous. Capital femoral cartilage has intrinsic vascularity. (B) At 8 months, the femoral neck (metaphysis) and capital femoral ossification center develop. (C) At 8years, the capital femoral physis undulates. (D) At 12 years, the ossification center at the capital femoral ligament attachment is normal. At 8, the capital femoral physis undulates. (L); The capital femoral physis is undulated and has a mammillary process (arrow) (Zaghloul & Mohamed, 2018).

The cartilaginous continuity of the capital femoral and trochanteric epiphyses along the superior and posterior sections of the neck of femur is shown in (Fig: 1.5). This continuity is present during most of the development process. Even though this area becomes thinner and thinner as the kid develops, it is indispensable for the appropriate expansion of the neck of femur and, at least partly, average reduction in anteversion (Schoenwolf et al., 2020). Establishing a distinct neck of femur requires selective development along the capital femorointertrochanteric physis. The major spongiosa, which forms first during the formation of the neck, is not oriented to the biological pressures that act across the hip joint. The secondary spongiosa, which is more receptive, creates the usual trabecular patterns in response to compression and tension stresses. The second decade of life is when this process becomes more noticeable. It is common to refer to Ward's triangle as the region between these three primary osseous patterns (Girsh, 2021).

Alteration in the form of the capital femoral physis are brought about as a result of the development of the neck of femur. Initially, the neck of femur is positioned in a transverse orientation (Fig: 1.5), but over the first year, the preferred development happens in the medial and central regions of the bone. The capital femoral physis grows more medially (varus) and posteriorly orientated as these areas mature, slipping the capital femoral epiphysis. The physis develops lappet formation, undulations, and mammillary processes (Fig: 1.5*)*, becoming more apparent after the child reaches the age of ten. These processes and contours are to "anchor" or stabilize the epiphysis of head of femur so that it does not move due to physiologic shear forces (Moore et al., 2018). Ossification of the greater trochanter starts between the ages of five and seven years (Fig-1.6), and it first appears right above the trochanteric physis. As growth continues, ossification will progress cranially into the remaining portion of the epiphysis. The epiphysiodesis of the greater trochanter occurs between the ages of 14 and 16 (which is later than the epiphysiodesis of the capital femoral physis). In most people, the lesser trochanter does not ossify until they reach their teenage years (Fig-1.6). Fusion often takes place between the ages of 15 and 19. This area is characterized as a traction apophysis because it is susceptible to solid tensile strains of the associated iliopsoas tendon. Chronic stress, such as that seen in patients with cerebral palsy, may cause overgrowth (Zaghloul & Mohamed, 2018).

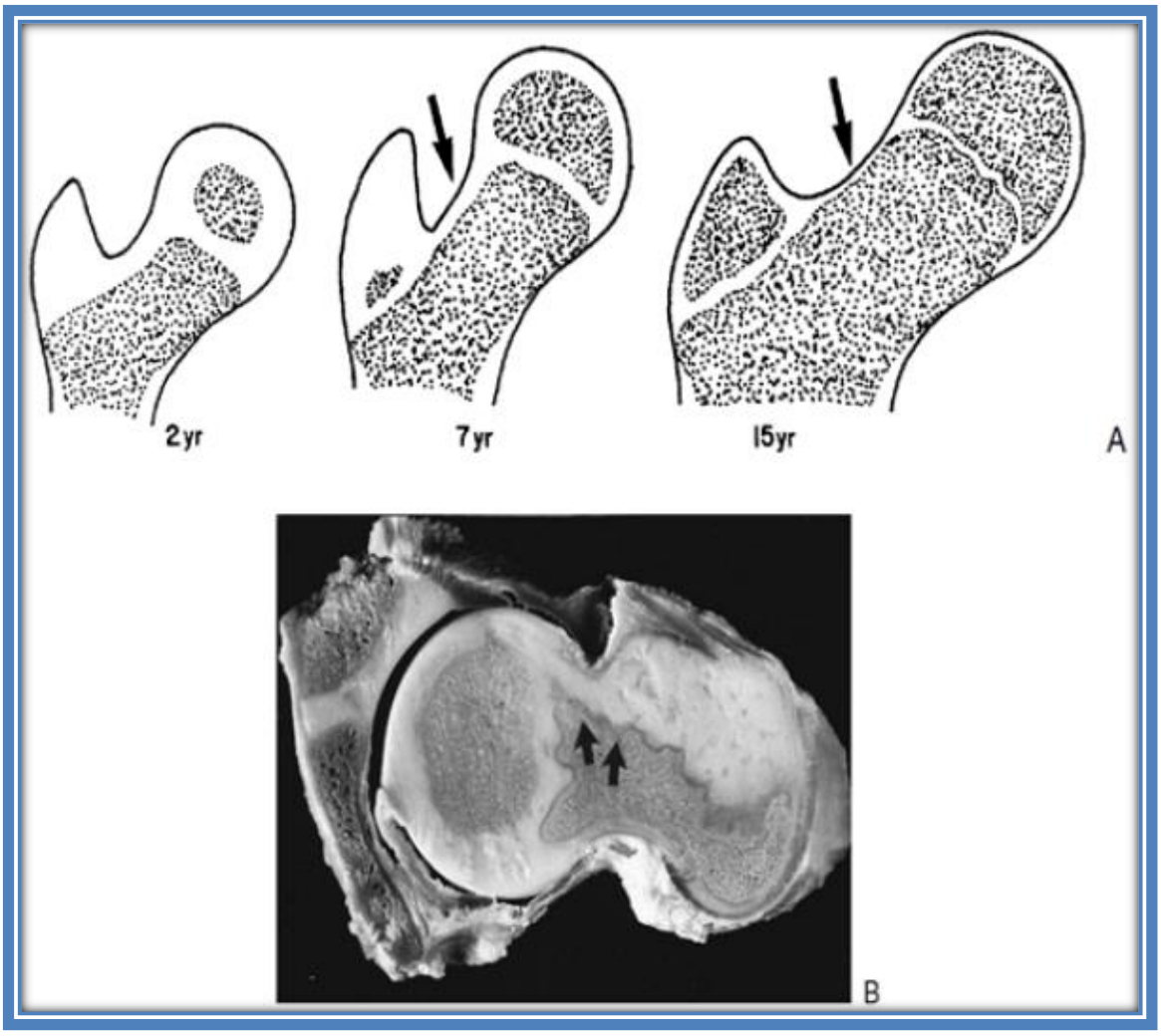

Figure-1.5: (A) Progressive proximal femoral development. A segment of physeal cartilage (arrows) is present along the posterosuperior femoral neck throughout most of development. It is necessary for widening of the femoral neck and posteriorly directed growth of the femoral neck to spontaneously decrease the amount of anteversion. (B) Transverse section through the proximal femur showing the capital femoral epiphysis and the posterior cartilaginous continuity (arrows) with the unossified greater trochanter (Zaghloul & Mohamed, 2018).

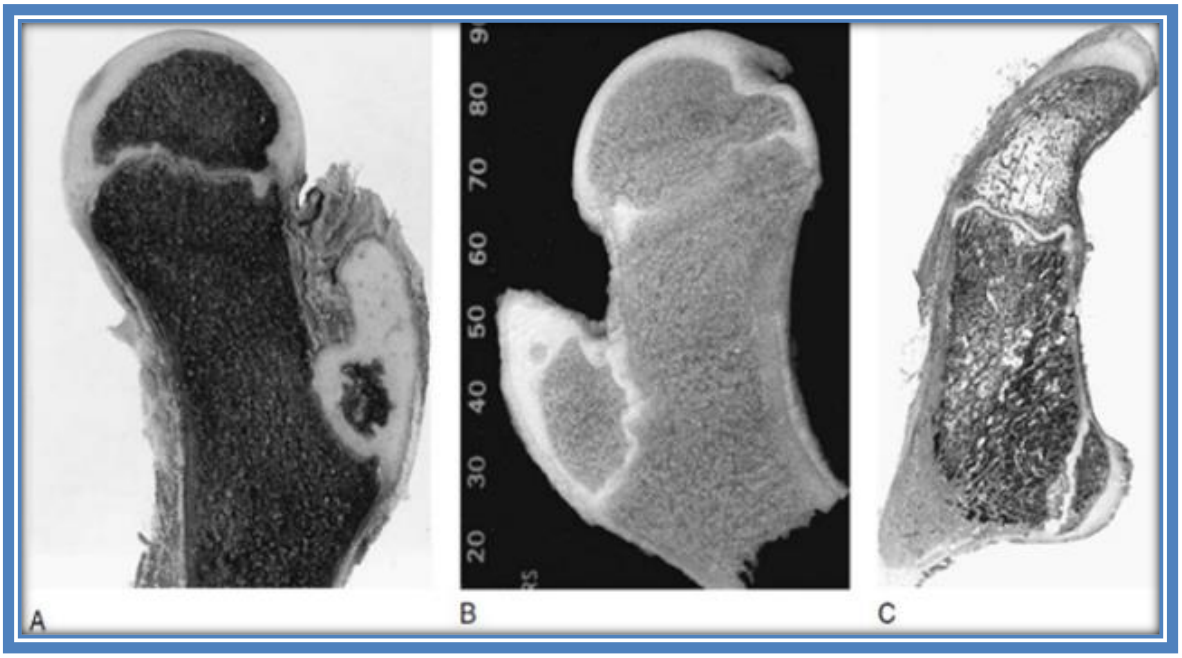

Figure-1.6: (A) Development of trochanteric ossification in an 8-year-old child, showing the irregular margins of secondary ossification and the extensive cartilaginous nature of the trochanteric epiphysis, especially proximally at the tip. (B) Later stage (12years) showing an accessory (tertiary) ossification center. (C)Histologic section through the greater and lesser trochanters in a 15-year-old boy (Zaghloul & Mohamed, 2018).

1.3 ANATOMY OF HIP JOINT

1.3.1 Hip Joint

The hip joint is a synovial variety of ball and socket joint. It is solid and multiaxial, in which head of femur articulates with acetabulum of hip bone. It is a highly stable joint with a wide range of movements. Adjustment of the head of femur and acetabulum to each other results in instability of the joint. The narrow and long neck of the femur provides a great range of mobility. (Fig: 1.7) (Sinnatamby, 2011).

13.2 Acetabulum

Three bones come together to form the acetabulum, a hemispherical hollow on the lateral side of the hip (Fig-1.8). The acetabulum's lunate surface, which forms its thick, pronounced rim, is an articular portion covered with articular cartilage. The acetabular rim and lunate surface make up about three quarters of a circle. The acetabular notch is the missing lower part of the circle. The lip-shaped acetabular labrum is a fibrocartilage rim that is attached to the edge of the acetabulum. It makes the acetabular articular area about 10% bigger. The acetabular notch is connected to the acetabular labrum by the transverse acetabular ligament, which is part of the labrum (Fig-1.9). More than half of the femoral head fits within the acetabulum due to the height of the rim and labrum. Therefore, to permit disarticulation of the joint during dissection, the femoral head must be separated from the acetabular rim. The ischium mostly forms a deep non-articular portion termed the acetabular fossa in the middle of the joint. This fossa is connected inferiorly with the acetabular notch and has thin walls (sometimes transparent) (Moore et al., 2014).

The rounded femoral head is wholly draped with articular cartilage, which is thicker on the weight-bearing part. Only the area for the ligament of the femoral head (pit or fovea) is not covered (Drake et al., 2020).

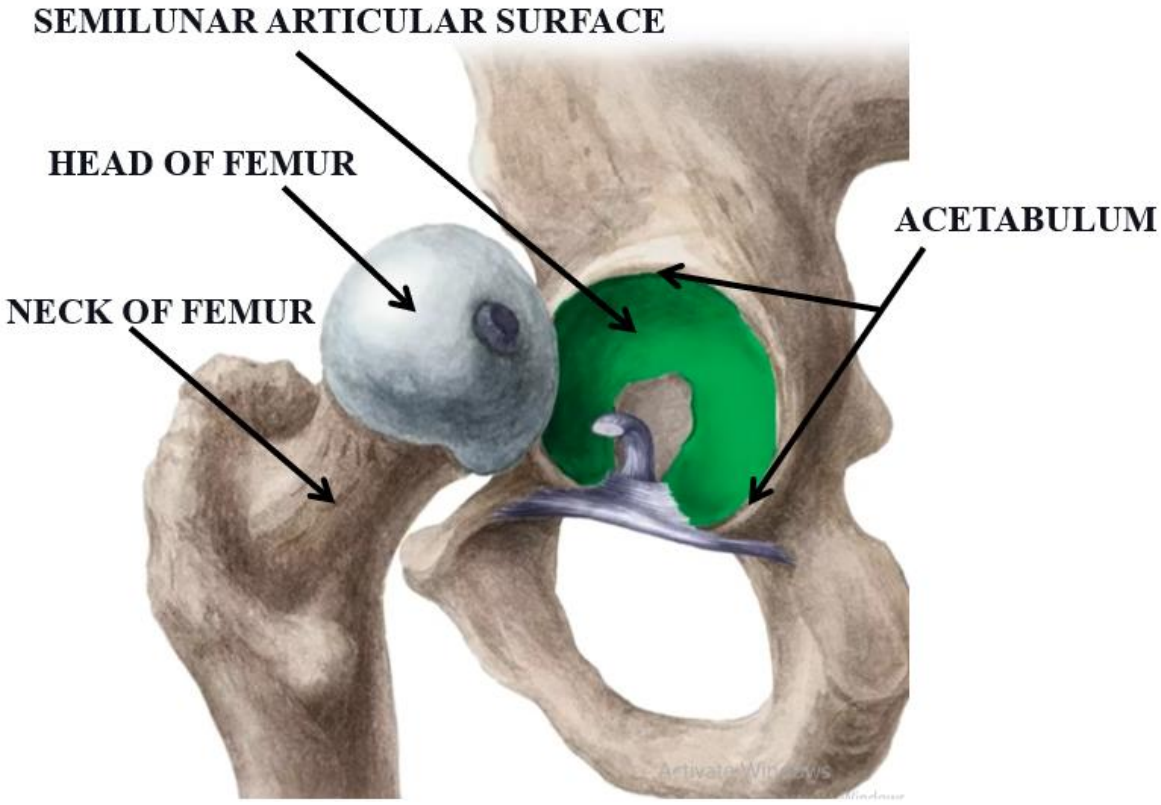

Figure-1.7: Diagram above is showing anatomical landmarks of hip joint.

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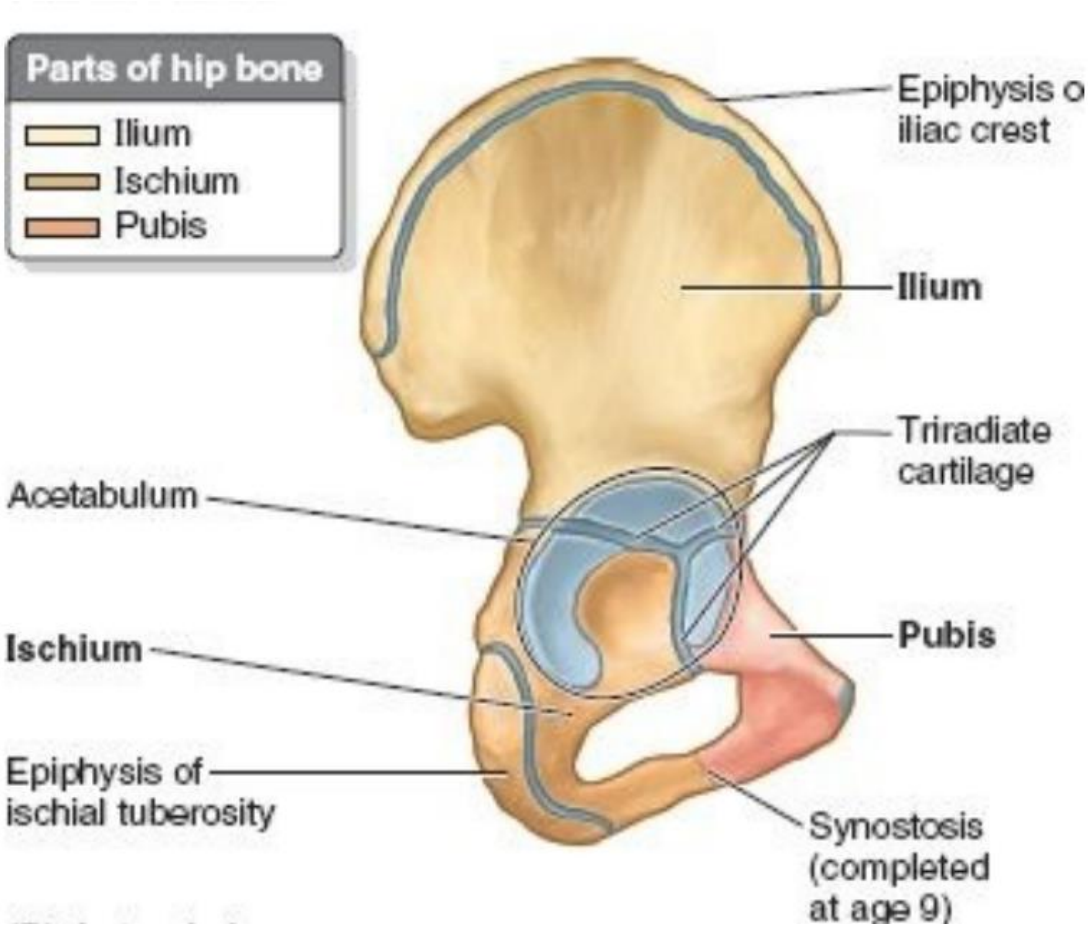

Figure- 1.8 The lateral view of right hip bone of a 13-year-old demonstrating the Y-shaped triradiate cartilage and three parts of hip bone (Moore et al., 2014).

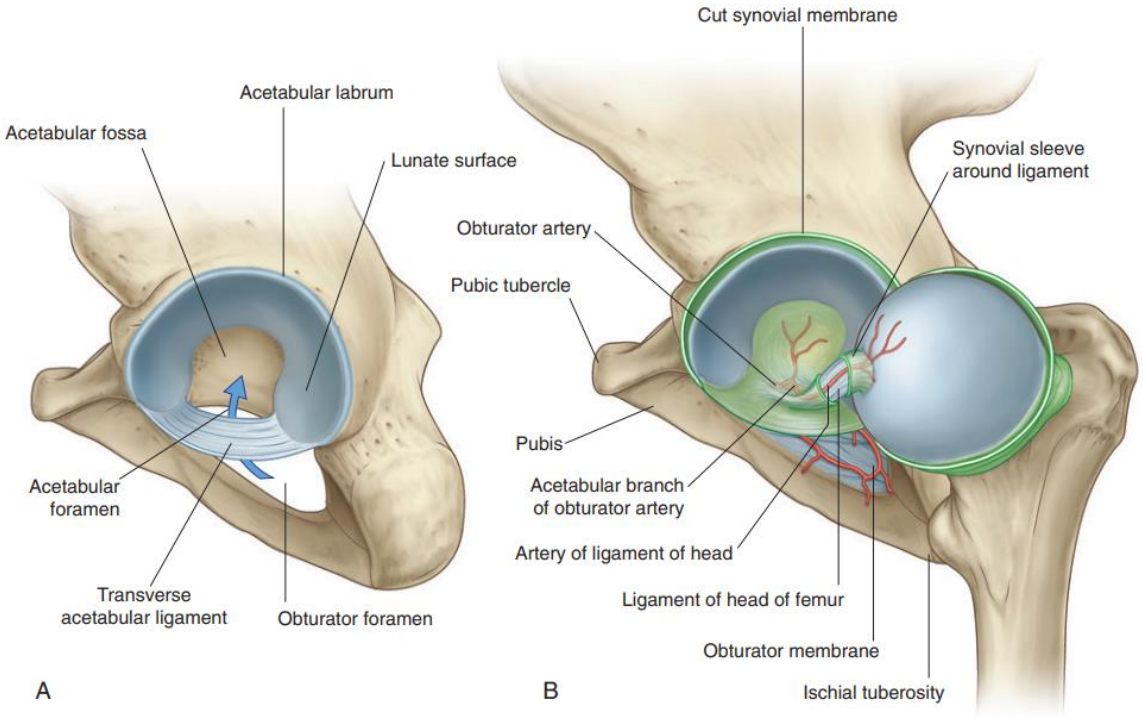

Figure-1.9: Illustration showing A. Transverse acetabular ligament. B. The ligament that connects the head of the femur to its shaft. In order to view the ligament, the acetabulum has been laterally moved so that the head of the femur is now outside of it (Drake, 2020).

1.3.3 Ligaments

The ligament of femoral head is a delicate connective tissue band which is attached to the fovea on the head of the femur at one end and to the fossa of acetabulum, margins of the acetabular notch and transverse acetabular ligament at the other end (Fig-1.9) (Sinnatamby, 2011).

The iliofemoral, pubofemoral, and ischiofemoral ligaments play an important role in reinforcing the external fibrous membrane surface and supporting joint stability (Fig-1.10). Iliofemoral ligament is triangular-shaped and reinforces the hip joint anteriorly. The ilium provides attachment to the apex of the ligament between the anterior inferior iliac spine and the margin of the acetabulum, and the femur provides attachment along the intertrochanteric line to the base of the ligament. The pubofemoral ligament is present anteroinferior to the hip joint. Again, a triangular ligament, iliopubic eminence, obturator membrane, and adjacent bone provide attachment to the base medially. The ligament blends with the deep surface of the iliofemoral ligament laterally and with the fibrous membrane. The ischiofemoral ligament strengthens the fibrous aspect posteriorly. The ischium provides attachment to the ligament medially the acetabulum posteroinferiorly, and the greater trochanter deep to the iliofemoral ligament provides attachment laterally (Drake et al., 2020).

134.4 The proximal end of the femur

The thigh bone is the longest bone in the body and is called the femur. A head, neck, and two prominent projections on the upper portion of the shaft (the greater and lesser trochanters) are features of its proximal end. The acetabulum of the pelvic bone articulates with the spherical head of the femur. It is identified by a nonarticular pit (fovea) for the attachment of the head ligament on its medial surface (fig-1.9). The femur's head and shaft are joined by a cylindrical bone strut called the neck. It extends somewhat forward and superomedially from the shaft at an angle of around 125°.The orientation of the neck in relation to the shaft increases the hip joint's range of motion. The upper portion of the femur shaft contains the greater and lesser trochanters, which serve as attachment points for the muscles that move the hip joint. The greater trochanter is located superiorly on the femur, and it extends superiorly from the shaft of the femur just laterally to the region where the shaft joins the neck of the femur. It then extends posteriorly, where its medial surface forms a deeply grooved trochanteric fossa (Drake et al., 2020).

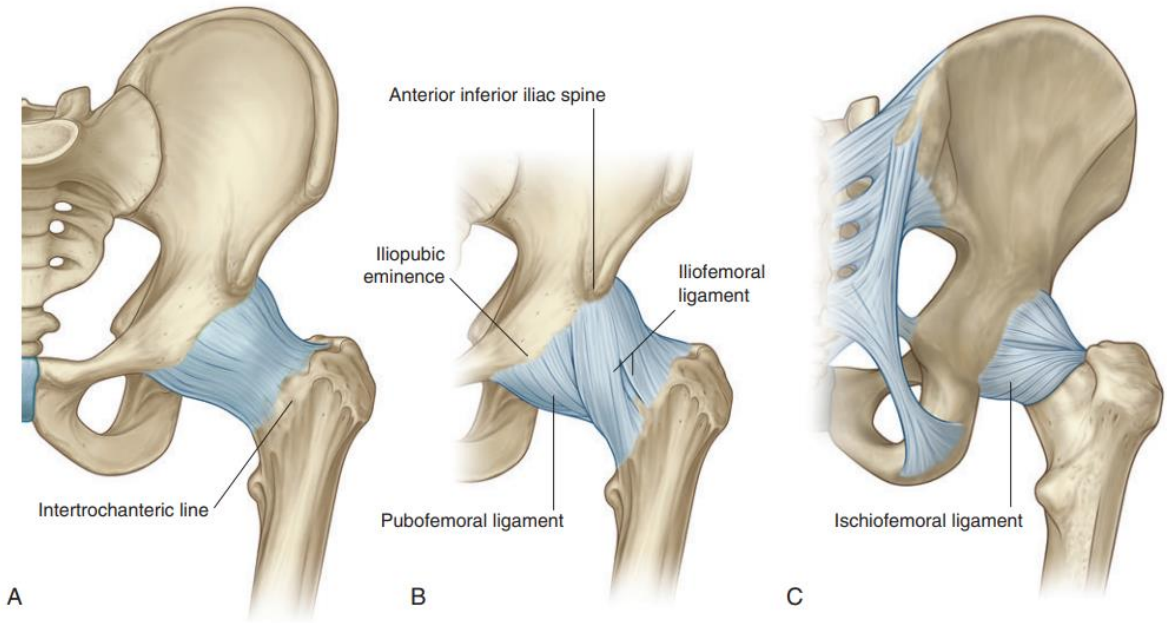

Figure-1.10: Illustration showing Fibrous membrane and ligaments of the hip joint. **A**. Fibrous membrane of the joint capsule. Anterior view. **B.** Iliofemoral and pubofemoral ligaments. Anterior view. **C.** Ischiofemoral ligament. Posterior view (Drake, 2020).

1.3.5 Blood Supply of Hip Joint

The medial and lateral circumflex femoral arteries, which are normally branches of the profunda femoris artery but can sometimes develop as branches of the femoral artery (Fig-1.11). The variable-sized branch of the obturator artery that supplies blood to the head of the femur; these branches go all the way through the ligament in the head shown in Fig-1.13 (Agur, 2009).

The hip joint receives the majority of its blood supply via the retinacular arteries, which are branches that originate from the circumflex femoral arteries. The most numerous retinacular arteries are those that originate from the medial circumflex femoral artery (fig-1.11). These arteries are able to travel beneath the detached posterior border of the joint capsule, which allows them to deliver a greater quantity of blood to the head and neck of the femur. The retinacular arteries that arise from the lateral circumflex femoral must penetrate the thick iliofemoral ligament and are hence smaller and fewer in number (Sinnatamby, 2011).

134.6 Innervation of Hip Joint

According to Hilton's Law, the nerves that feed the muscles that immediately cross a joint and act on it likewise innervate the joint.

Flexors innervated by the femoral nerve pass anterior to the hip joint; the femoral nerve innervates the anterior aspect of the hip joint (directly and via articular rami of the muscular branches to the pectineus and rectus femoris). Lateral rotators pass inferior and posterior to the hip joint; the obturator nerve innervates the inferior aspect of the joint (fig-1.12) directly and via articular rami of the muscular branch to the obturator externus), while the quadratus femoris innervates the posterior part. Superior gluteal nerve innervated abductors pass superior to the hip joint; the superior aspect of the joint is innervated by the superior gluteal nerve shown in fig-1.12 (Moore et al., 2014).

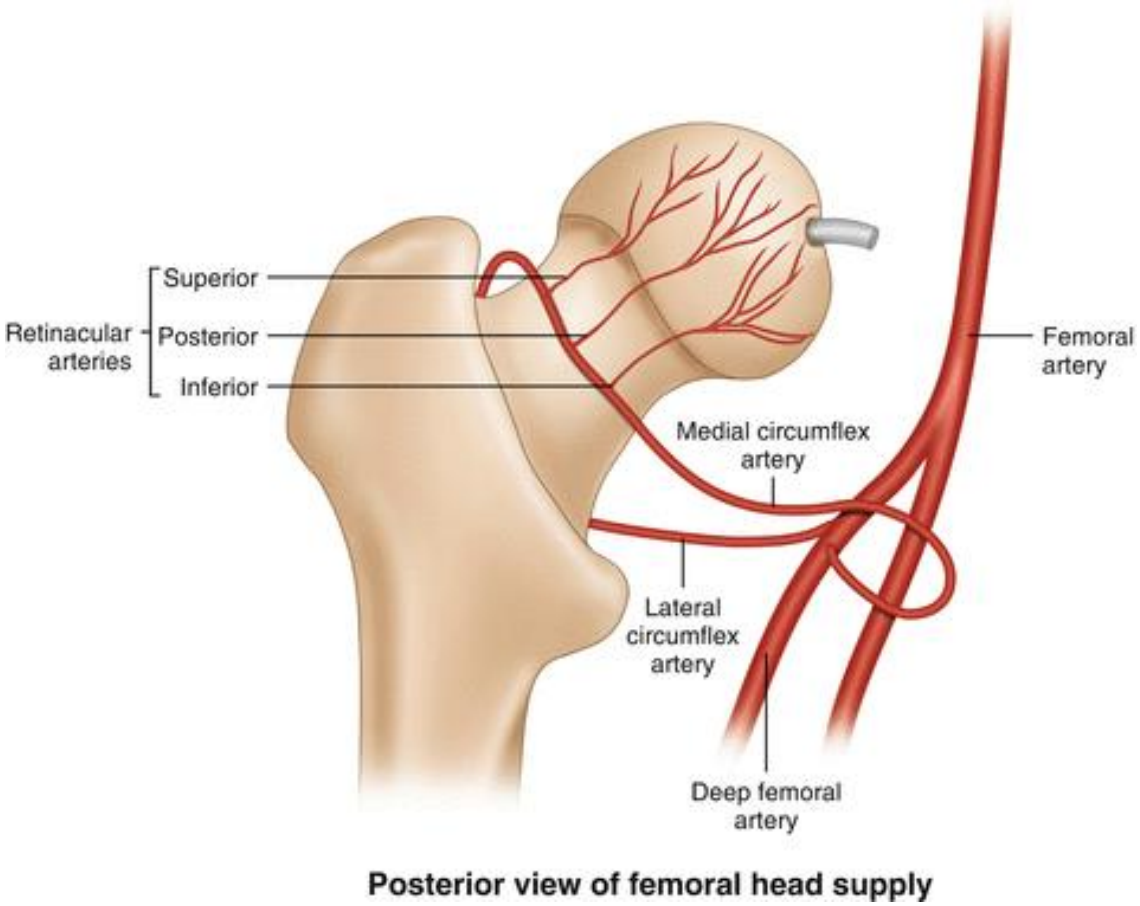

Figure-1.11: Schematic diagram demonstrating posterior aspect of the arterial supply of the femoral head and neck. The medial circumflex femoral artery, a branch of the deep femoral artery (profunda femoris, branch of femoral artery) traversing the femoral neck, supplies retinacular arteries, which give the main blood supply to the capital epiphysis **(**Bittersohl et al., 2015).

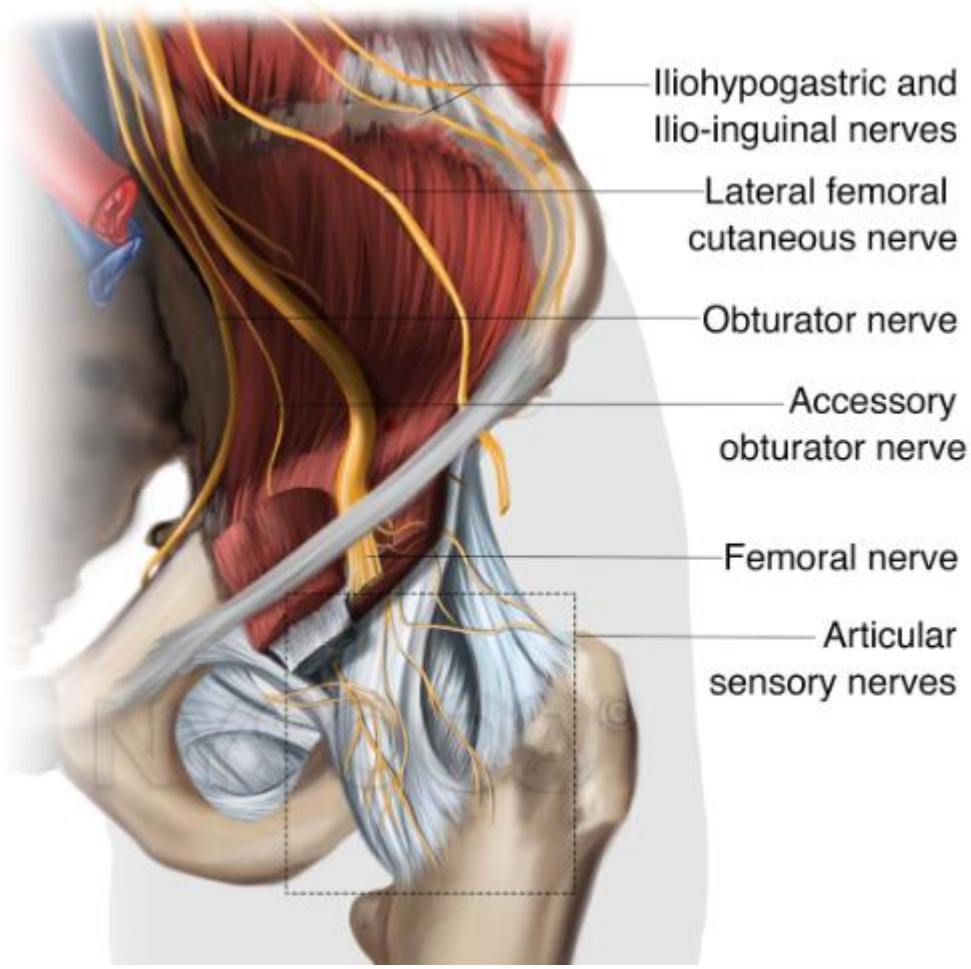

Figure 1.12: illustration above highlighting the innervation of hip joint.

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1.4 HISTOLOGY OF BONE

1.4.1 Bone Cells

Bone is a specialized form of connective tissue distinguished by its calcified extracellular substance, or bone matrix, and the three main cell types that make up bone:

Osteocytes located in the spaces between the layers of the bone matrix, osteoclasts have cytoplasmic processes that extend into the matrix through tiny canaliculi. **Osteoblasts** proliferating cells that produce and secrete the organic matrix components. **Osteoclasts** large, multinucleated cells responsible for resorbing calcified bone matrix and reshaping bone tissue shown in figure 1.13 & 1.14. Both of the bones' surfaces, internal and external, are lined by connective tissue layers called as periosteum & endosteum respectively as shown in fig-1.13 (Anthony, 2013).

14.2 Bone Matrix

Inorganic components make up about 50% of the dry weight of bone matrix. The most prevalent mineral is calcium hydroxyapatite, but other elements like bicarbonate, citrate, magnesium, potassium, and sodium are also present. Additionally, there are substantial amounts of noncrystalline calcium phosphate shown in figure 1.18 (B.Young et al., 2013).

14.3 Types of Bone

Woven bone, also known as immature bone; primary bone or bundle bone. It is a newly calcified bone. Irregular and random arrangement of cells and collagen is found; lightly calcified. Mainly found in developing and growing bones; hard callus of bone. **Lamellar bone**, remodeled from woven bone also called as mature bone or secondary bone. In this bone the parallel bundles of collagen in thin layers (lamellae) are arraigned, with regularly spaced cells between; heavily calcified. Found in all normal regions of adult bone. **Compact bone**, ~80% of all lamellar bone also known as cortical bone. Parallel lamellae or densely packed osteons, with interstitial lamellae are seen. Found in thick, outer region (beneath periosteum) of bones.

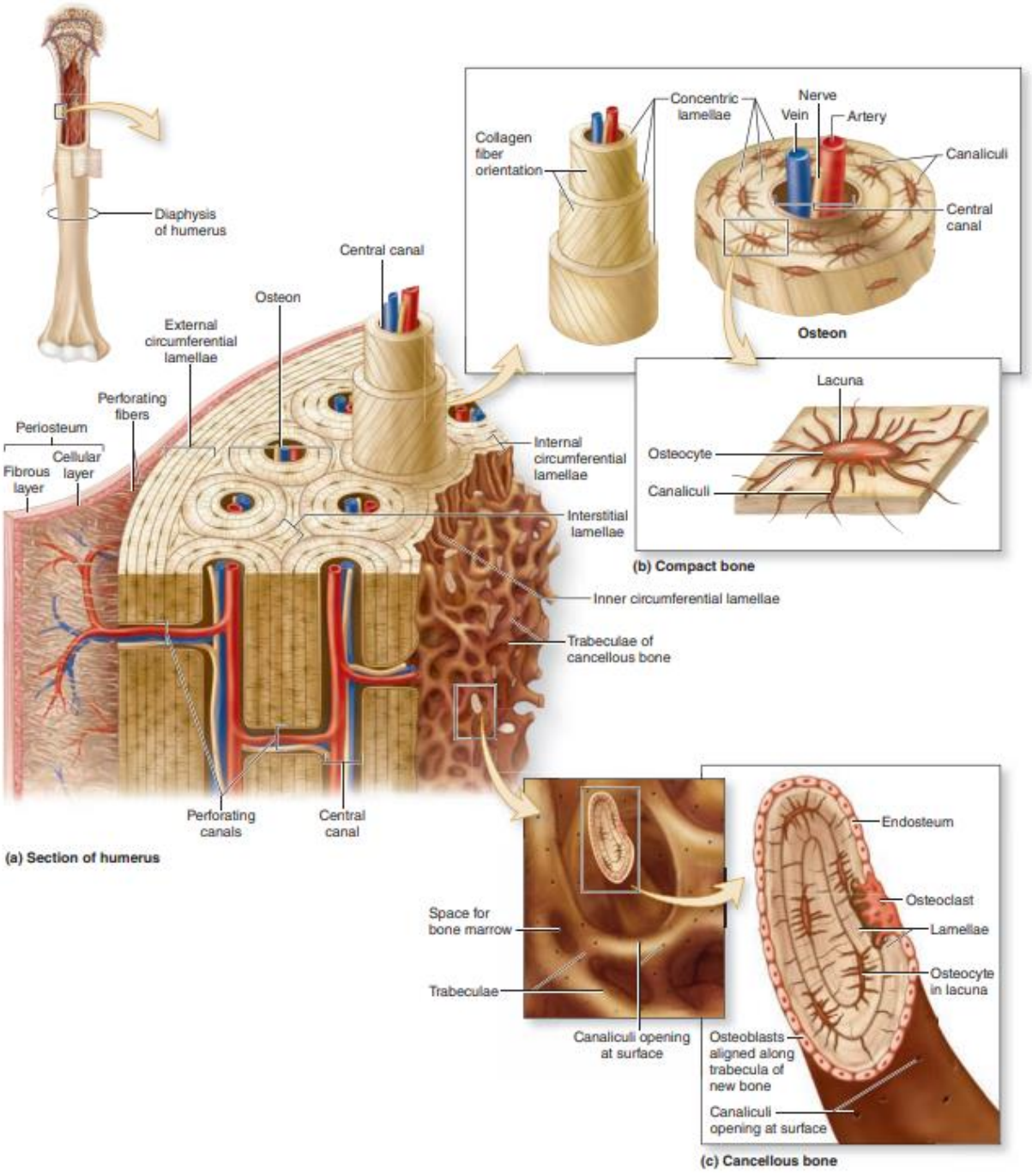

Figure 1.13: A schematic overview of the basic features of bone, including the three key cell types: osteocytes, osteoblasts, and osteoclasts; their usual locations; and the typical lamellar organization of bone.

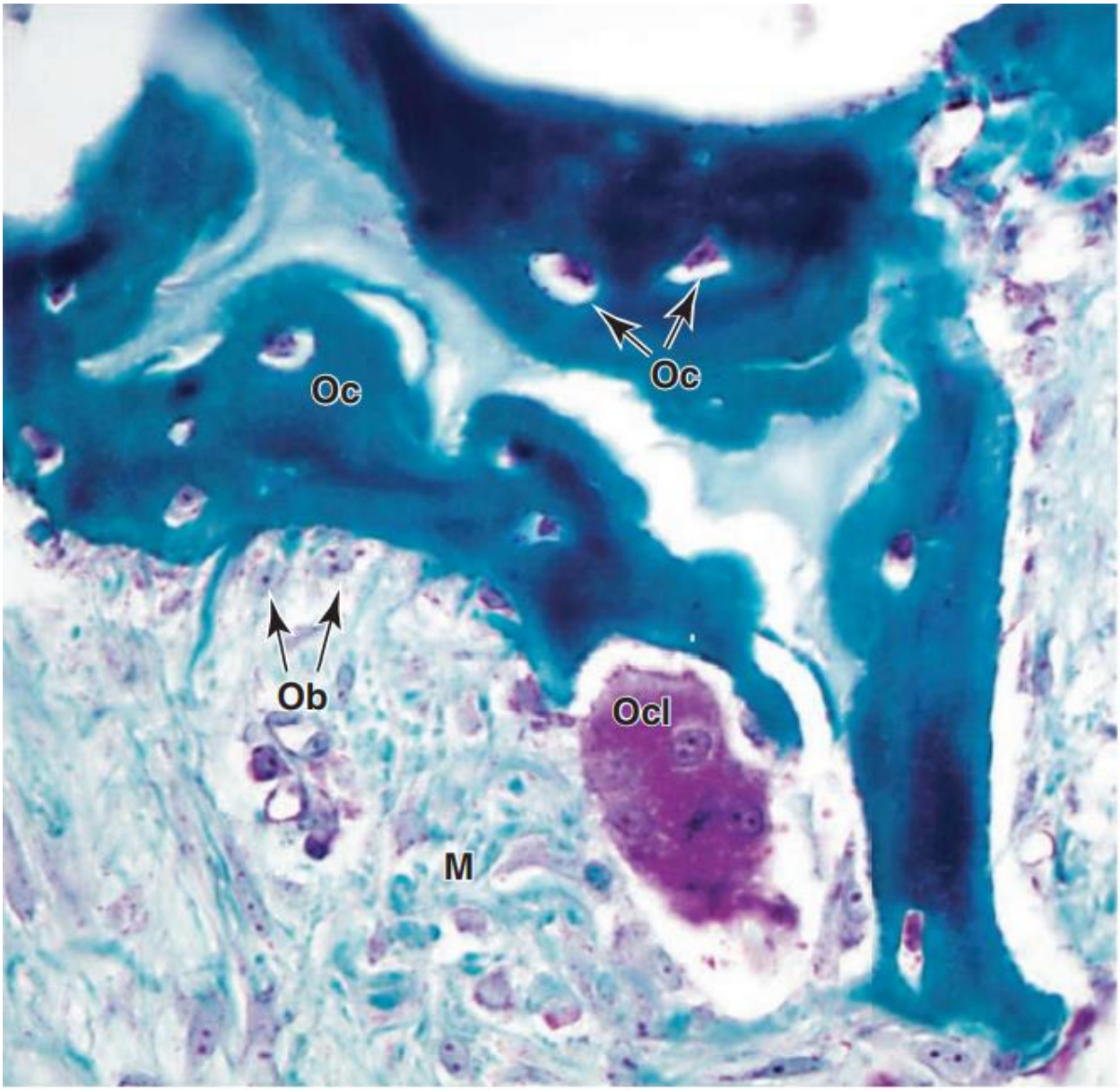

Figure-1.14: Newly formed bone tissue decalcified for sectioning and stained with trichrome in which the collagen-rich ECM appears bright blue. The tissue is a combination of mesenchymal regions (M) containing capillaries, fibroblasts, and osteoprogenitor stem cells and regions of normally calcified matrix with varying amounts of collagen and the three major cell types found in all bone tissue. Bone-forming osteoblasts (Ob) differentiate from osteoprogenitor cells in the periosteum and endosteum, and cover the surfaces of existing bone matrix. Osteoblasts secrete osteoid rich in collagen type I, but also containing proteoglycans and other molecules. As osteoid undergoes calcification and hardens, it entraps some osteoblasts that then differentiate further as osteocytes (Oc) occupying lacunae surrounded by bony matrix. The much less numerous large, multinuclear osteoclasts (Ocl), produced by the fusion of blood monocytes, reside on bony surfaces and erode the matrix during bone remodeling.

Cancellous bone, ~20% of all lamellar bone called as spongy bone or trabecular bone or medullary bone. Interconnected thin spicules or trabeculae covered by endosteum are seen. Found in inner region of bones, adjacent to marrow cavities (Fig-1.13 & 1.15).

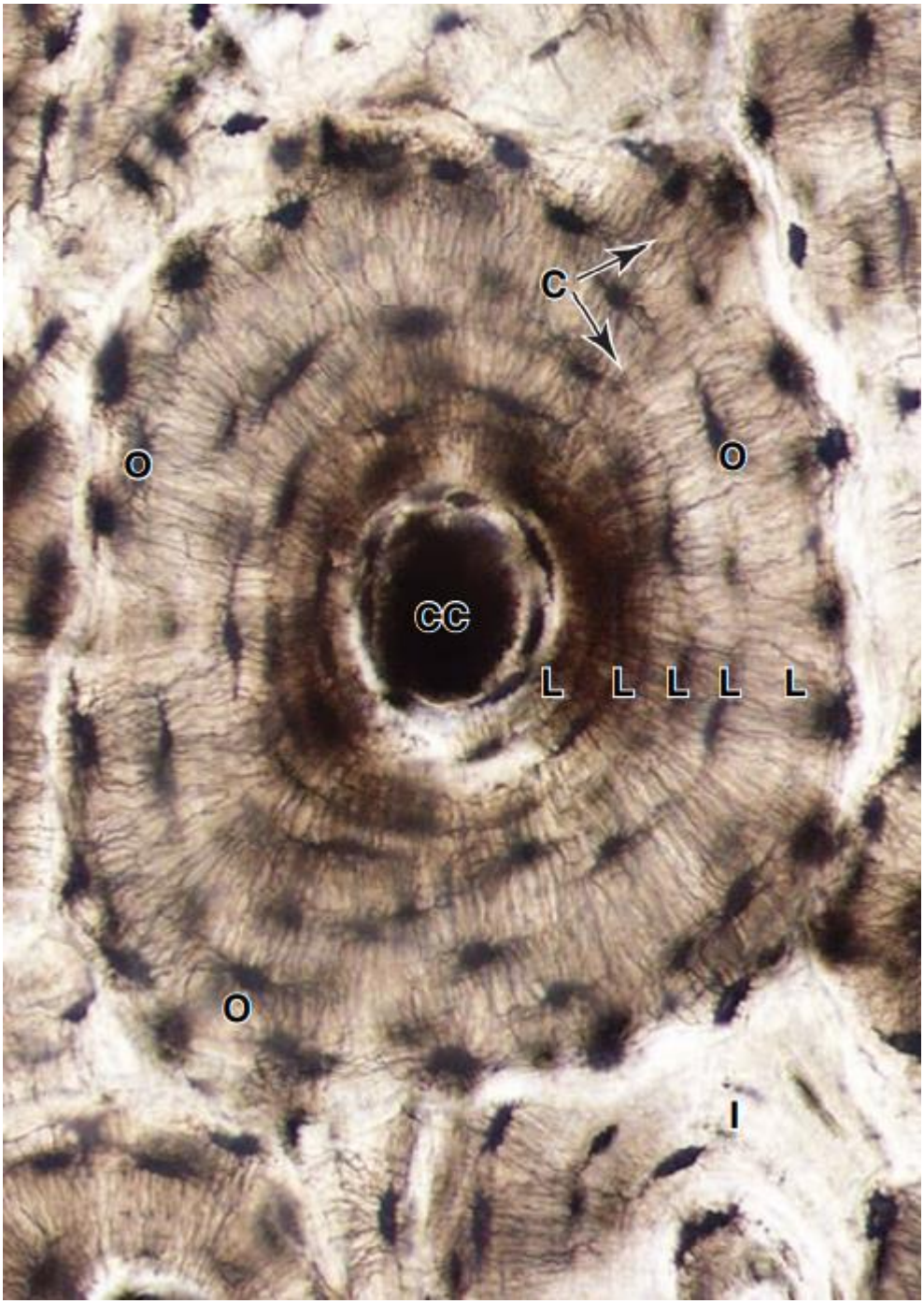

Figure-1.15: Osteons (Haversian systems) constitute most of the compact bone. Shown here is an osteon with four to five concentric lamellae (L) surrounding the central canal (CC). Osteocytes (O) in lacunae are in communication with each other and with the central canal and periphery of the osteon via through hundreds of dendritic processes located within fine canaliculi (C). Also shown are the partial, interstitial lamellae (I) of an osteon that was eroded when the intact osteon was formed. (Ground bone

1.5 HYPOTHESIS

Null hypothesis:

The developmental dysplasia of the hip cannot be diagnosed precisely by Graf method ultrasound screening in newborns.

Alternate hypothesis:

The developmental dysplasia of the hip can be diagnosed precisely by Graf method ultrasound screening in newborns.

1.6 OBJECTIVES OF STUDY:

To assess early identification of the DDH in newborns
To correlate association of Barlow's & Ortolani's tests with ultrasound
To identify the risk factors related with the occurrence of DDH
To increase awareness about the advantages of Graf method US as an early diagnostic tool to reduce the rate of complications

1.7 STATEMENT OF THE PROBLEM

Developmental dysplasia of the hip is a fundamental reason of disability in children and young adults, making it a considerable socioeconomic burden on the society. It is a preventable and treatable disorder. The use of ultrasound hip in newborns under 01 month of age should be carried out as early detection of DDH is the need of the day in order to ovoid complications and surgical interventions. This study aims to highlight the advantages of the Graf method ultrasound screening, clinical examination, and association of factors involved in every newborn to reduce the overall suffering of the patients.

1.8 SIGNIFICANCE OF STUDY

Developmental dysplasia of the hip is a frequent disorder of musculoskeletal system. If not diagnosed and treated early, it can lead to tiptoe walking on the affected side or waddling gait if both hips are affected, due to less efficient hip abductors. Over time, the patient develops lumbar lordosis resulting in pain in the hip, lower back, and ultimately knee. Therefore, it is crucial to take early preventive measures to diagnose the anomaly with the help of clinical as well as ultrasound screening of a newborn to achieve an optimum functional outcome.

In this cross-sectional study, early developmental dysplasia has been identified, alleviating the suffering, and lessening the rate of complexity associated with interventional techniques in the patients. The clinical evaluation followed by ultrasound screening is cost-effective, decreasing the financial load, which can be much higher in the future if the condition is diagnosed later in life.

CHAPTER 2 LITERATURE REVIEW

In 2021 a retrospective analysis was conducted in Italy. The purpose of the research was to analyze the efficacy of a universal ultrasound screening protocol at a university hospital as well as to investigate the level of general knowledge apprehended by paediatricians and neonatologists regarding the subject matter. Buonsenso et al (2021) enrolled babies who were born between January 2016 and April 2019 and were subjected to hip ultrasound (Graf method). The characteristics of family history of DDH, breech presentation, female gender and twin birth were evaluated as potential risk factors. Ultrasound examination was carried out on 4000 hips. Of those hip joints, 98.8% were found to be mature or immature but appropriate for age, while 1.2% hips were found to have pathology. Upon clinical examination, 2.4% of the mature hips and 97.6% of the immature hips were positive for DDH, respectively; the remaining hips were negative. Regarding ultrasound findings of hip joints which had some pathology, 33.3% of patients had positive finding on clinical examination, while 66.7% of patients had negative findings. Ultrasound pathological findings were significantly associated with history of DDH, presentation as breech at birth and female sex, as shown by study of risk factors. The findings of the survey indicated that students in medical schools receive insufficient training regarding DDH. The study recognized that a number of infants were diagnosed with DDH with universal ultrasound screening without risk factors and normal physical examination. Implementation of specified Graf method ultrasound training courses for the pediatricians and neonatologists is essential for the accuracy in diagnosing DDH (Buonsenso et al., 2021).

A nationwide surveillance program in Australia was established in 2018, and as part of it, ultrasounds were performed on a sequential series of 28,092 neonates and then classified using the Graf method ultrasound classification system. At birth, the hips of 90.2% of all babies were considered as normal. Hips with a prevalence of type IIa (8.9%) returned to normal within six weeks on average (interquartile range (IQR) of six to nine weeks). Type IIc and Type IId hips returned to normal after ten weeks for 0.67% of patients (IQR 7 to 13weeks). At baseline, there were nineteen hips classified as type lll and 8 hips classified as type lV. There was one open reduction and 24 closed reductions at this place. Within the first five years of life, there were no instances of late presentations of DDH found. A significant relationship was found between

the time of abduction and degree of developmental dysplasia until the hip turn into Graf type 1 (normal) such as wide diapering had better outcomes for children with milder forms of DDH if started earlier. For all patients with developmental dysplasia, early detection followed by abduction treatment is essential to decrease the frequency of open reductions and surgical interventions (Biedermann et al., 2018).

Another retrospective study conducted from 1998 to 2006 on Norwegian neonates in 2018, within the first three days of life, both clinical and ultrasound hip assessments were performed on all eligible infants (n = 4245). Positive results on the Barlow or Ortolani techniques, as well as sonographic dysplasia, were indications that rapid treatment was necessary. Sonographic hips that were not fully developed were monitored until they reached the normal. Hospital records were searched for information regarding treatment rates and rates throughout the pre study period from 1989 - 1997 (number of subjects= 3594), including rates for delayed diagnoses. Ninety (2.1%) infants (74 females) were given treatment, with 63 (70%) receiving it from birth, whereas only 33 (0.9%) did so in the pre- study period. There was no difference in the rate of follow-up (11%). Two cases were discovered late and cases of avascular necrosis found or other surgical procedures were performed on infants within the first year of life. Olsen et al (2018) concluded that universal ultrasound (Graf method) screening, which was carried out by a same highly proficient consultant pediatrician during the newborn period, resulted in higher treatment rate of 2.1%, compared to the 1% recorded during the pre-study period. The rate of late cases also decreased, with the exception of one having residual acetabular dysplasia. Clinical screening if done with the aid of universal ultrasound conducted by the same skilled radiologist, improved the treatment rate without affecting the number of late presentations (Olsen et al., 2018).

A retrospective study including 11,820 Swiss newborns was done in 2017. The aim of this study was to examine the effect of both independent and combined risk and protective elements on the hip maturity of neonates as measured by the Graf ultrasonography technique. Logistic regression and univariate analyses were run to see whether or not there was a correlation between risk and preventive factors and hip types which were either mature or physiologically immature. Preceding family history of DDH, female sex, breech presentation and presence of both female gender as well as increased birth weight were recognized as independent predictive risk factors. It was found that low birth weight was the only significant protective factor individually, but any combination of protective factors was not significant statistically. The

recognition of risk and protective factor combinations, such as for selected ultrasound surveys, as well as the informative value of these combinations, are restricted. Thus early universal screening utilizing the Graf method of ultrasound is recommended to identify hip immaturity and diseases and gives ideal strategy for treatment of physiological and pathologic hip types (Schams, et al., 2017).

In 2019 a retrospective case control study enrolled control group comprising of 760 Turkish babies with a mean age of 33 days. There were 377 girls and 383 boys in the group. There were 192 babies in the study, with an average age of 105 days. There were 154 girls and 38 boys. In 116 participants, only one side was affected (41 on the right and 75 on the left), while 76 had both sides affected. There were 141 babies in the stable group and 51 babies in the unstable group. The rate of DDH was higher in babies who had at least one risk factor than in babies who had none ($p < 0.001$). Also, the occurrence of DDH was elevated in babies with more than one risk factors as compared to babies with single risk factor ($p = 0.008$). Babies who had a family history of DDH, were born with breech presentation, or were swaddled had an enhanced rate of DDH than babies without such history. When comparing the study groups, the unstable/decentered group had higher rates of previous family history, oligohydramnios and swaddling than stable group. This showed that the risk of development of DDH increases predominantly with previous family history, traditional swaddling, breech presentation and oligohydramnios leading to the development of consequential hip dysplasia ultrasonographically (Graf type D, III, IV hips) and infants with above described four risk factors should be regarded as “absolute risk factor” to selective infant ultrasound screening of hip programs (Ömeroğlu et al., 2019).

In United Kingdom a retrospective cohort study was done in 2018. The purpose of the study was to ascertain whether universal ultrasound screening for DDH reduces the number of delayed presentations by analyzing data from 28,068 newborns. Within the group that was subjected to universal screening, there were a total of five occurrences of delayed presentation (0.5 per 1000 newborns). These cases were missed by administrative errors in which appointments were either not given or not followed (in none of these cases ultrasonography missed significant pathology). Two of the five infants who were scheduled to have a newborn scan did not show up. At 4 months of age, they were both taken to the clinic after clinical examination revealed that both had a dislocated hip. The harness method was used successfully

on one, but closed reduction and spica casting were necessary for the other. In three cases, ultrasound on newborns revealed diaphragmatic hernia (DDH), but the infants weren't evaluated by the surgical department for more than 90 days due of documentation mishaps. Two of the three were seen at the clinic at 4 months of age, and were effectively managed in a harness (the other needed a pelvic osteotomy when 4-year-old for remaining dysplasia). The hips of the third baby, who was 5 months old when diagnosed, had to be treated with closed reduction because of the severity of the deformity. She then became severely afflicted with avascular necrosis and was subsequently lost to follow-up. Five delayed presentation cases were found in the cohort that underwent selective screening (0.28 per 1000 live births). One was found to have limited abduction (dysplasia) at 5 months of age and responded well to harness treatment. Adductor tenotomy, closure reduction, and hip spica casting were performed on two decentered hips at 6 and 13 months. Two 19- & 20-month-old toddlers with dislocations needed surgical treatment and pelvic osteotomy was carried out. Universal screening showed improved ratio of treatment (0.79 vs. 0.23 percent, $P< 0.01$) with conservative methods. Less number of babies who were part of the universal cohort required invasive surgery [n=9 (12%) vs. N=11 (26%)]. Only two patients among the nine patients who required surgery in the universal cohort received open reduction and/or pelvic osteotomy, as compared to five of the eleven patients who were in the selective screening group. The study concluded that universal ultrasound screening did not change the rate of late presentations after age of 3 months and remarkably amplified treatment rate for DDH. However, age at presentation was markedly reduced by universal screening and decreased the incidence of surgical procedures (Westacott et al., 2018). A study by Shirai et al (2018) focused on Japanese children. The goal of this study was to find out if ultrasonographic hip images could be taken and evaluated in the same way after the examiners took an ultrasound training of infant hip. The Graf method ultrasonography approach was utilized to analyze ultrasonographic images of 70 hips that were taken from 35 neonates. Two unskilled examiners who had taken the training course captured these images. On the basis of the collected images, measurement errors between the examiners and their reliability were estimated. The intra-examiner measurement error in images of the same hip was minimal. The measurement error of inter-examiner was also less. The identification of the Graf classification were elevated between intra- and inter-evaluators. The intra-examiner reproducibility of the acquired ultrasonographic images was significant, whereas the inter-examiner reproducibility was nearly flawless. The study concluded that untrained ultrasonographers might derive child

ultrasonographic images of hip joint with slight variations and higher reproducibility after attending the training program. The study results increase the possibility of expanding the infant hip ultrasound training program and precision of the ultrasound Graf method is dependant on the proficiency and skills of the ultrasonographer (Shirai et al., 2018).

An Epidemiological Nationwide Study in 2021 was carried out in Italy. Based on hospitalization reports, the goal of this study was to figure out how many Italian patients were admitted to the hospital each year for DDH from 2001 to 2016. Longo et al (2012) revealed that 2.33% cases out of 100,000 of young patients being admitted to hospitals in Italy due to DDH represent the country's annual incidence rate (from 2001 to 2016). DDH requires prompt diagnosis and therapy, however, there is currently no international consensus on screening technique or treatment options that can be found in the relevant published research. Epidemiological studies are beneficial for understanding the countrywide variation of a certain surgical treatment and comparing those results with those from other nations. Researchers from a variety of nations could contribute to the development of international screening and treatment standards for DDH by providing relevant data (Longo et al., 2021).

In 2022, Hareendranathan et al developed a study in Canada to recognize the consequence of quality of ultrasound scan on artificial intelligence (AI) assessment in hip dysplasia. They devised a 10-point scoring system for reporting the quality of ultrasound scans in cases of DDH, analyzed the system's inter-rater agreement, and investigated the system's effect on automated evaluation by an artificial intelligence system called MEDO-Hip. The evaluation was graded depending on the straightness and angulation of the iliac wings, as well as the observability of the labrum, head of femur and os ischium. The 10-point scale had much higher inter-rater agreement than holistic scoring (ICC 0.68 vs 0.93). According to Cohen's kappa, the level of inter-rater agreement on the categorization of independent features was highest for the os ischium (0.670.06), head of femur (0.650.07), and ilium (0.490.12) indices, while it was lowest for the presence of labrum (0.210.19). MEDO Hip evaluated all of the images with a quality of 7 or higher, however it flagged 13/107 of the images as being uninterpretable. These photos were of poor quality (31.2 versus 71.8 in others, $p<.05$), with reduced visualization of the os ischium and apparent motion. Other images had better quality. AI accuracy was 57 percent in cases where the quality score was less than 7, compared to 89 percent in other circumstances ($p<.01$). The results of the study demonstrate that rating method accurately portrays the quality of the scans and identifies instances that are likely to be misinterpreted by AI, leading to a more

precise application of AI in the identification of DDH by determining ultrasound scan of poor quality with a possibility to make an inaccurate diagnosis right away (Hareendranathan et al., 2022).

A multicenter prospective international narrative review was established by Schaeffer & Mulpuri (2018) which revealed that there was a dearth of evidence that was of sufficient quality to serve as a basis for clinical guidelines in identifying, treat, and manage DDH. The relevant information was scarce due to the continuing misunderstanding on diagnostic and categorization terms, variation in establishing diagnosis by physicians, dependence on retrospective research, single center and small sample size. There was not enough evidence to recommend routine ultrasound screening for all infants; instead, view was that screening should begin between 6 and 8 weeks of age for those who have risk factors such as a previous history of DDH in the family and breech presentation. Babies who had any of the above-mentioned factors and a normal first ultrasound should have been followed for a minimum of another six months (Schaeffer & Mulpuri, 2018).

A prospective cohort study was established in Denmark. Initiative of the study was to define the correlation between DDH and various causes for referral to pediatric, orthopedic and radiological examination, as well as to identify the prevalence of DDH and hip dislocation among babies. Enrolled participants of the research were from 2013 to 2019. The infants between the ages of 0-6 months were referred for a comprehensive assessment of hip. Incidence of unstable cases of hip and DDH was determined based on the reasons for referral. Diagnosis of DDH was established when acetabular index was greater than 30◦ on radiographs or when the Graf Type IIb or worse on ultrasonography. 17% of the 1,989 involved Danes newborns studied had dysplastic hips which were stable, whereas 4.7% newborns had dysplastic hips which were unstable. The percentages of cases with DDH were 36% for those who were breech, 25% were those who had previous history of DDH in the family, 14% presented with hip click, 8% had asymmetry, 3% for twins while 1% for asymmetry within infants who were referred for a single indication. The findings showed that a significant number of children submitted for a combined assessment had radiographic evidence of DDH, and that DDH was frequently detected in newborns referred for hip click or asymmetry (Norlén & Faergemann, 2022).

Point-of-care Ultrasound (POCUS), relates to the use of ultrasound by educated medical personnel to diagnose issues wherever one patient is treated, either in a modern hospital, an ambulance, or a rural community. In the year 2021, research established by Herrero et al, on

American children to see if there was a difference in the length of time & cost for patients with DDH spent in the office when POCUS was used instead of standard "formal" sonography. The POCUS group had a 42-minute encounter (range 16–75 minutes), while the "official" US group had a 92-minute encounter (range 36–163 minutes). Thus the difference seen was significant statistically. Average cost of the visit was $121.13 for the POCUS group and $339.38 for the "formal" US group (Herrero et al., 2021).

Treiber et al (2021) evaluated 21,676 infants born between 2006 and 2015 in Slovenia. Ultrasound of hip was carried out during first week of life in all hips. Graf approach was used to examine the occurrence of sonographic hip-types, which were subsequently followed prospectively. The number of initial surgeries before the age of three years, as well as DDH risk factors and therapeutic strategies, were also noted. At the time of the initial examination, mature (Graf types Ia, Ib) hips were 92.5%, physiologically immature (Graf type IIa) were 7.2%, whereas hips showing pathology (Graf types IIc to IV) were 0.3%. In 118 neonates, 146 abnormal hips were discovered (0.6%). Only 0.26% of the people who were screened received an orthosis. Surgical procedures was done only in 0.23 per 1000 live births, while the occurrence of delayed diagnosed DDH was 0.09. In terms of risk variables, neonates with pathological hips had either a breech presentation, a positive family history, high birth weight, and a female gender (Treiber et al., 2021).

In Hungary, a prospective study was done in 2021 to determine the efficacy of early universal ultrasonographic screening for DDH. From 2012 to 2013, all mature neonates were studied. Clinical examination and hip ultrasound by the Graf method was done in 1636 newborns (3272 hips) within first 3 days of life. Sensitivity as well as specificity of Barlow and Ortolani's tests were assessed along with prevalence of DDH and associated risk factors. First ultrasound showed that out of 3272 hips examined, 70 (2.14%) were found to be positive for DDH. The following distribution was observed using Graf categories: Type II C had 21 hips, type D had 24 hips, type III had 24 hips, and type IV had one hip. A positive family history, female gender and breech presentation were found as important risk factors. The sensitivity and specificity of the physical examination were calculated to be 98.34%. 28 (50.90%) of the 55 babies with developmental dysplasia lacked any positive physical indicators or risk factors other than being female. Thus, early universal ultrasound screening of hip made it possible to detect each and every occurrence of hip dysplasia. In orthopaedics, ultrasound of hip joint is an efficient method

of prevention; nevertheless, additional research is required to assess frequency of surgical interventions in selective and universal models of screening (Gyurkovits et al., 2021).

Castaneda et al (2021) carried out a study and looked at the hospital records of 9,299 children who had been diagnosed with hip dysplasia (DDH) and identified their age at the time of presentation at the hospital. It was a continuous series of patients who presented from 1998 to 2019. According to the records, 8011 females (86.15%) and 1288 males (13.85%) had the same diagnosis of DDH. In 4588 cases (49.34%), left hip was affected, whereas the right hip was involved in 1824 cases (19.62%). 2887 cases had bilateral occurrences (31.05%). The average age at the time of presentation was 2.36 years across the 21-year period (ranging from 0.1-17 year). In 1998, average age was 2.49 years (ranging from 0.1-16 year). An exclusive ultrasound-screening center was established in 2006. In 2019, the average age fell to 1.70 (Range, 0.1 to 14 year). From 1998 to 2005, the average presentation age declined significantly, from 2.65 years to 2.19 years (P=0.0067) (Roof et al., 2021).

In Korea a meta-analysis of five studies was conducted in 2020. The included quality assessment of studies carried out in a fixed-effects model with no differences among studies. The meta-analysis of these studies revealed a significant difference in late-diagnosed DDH between newborns checked (n=29,070) and those screened using selective hip ultrasonography screening. Results from sensitivity analysis showed that individual studies had little effect on the overall findings. The included studies did not exhibit any discernible asymmetry in their funnel plots. Jung & Jang (2020) concluded that ultrasound is recognized as a dependable tool for early identification of the developmental dysplasia of the hip. Neonatal ultrasound hip screening protocol has been implemented in many countries for prompt diagnosis of DDH since it is a cost-effective and non-invasive method that can recognize deformities when the hip joint is still cartilaginous much earlier as compared to radiography. Decreased frequency of surgical treatment for DDH has been reported after enforcement of universal ultrasonography screening (Jung & Jang, 2020).

OPERATIONAL DEFINITIONS

Developmental dysplasia of the hip (DDH): is a term that includes a wide spectrum of pathology ranging from mild acetabular dysplasia with or without instability to a complete dislocation at birth which may or may not be reducible (Biedermann and Eastwood, 2018).

Graf method ultrasound: The ultrasound assessment of the hip according to Graf quantifies the maturity of the cartilaginous and bony acetabular roof and the position of the femoral head based on sonographic structures (Schams et al., 2017).

Barlow maneuver: provocative maneuver attempted to identify a dislocated hip by adduction of the flexed hip with gentle posterior force (Sulaiman et al., 2011).

Ortolani maneuver: attempt to relocate a dislocated hip by the abduction of the flexed hip with gentle anterior force (Sulaiman et al., 2011).

Premature birth: Infants who are born before 34 weeks of gestation (Orak et al., 2015).

Dysplasia: includes hips that are unstable, subluxated, or dislocated (Schmitz et al., 2020).

Unstable: is the inability of the hip to resist an externally applied force without developing a subluxation or dislocation (Zimmerer et al., 2021).

Subluxation: is an incomplete dislocation with some residual contact between the femoral head and acetabulum (Tani et el., 2021).

Dislocation: complete displacement of the femoral head from the acetabulum (Heckmann et al., 2021).

Acetabular dysplasia: an abnormally shallow hip socket that leads to uncovering of the femoral head and excessive pressure on the rim of the hip socket (Shapira et al., 2021).

Laxity: When the ligaments around a joint become loose, torn, or weak, they may not be able to hold the bones in place. This is when dislocation or misalignment of the joint (subluxation) can happen (Sacks et al., 2019).

Waddling gait: Waddle is to walk with short steps, tilting the body from side to side. In order to maintain the balance, the patients compensatory bend their upper body to the side of the stance leg (Shapira et al., 2021).

Limping: to walk lamely, as if favoring one leg (Shapira et al., 2021)

Lumbar lordosis: This condition is due to an exaggerated lumbar curvature. In common jargon, this is known as "swayback," where the lower back will be abnormally curved instead of the upper back (Berven et al., 2018).

Breech presentation: a fetus in a longitudinal lie with the buttocks or feet closest to the cervix (Schlaeger et al., 2018).

Oligohydramnios: a condition in which the amniotic fluid measures lower than expected for a baby's gestational age (Miremberg et al., 2020).

Polyhydramnios: when there is excess amniotic fluid in the uterus (Ahmad et al., 2021).

Swaddling: Babies are traditionally wrapped in soft, light sheets to help them fall asleep and stay that way. Swaddling is a common technique. To minimize the risk of asphyxia, they should only have their bodies wrapped, not their necks or heads. (Vaidya et al., 2020).

Newborn: Baby in the first 4 weeks of extrauterine life (Kacirova, Grundmann & Brozmanova, 2021).

Infant: infant period is the period from 1st day of life to one year (Carter, 2018).

Preterm: Babies born alive before 37 weeks of pregnancy (Fettweis et al., 2019).

Post term: A pregnancy that lasts longer than 42 weeks (294 days) from the first day of the last menstrual period (Fettweis et al., 2019).

Frog Leg Posture: A type of resting position for babies in which hips are bent and legs are pulled away from the body to the point where the outside of the thigh rests on the supporting surface (Banerjee et al., 2019).

Mature hip: Refers to the morphologically normal hip (Atalar et al., 2021).

Physiological Immature hip: Morphologically not normal but stable hips (Patrikov et al., 2022).

Pathological immature: Morphologically unstable but not completely dislocated hip (Zomar et al., 2021).

Pathological hip: dislocated hip or completely unstable hip (Onay et al., 2019).

Frejka's Pillow: The Frejka cushion, used in children who have "luxated" hips and is put over the diaper (Zídka, 2019).

Pavlik Harness: a brace used for babies with a hip disorder or femur fracture. The harness has chest, shoulder, and leg straps to keep the legs bent and turned outward (Zídka, 2019).

Harcke's Method: In order to check femoral head coverage, a dynamic ultrasonography evaluates the stability of the hip by measuring the movement of the acetabulum (Bowen & Kotzias-Neto, 2006).

Galeazzi Sign: It is elicited by placing the child supine with both hips and knees flexed. An inequality in the height of the knees is a positive Galeazzi sign (Touzopoulos, 2020).

CHAPTER 3 METHODOLOGY

3.1 STUDY DESIGN

The research design was an analytical cross-sectional study of the observational type. This was a human study conducted over a six-month period between January-June 2022. After obtaining FRC (Annexure-A) and ethical review from ethical review committee (Annexure-B) of Bahria University Health Sciences (BUHS), National Institute of Child Health (NICH), Fazaia Ruth Pfau Medical College (FRPMC), Zubaida Medical Center, and Bantava Anis Hospitals in Karachi

3.2 SUBJECTS

Healthy male & female newborns under 28 days of age after obtaining informed consent (Annexure-C) from the parents.

3.3 SETTING

The Radiology Department of National Institute of Child Health (NICH), Fazaia Ruth Pfau Medical College (FRPMC), Zubaida Medical Center, and Bantava Anis Hospitals in Karachi, Sindh, Pakistan.

3.4 INCLUSION CRITERIA

-Healthy male & female newborns under 28 days of age

-Newborns referred from OPD, admitted and delivered in the National Institute of Child Health (NICH), Fazaia Ruth Pfau Medical College (FRPMC) Zubaida Medical Center, and Bantava Anis Hospitals.

3.5 EXCLUSION CRITERIA

-Newbornss more than one month of age

-Sick newborns

3.6 DURATION OF STUDY

Total period of study: six-month period between January-June 2022

Individual study period: Approximately 2 hours (for maternal history and clinical & ultrasound examination of baby).

3.7 SAMPLE SIZE

115

Sample Size Calculation:

Sample size was calculated according to the reference given bellow.

(Treiber et al., 2021).

Sample Size for Frequency in a Population

Population size (for finite population correction factor or fpc) (*N*):	1000000
Hypothesized % frequency of outcome factor in the population (*p*):	2.7%+/-3
Confidence limits as % of 100(absolute +/- %) (*d*):	3%
Design effect (for cluster surveys-*DEFF*):	1

Sample Size(*n*) for Various Confidence Levels

Confidence Level (%)	Sample Size
95%	**113**
80%	48
90%	79
97%	138
99%	194
99.9%	316

99.99%	442

Equation

Sample size $n = [DEFF*Np(1-p)]/ [(d^2/Z^2_{1-\alpha/2}*(N-1)+p*(1-p)]$

3.8 SAMPLING TECHNIQUE:

Non-probability convenient technique was used.

3.9 HUMAN SUBJECTS AND CONSENT

All of the participants' parents gave their permission to enroll in the study and signed an informed consent form.

The consent forms were prepared in both languages, namely English (Annexure-C) and Urdu (Annexures-C), and both languages' versions contained all the information relevant to the study.

3. 10 MATERIALS:

Informed Consent Form

Subject Evaluation Proforma (Annexure-D)

Ultrasound Hip Report (Annexures-E) by Graf Method for:

Alpha & Beta angles of hip joint

Position of the femoral head

Proforma having Graf Method Ultrasound Classification System (Fig 3.1) used to calculate the angles of hip joint

Ultrasound Hip Graf Method Images

Equipment: Toshiba Aplio 300, High Frequency Linear Probe 7.5 MHz (Figure-3.2)

3.11 PARAMETERS OF STUDY

Demographic Parameters:

Age (in days)

Gender

Length (in cm)

Weight (in Kg)

Ethnicity

Clinical Parameters:

Gestational age (in weeks)

Mode of delivery

Family history of DDH

Medical obstetric history

Co-existing anomalies

Difference in leg lengths (Galeazzi sign)

Asymmetry of thigh folds

Barlow's test

Ortolani's test

Ultrasonographic Parameters:

Alpha angle of hip joint on ultrasound on US

Beta angles of hip joint on US

3.12 PROTOCOL / PROCEDURE OF STUDY

Subjects meeting the inclusion criteria were enrolled after acquiring ethical approval from ethical review committee of the respective hospitals. Informed consent was obtained from the parents of all participants. A detailed history was taken from parents. The weight and length of newborn were recorded. Then inspection of both legs was carried out. After inspection of both legs for length and thigh folds, a clinical examination for Barlow and Ortolani's maneuver was performed (Fig 3.3 A & B). It was followed by Graf method ultrasound of both hip joints on all neonates referred from OPD, as well as admitted and delivered in the National Institute of Child Health (NICH), Fazaia Ruth Pfau Medical College (FRPMC), Zubaida Medical Center, and Bantava Anis Hospitals. Both clinical and ultrasonographic examinations were performed by the investigator and counter-checked by the consultant neonatologists and radiologists.

Information regarding family history, presentation of the baby at birth, birth weight, duration of gestation, presence of oligo/ polyhydramnios during gestation, mode of delivery, parity, gender, ethnic background, co-existing musculoskeletal deformities, lower-limb malformations, and multiple pregnancies were recorded in the subject evaluation proforma.

Barlow's and Ortolani maneuver were performed by the principal investigator and counter-checked by the consultant neonatologist or trained examiners (Fig 3.3 A). Barlow provocative maneuver identifies a dislocated hip by adducting the flexed hip while applying slight posterior pressure (Fig 3.3 B) (Geswell et al., 2021). Ortolani's maneuver relocates a dislocated hip by abducting flexed hip while applying slight anterior push (Figure-3.3 B) (Geswell et al., 2021).

3.13 EQUIPMENT

Toshiba Aplio 300, High Frequency Linear Probe 7.5 MHz was used. (Figure-3.2)

3.14 POSITIONING OF THE BABY

Ultrasound examination was done in coronal view. The baby was placed either in the lateral decubitus or supine position and knees were flexed at 90º. Transducer was placed parallel and lateral to the hip (Figure- 3.4). The image showed femoral head centered in joint space (Figure-3.5). Ilium appeared as a straight line perpendicular to the femoral head and parallel to the transducer (Figure- 3.5).

3.15 IMAGING PLANE

The iliac bone was drawn in a straight horizontal line in order to create a standard image for taking measurements (Figure-3.5). Important anatomical landmarks were identified, such as, bony acetabular roof, labrum, iliac bone, triradiate cartilage and head of femur (Figure- 3.5). Reporting was done in ultrasound reporting room (Figure-3.6).

3.16 MEASUREMENTS

The type of hip joint was estimated according to the Graf method by looking at alpha and beta angles and analyzing the hip type and was classified accordingly (Figure- 3.1), (Çekiç et all., 2015; Shirai et al., 2018).

The images showing Graf type IIa+ (fig-3.7), Graf type IIa- (figure-3.8), Graf type IIc (fig-3.9), Graf type D (fig-3.10), Graf type III (fig-3.11) and Graf type IV (fig-3.12) have been displayed in subsequent pages.

Graf Method Ultrasound Classification System

Graf classification	Alpha angle (bone roof)	Beta angle –Age (cartilaginous roof)	Explanation
Type 1a	$\alpha > 60^\circ$	$\beta < 55^\circ$	Normal hip
Type 2a (+)	$\alpha = 55^\circ$-60°	$\beta > 55^\circ$ < 3 month	Physiological immature hip
Type 2a (-)	$\alpha = 50^\circ$-55°	$\beta > 55^\circ$ < 3 month	Pathological immature hip
Type 2b	$\alpha = 50^\circ$-60°	$\beta > 55^\circ$ > 3 month	Centered hip - stable
Type 2c	$\alpha = 43^\circ$-49°	$\beta < 77^\circ$	Centered hip - unstable
Type D	$\alpha = 43^\circ$-49°	$\beta > 77^\circ$	Decentered hip
Type 3	$\alpha < 43^\circ$	$\beta > 77^\circ$	Eccentered hip
Type 4	$\alpha < 43^\circ$	$\beta > 77^\circ$	Dislocated hip

Figure- 3.1: Graf Method Ultrasound Classification System, for calculation of alpha and beta angles of the hip joint (Çekiç et all., 2015).

Figure-3.2 Toshiba Aplio 300, High Frequency Linear Probe 7.5 MHz Ultrasound Machine used in radiology department of National Institute of Child Health (NICH) Karachi.

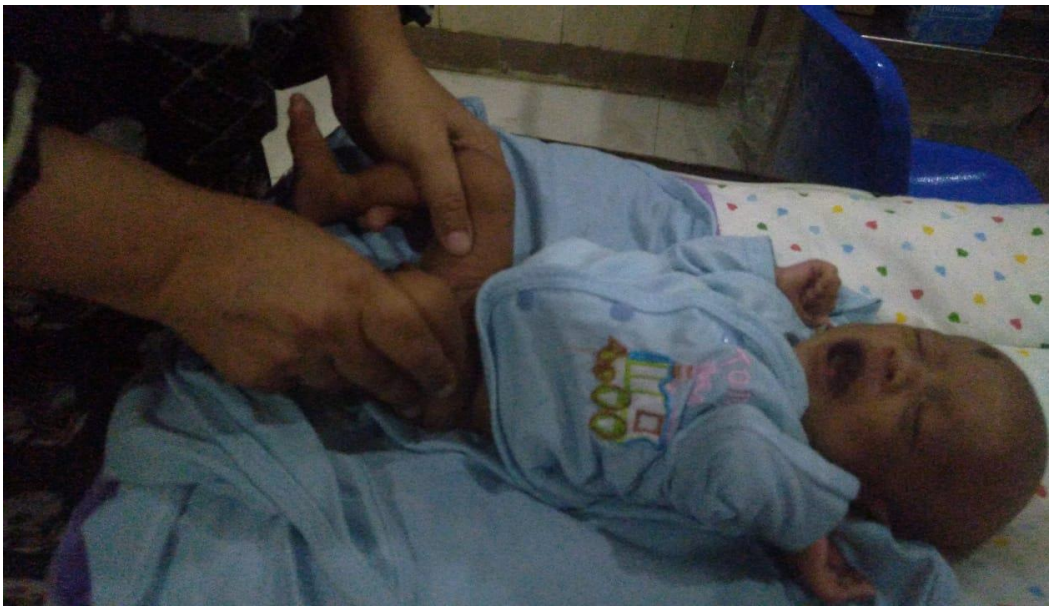

Figure-3.3 A: Barlow and Ortolani tests showed in the above photograph of current study.

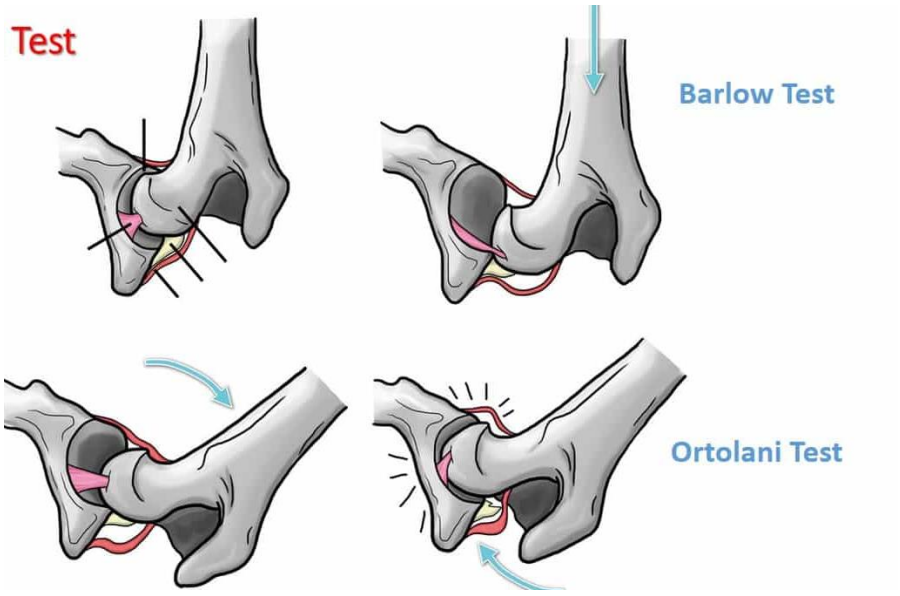

Figure-3.3 B: Barlow and Ortolani tests showed in the above diagram

https://orthofixar.com/wp-content/uploads/Ortolani-Test-1.jpg

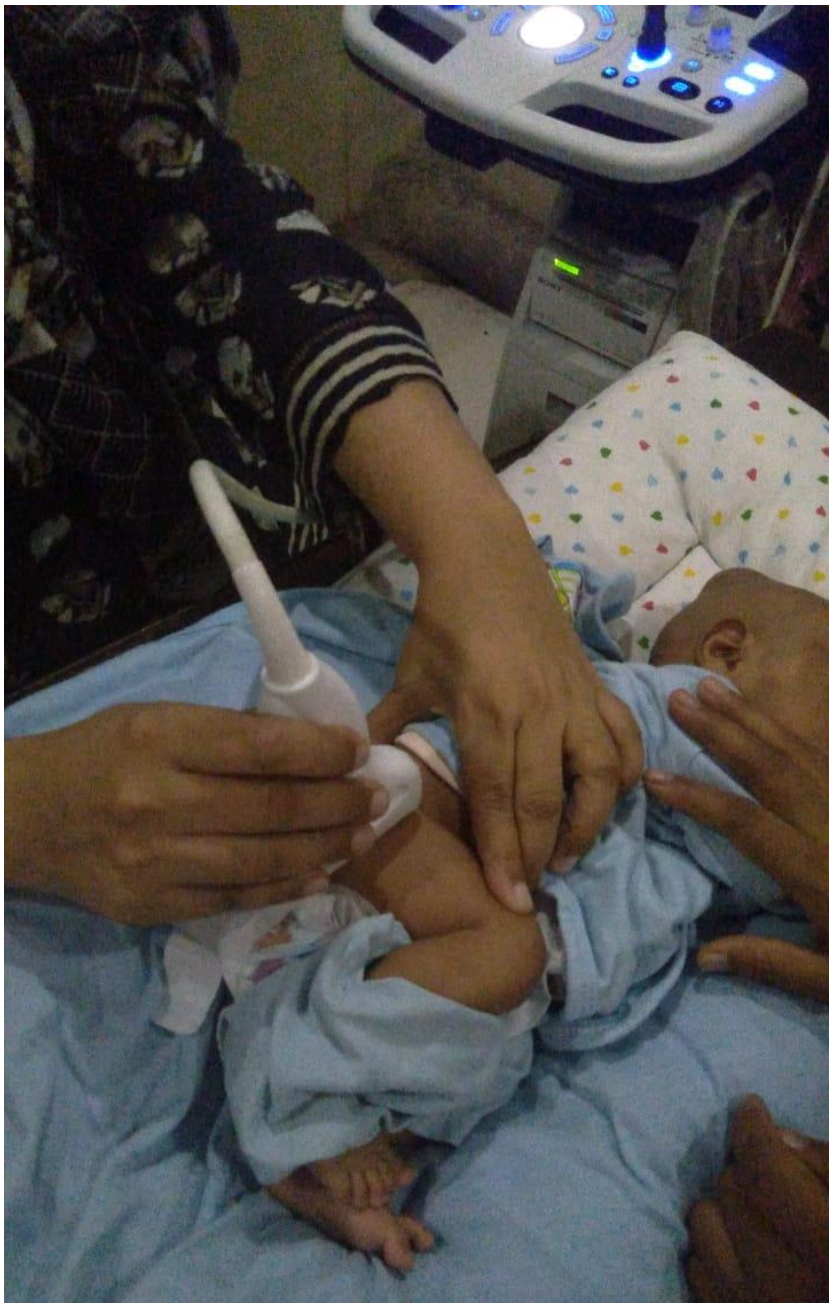

Figure-3.4: Current study examination showing lateral decubitus position of the newborn while ultrasound examination is being done with knees flexed at 90º.

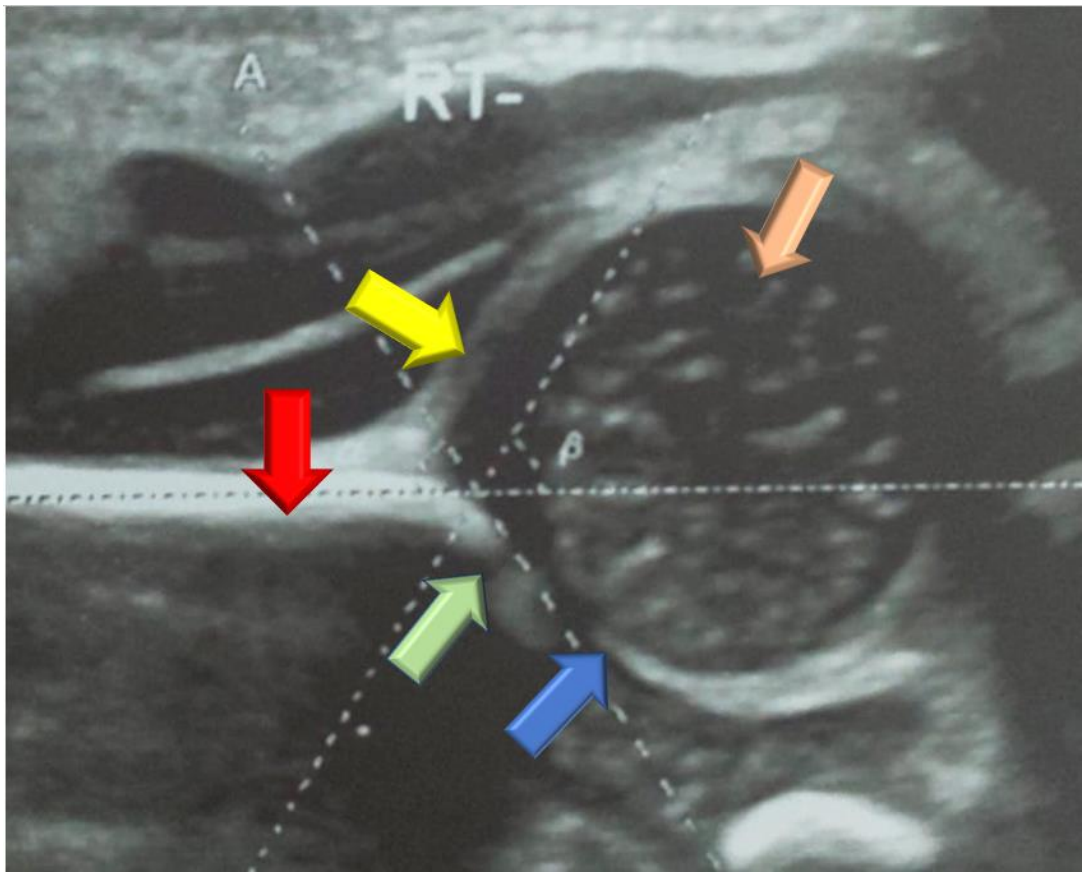

Figure-3.5: An ultrasound image from the current study indicating anatomical landmarks with arrows of different colors. Light green arrow-Bony acetabular roof, Yellow-labrum, Red arrow-Iliac bone, Blue arrow-Triradiate cartilage & Orange arrow-Head of femur.

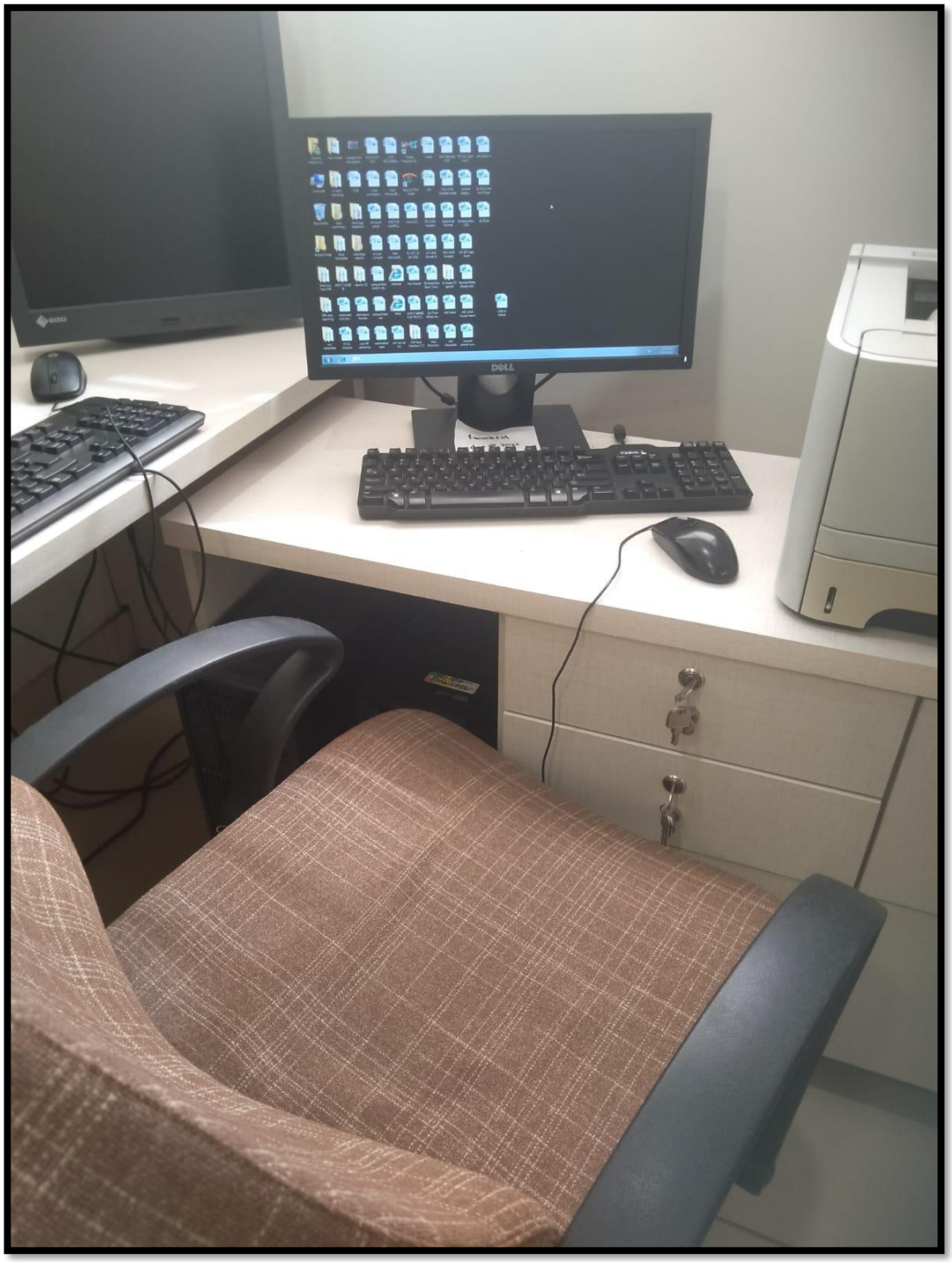

Figure-3.6: Ultrasound Reporting Room

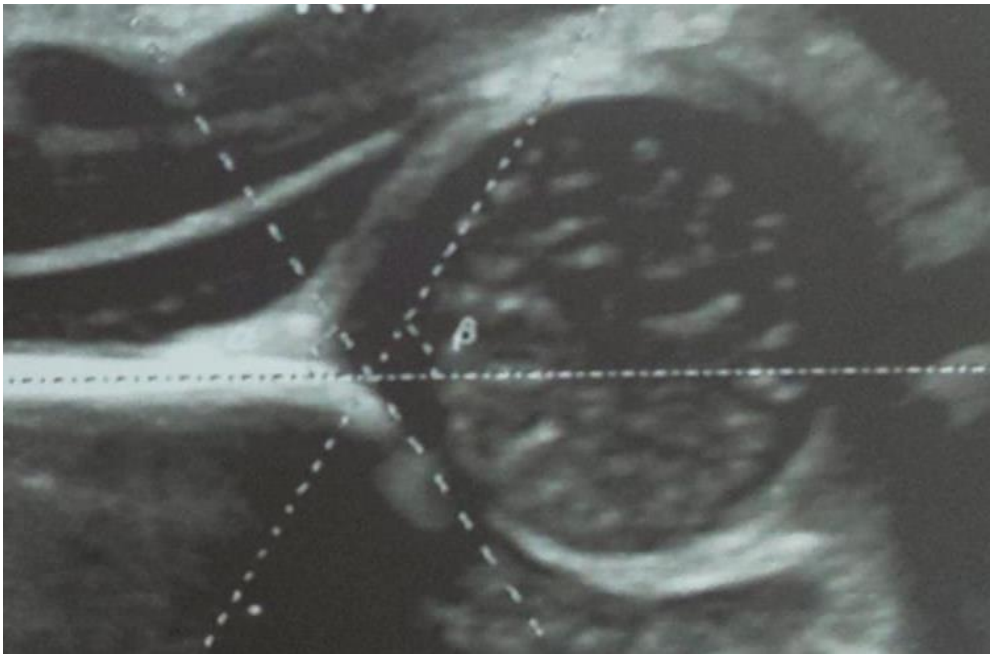

Figure-3.7: An ultrasound image of current study showing a 14 day-old-boy with Graf Type- IIa+ with alpha angle 50 & beta angle 66 (Physiological Immature Hip).

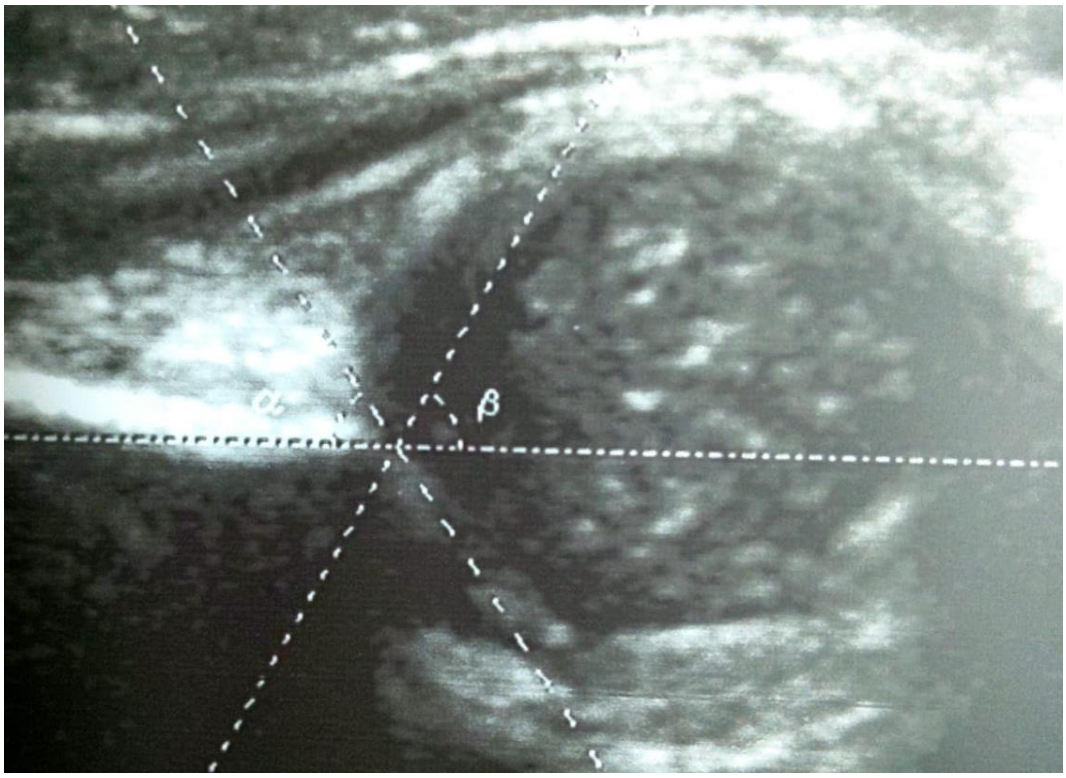

Figure:3.8 An ultrasound image from the current of a 10 day-old-boy showing Graf type lla- hip with alpha angle 50 and beta angle 65 (Pathological Immature Hip).

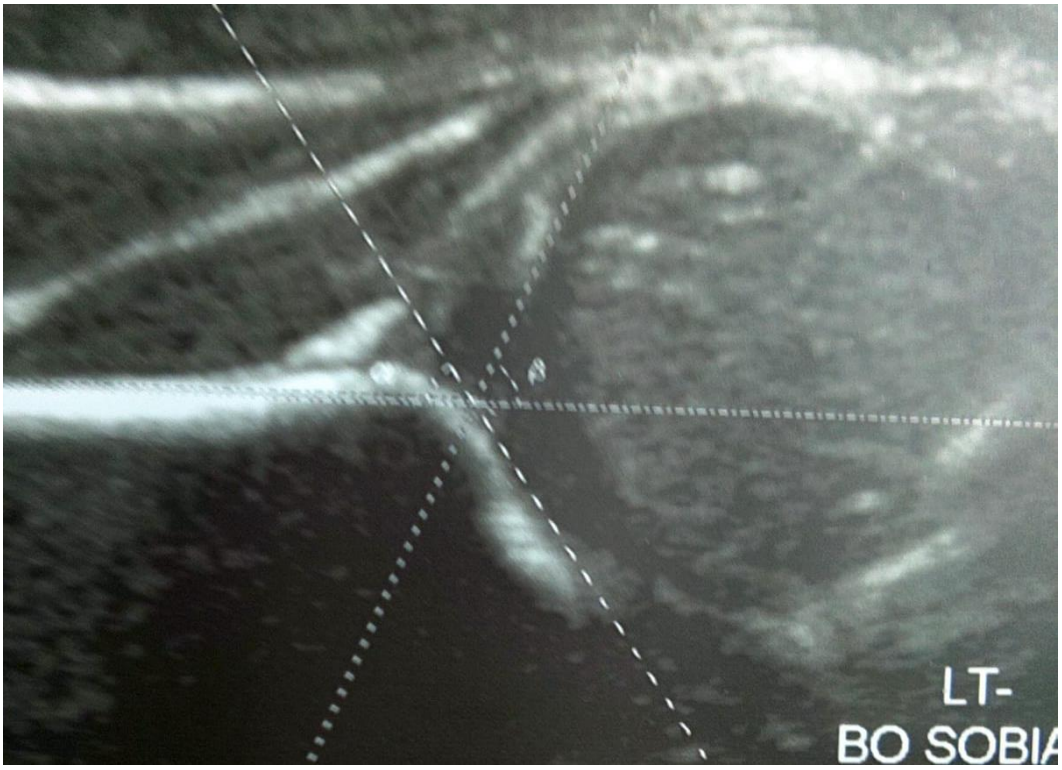

Figure-3.9: An ultrasound image from the current study of a 13 day-old-boy showing Graf type IIc hip with alpha angle 46 and beta angle 64 (centered hip-unstable).

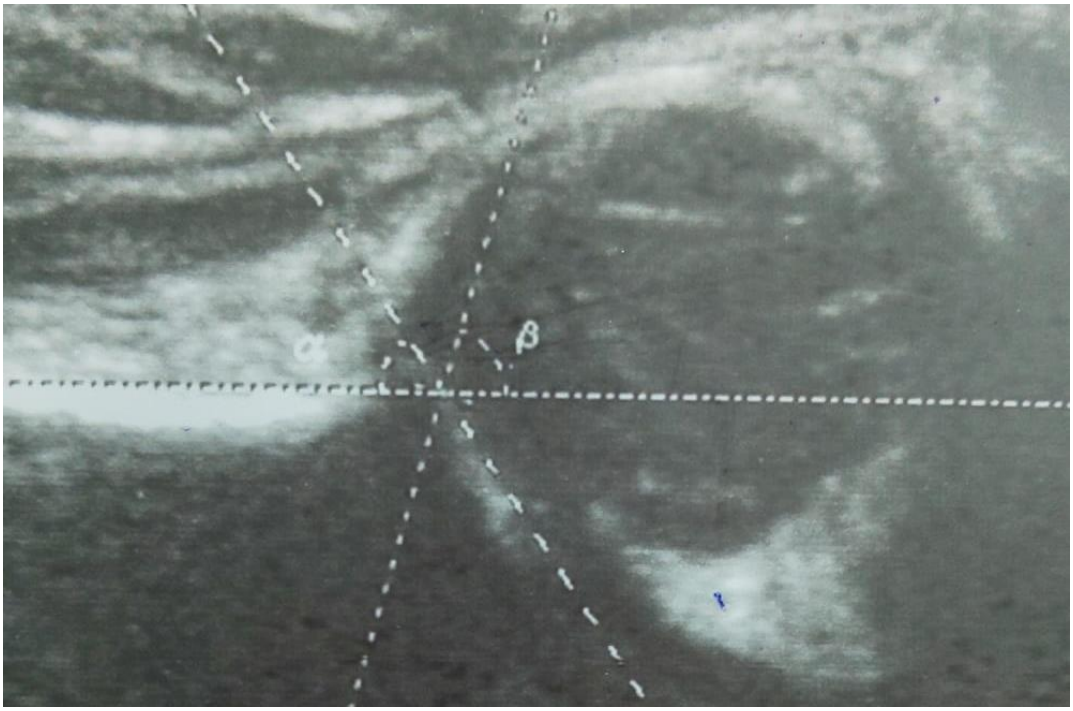

Figure-3.10: Ultrasound image of a 15 day-old-girl with Graf type-D Hip, showing alpha angle 43 & beta angle 76 (Decentered Hip).

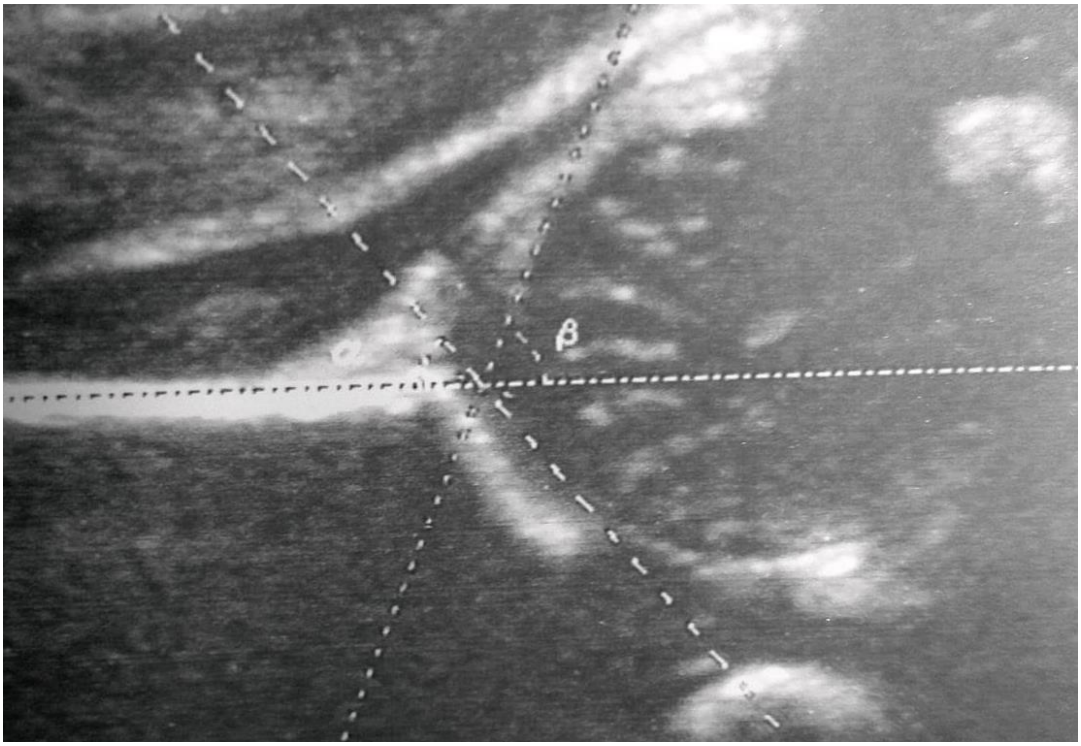

Figure-3.11: An ultrasound image of current study showing 8 day-old-boy with Graf Type-III Alpha 44 & Beta 81 (Eccentric Hip).

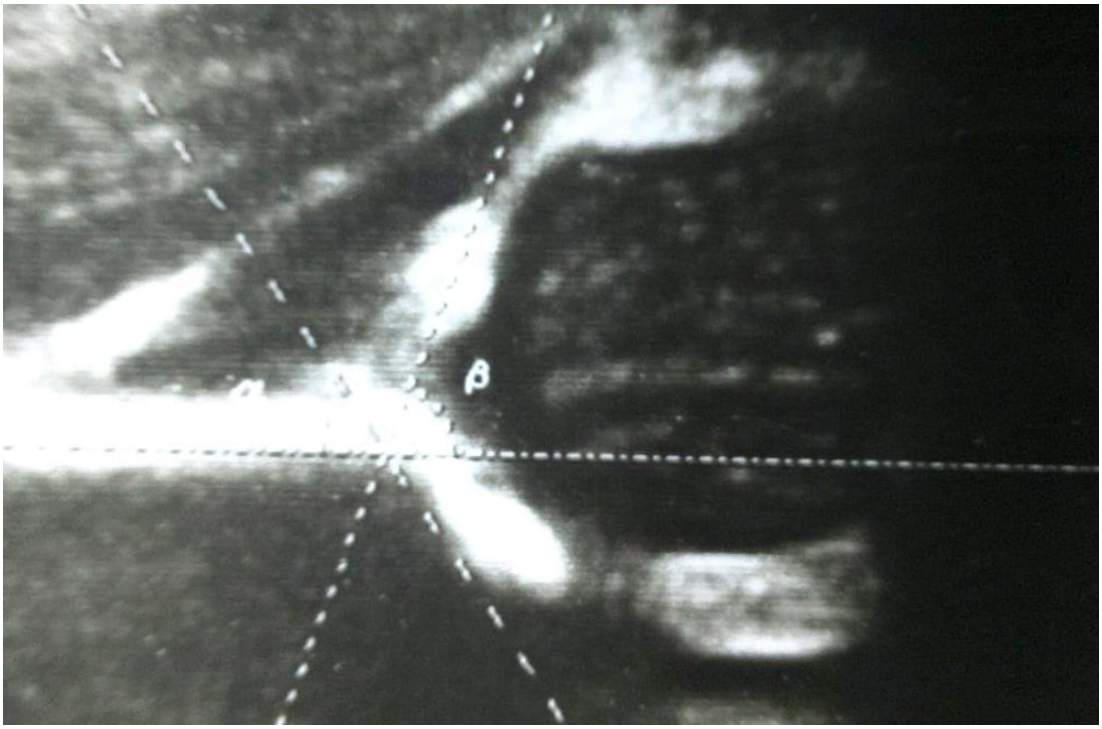

Figure-3.12: An ultrasound image of current study showing a 16 day-old-boy with Graf Type-IV with Alpha-40 & beta 88 (Dislocated Hip-Interrupted Labrum).

3.17 FLOW CHART / ALGORITHM OF STUDY:

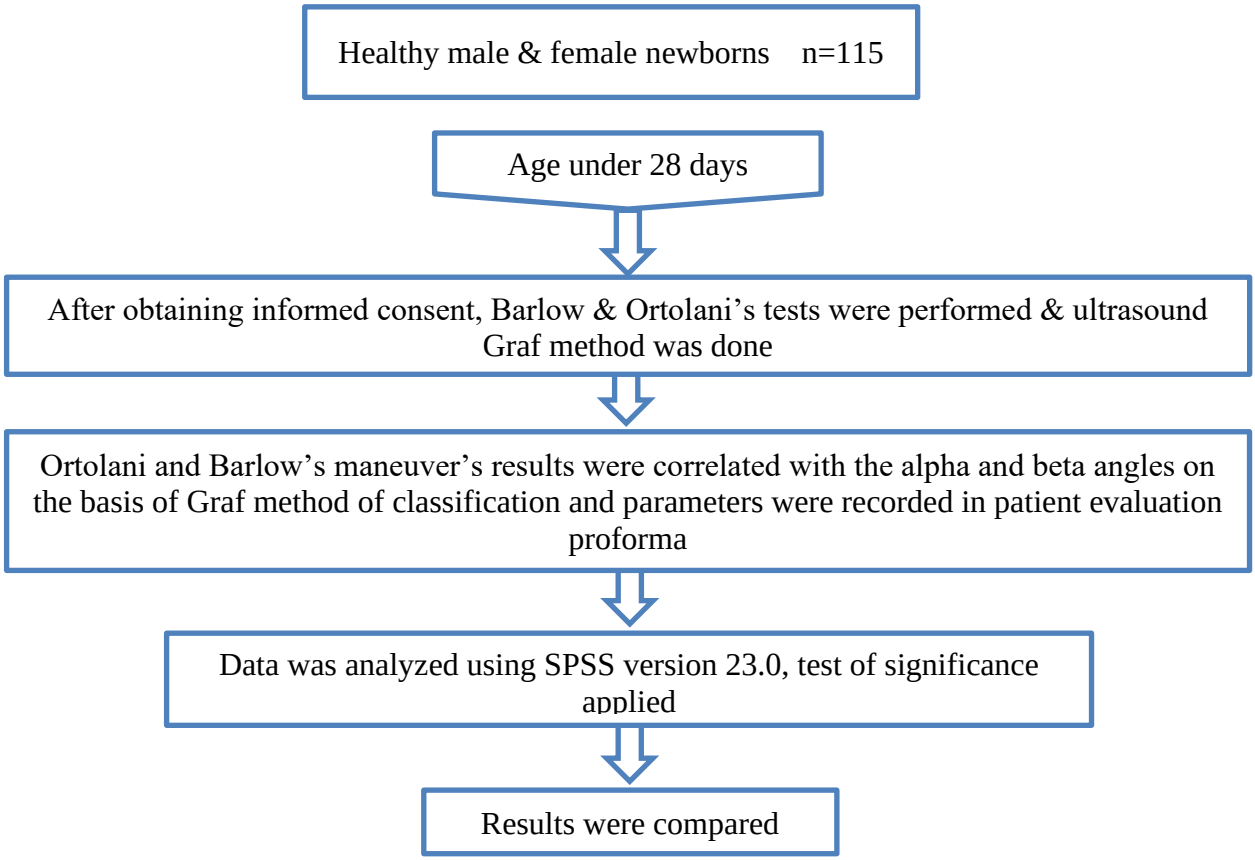

Figure-3.13: Algorithm of study

3.18 STATISTICAL ANALYSIS

Data was analyzed using SPSS 23.0. Chi-square and Pearson correlation tests were applied. A p-value less than 0.05 was considered statistically significant diffrence.

Software: SPSS version 23.0

p-value ≤ 0.05

Tests of Significance:

Chi-square (for categorical variables)

Pearson correlation test (for correlation of clinical and ultrasound parameters)

Student T- test

CHAPTER 4 RESULTS

DEMOGRAPHY

Age and Gender:

A total of 115 infants (230 hips) were enrolled in this study. 59 (51.3%) male babies and 56 (48.7%) female babies were examined (Figure-4.1). In order to maintain the balance aim was to obtain data on equal number for the gender. However due to limited duration of study this could not be achieved. Mean age of participants was 14.55 days (Table- 4.1). Table-4.2 demonstrates types of normal and pathological hips among both genders with 81 (35.21%) normal hips and 37 (16.08%) pathological hips in male neonates, whereas 78 (33.91%) normal hips and 34 (14.78%) pathological hips in female neonates (Table-2).

Ethnicity:

Overall, the subjects were from different "ethnicities" and backgrounds. The aim was to establish a connection between cultural behaviors and the goals of this study. Subjects included following communities: Urdu Speaking, Punjabi, Sindhi, Pathan, and Bengali. The hip type distributions of different ethnic groups of study participants are broken down and explained in table 4.3 and the bar chart in figure 4.2. The number of newborns belonging to the various ethnic groups were as follows: Urdu speaking 37 (32.17%), Punjabi 29 (25.21%), Sindhi 28 (24.34%), Pathan 14 (12.17%), and Bengali 7 (6.09), (Figure-4.2). The data showing pathological hips was highly significant in Pathan and Sindhi ethnicity with a *p* value of (0.021*), where equal number of normal and pathological hips were found in Pathan ethnicity (Table-4.4).

CLINICAL FINDINGS:

Graf method ultrasound

The incidence of DDH was determined on the basis of Graf method ultrasound. Types I and IIa+ were integrated into mature/physiologically immature group whereas Graf types IIa-, IIc, D, III, and IV were regarded in pathological immature or pathological hip types (Table-4.5). The data showed a highly significant result ($p < 0.001$) with 71 (30.86%) hips falling in the category of pathological hips (Table-4.5), hence highlighting the significance of this imaging modality.

BMI

The BMI calculation of the study participants showed that 111 out of 115 newborns had BMI < 18.5, indicating that 96.52% newborns were underweight. 4 (3.48%) participants had normal BMI (Table-4.6 & Figure-4.3).

Weight, Height, BMI and Gender

The mean values for weight (Kg) and height (cm) among study participants along with BMI (m/Kg^2) showed 59 male babies had a minimum weight of 1.5 kg and maximum weight 6.16 kg with a mean value of 2.956 ±0.712. Whereas, 56 female babies had minimum weight of 1.3 kg and maximum weight of 4 kg with a mean value of 2.839±0.518 (*p*-value of 0.267, table-4.7). Similarly, maximum height of 59 male babies was 55 cm and minimum height 36 cm. For the females the maximum and minimum height were 55 cm and 40 cm respectively with a *p*-value of 0.364, table-4.7. The mean BMI of male babies was 13.756 whereas it was 13.672 for the female newborns with a *p*-value of 0.844, table-4.7.

GESTATIONAL AGE

At Term

Out of a total study population, maximum number of newborns (105 (91.30%) were born "at-term". 78 newborns delivered at term were from type-Ia (physiological mature hips), 66 hips were found in type-IIa+ (physiological immature hips), type-IIa- hips were 43 (Pathological immature hips), type-IIc were 17 (Pathological hips), 2 hips were from type-D (Pathological hip), type-III had 1 hip (Pathological hip) and 3 hips were found in type-IV (Pathological hips) with over all *p* value of 0.649 (Table-4.8 & 4.9, Figure-4.4).

Pre-Term

7 newborn babies were born prematurely before 37 weeks of gestation (Table-4.8). Among them 7 hips were from type-Ia (physiological mature hips), 3 type-IIa+ (Physiological immature hips), 3 type-IIa- (Pathological immature hips) and 1 hip from type-IIc (Pathological hip) were observed (*p* value was 0.584, table-4.10). This shows that out of 7 newborns (14 hips), 10 fell into the category of normal/physiological hips whereas 4 hips belonged to the pathological types according to Graf method ultrasound.

Post-Term

3 newborns delivered Post term among the study population (Tale-4.8, Figure-4.4). Out of these, 6 (2.61%) hips, 3 hips were from type-Ia (physiological mature hips), 1 was found from type-IIa+ (physiological immature hips), 1 was found from type-D (pathological hip), and 1 from type-III (pathological hip) (Table-4.11).

MODE OF DELIVERY

Normal Vaginal Delivery (NVD)

There were 94 cases (188 hips) of normal vaginal deliveries among study population (Table 4.12, Figure-4.5). Out of these cases 74 newborn hips were found from hip type Ia, 56 were from IIa+, 36 hip fell under category of hip type IIa-, 15 were found in type IIc, 3 were from type-D, 2 cases were found in type-III and type-IV respectively. The *p* value was 0.847 (Table-4.13). The high number of normal vaginal deliveries found in physiological hips indicated that

occurrence of DDH is not affected by the normal vaginal deliveries (Table-4.12 and 4.13 & Figure- 4.5).

Cesarean Section (CS)

16 cases (32 hips) were delivered via Cesarean Section out of 115 cases (230 hips) (Table-4.12, Figure-4.5). Out of 32 hips, 12 newborns were found from hip type-Ia, 11 were from IIa+, 6 hip fell under category of hip type IIa-, 2 were found in type IIc and 1 hip fell under category of hip type-IV with a *p*-value of 0.962 (Table-4.14).

Instrumental Delivery

The total number 5 newborns (10 hips) were delivered by instrumental delivery (Table-4.12, Figure-4.5). Out of 10 hips, 2 hips were observed from hip type-Ia, 4 were from IIa+, 3 hip fell under category of hip type IIa-, and 1 hip belonged to type-III hip category according to Graf method ultrasound, with a *p*-value of 0.911. Thus, significant association was not found between instrumental deliveries and DDH cases (Table-4.15).

PRESENTATION

Vertex

The newborns of the present study were categorized into according to their presentation (vertex, breech and transverse) at the time of birth (Table-4.16, Figure-4.6). Presentation wise there were 96 (83.48%) cases of “vertex” presentation. When these newborns were evaluated for classification of their hips according to Graf method ultrasound, insignificant results were observed.

Breech

There were a total 16 (14 %) cases of breech presentation out of a total population sample of 115 (Table-4.16, Figure-4.7). From these 16 cases (32 hips), 8 hips were categorized as type Ia, 6 hips as type IIa+, 8 hips each as type IIa- and type IIc, and 1 hip each in type D and type III respectively (Table-4.17). Data showed highly significant relationship between breech presentation and occurrence of pathological hips (Table-4.17).

Transverse Lie

4 (3%) newborns had "transverse" presentation at the time of birth among study subjects (Table-4.16, figure-4.6). When these newborns were evaluated for classification of their hips according to Graf method ultrasound, insignificant results were observed.

Transverse lie cases were observed in normal delivery cases with the number of cases being 3 whereas 1 case was cesarean section (Table 4.16) (Figure 4.8).

CLINICAL FINDINGS AND DDH

Barlow and Ortolani's maneuver findings

The newborn babies were examined clinically by Barlow's and Ortolani's test. The data showed that out of 115 subjects (230 hips), these maneuvers were positive only in 6 hips of pathological types (type-lll & type-lV) again highlighting the importance of Graf method ultrasound in early detection of DDH (Table- 4.18 & 4.19).

First born babies (Primigravida)

28 newborns (56 hips) were first born among the study population. Out of 56 hips, 51 were mature/physiological immature hips (out of 159) and only 5 were pathological immature/Pathological hips (out of 71). Highly significant association were found between first born babies and pathological hips shown in Table-4.20.

Oligohydramnios

There were 6 (12 hips) Oligohydramnios from 115 (230) cases. Out of 12 hips 9 were mature/physiological immature hips (out of 159) and only 3 were pathologic immature/Pathological hips (out of 71). No significant association were found between Oligohydramnios cases and pathological hips shown in (Table 4.21).

Risk Factors Distribution according to the Graf Method

From the univariate analysis, a significant correlation was observed in the newborn subjects with breech presentation, first born (primigravida) and ethnicity for DDH with the ultrasound

results of a pathological hip (Table-4.17, 4.20, and 4.4 respectively). On the other hand, ultrasound diagnosis of developmental dysplasia of the hip did not show significant correlation with female gender, preterm, or oligohydramnios (Table: 4.2, 4.10 & 4.21 respectively) (Figure 4.8).

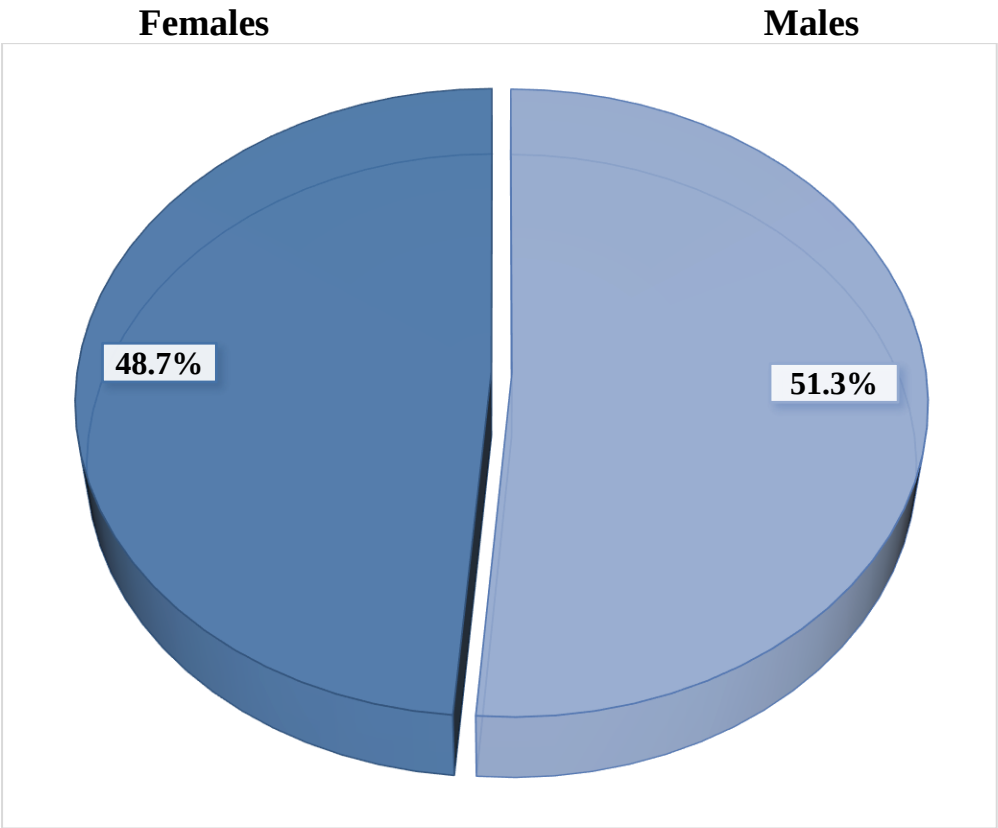

Figure-4.1: Gender distribution of the Study Participants

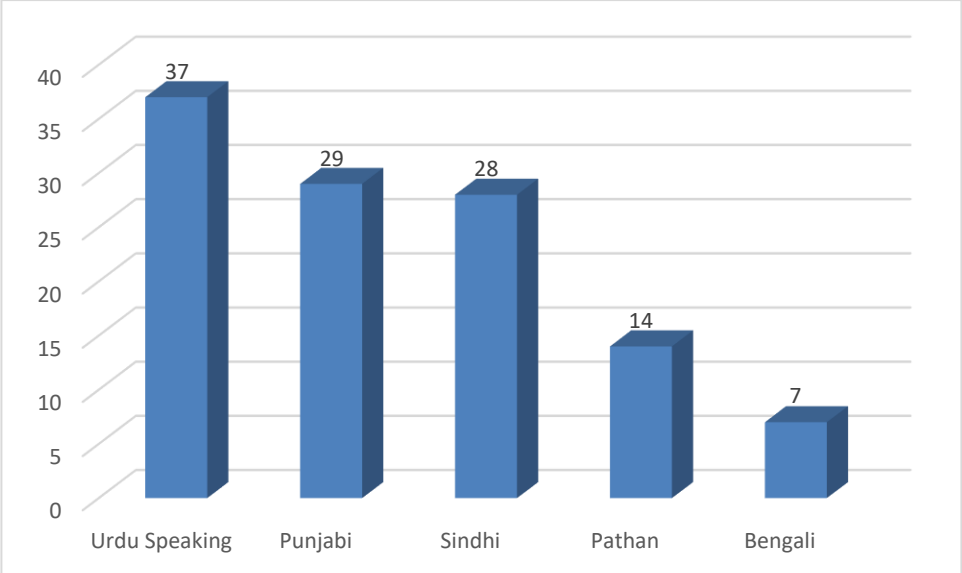

Figure-4.2: Bar chart showing ethnic distribution between groups.

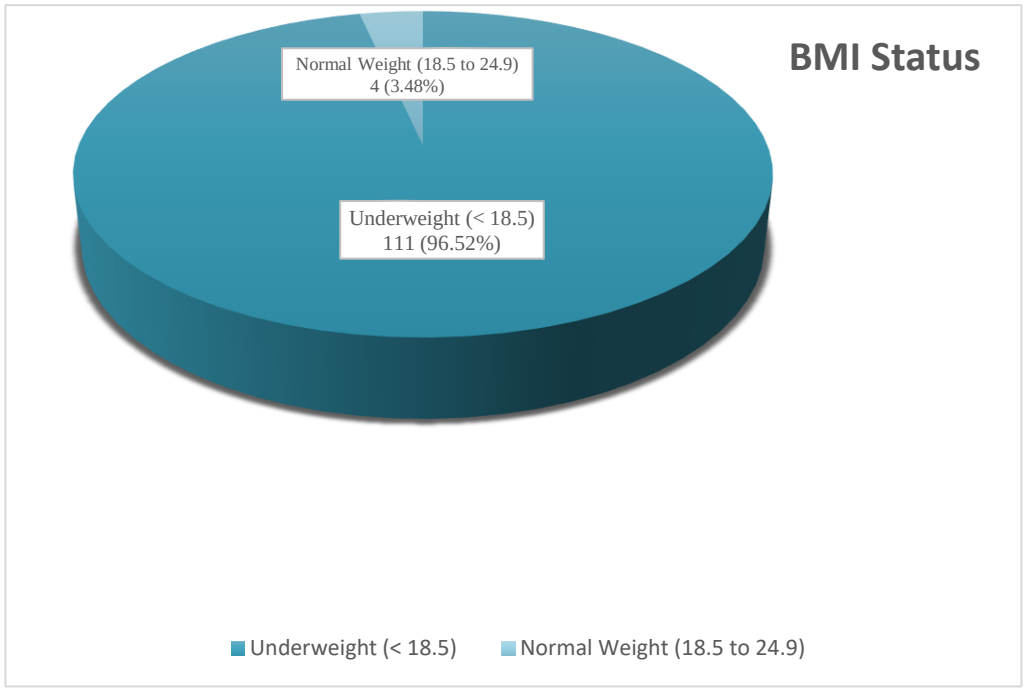

Figure-4.3: BMI Distribution of Study Participants showing normal, underweight and overweight newborns.

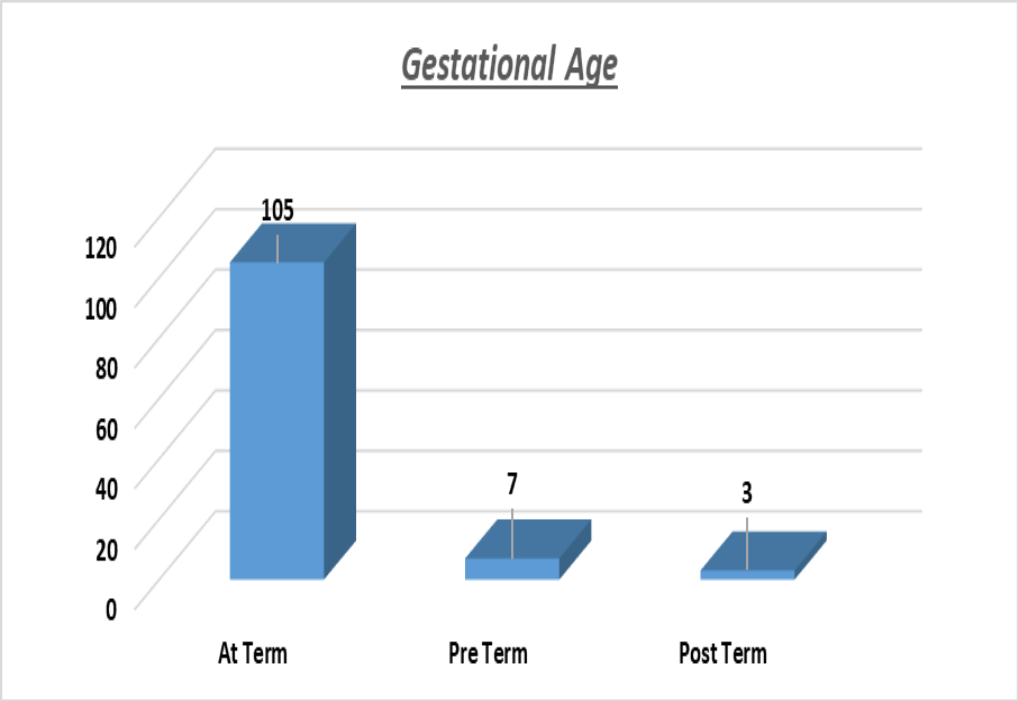

Figure-4.4: Distribution of study participants according to Gestational Age.

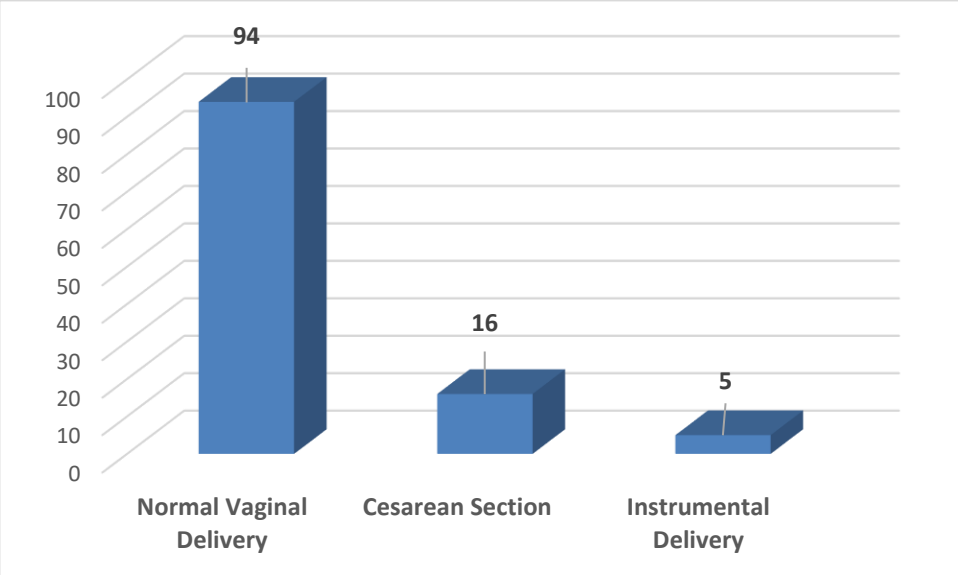

Figure-4.5: Distribution of study population according to Mode of Delivery.

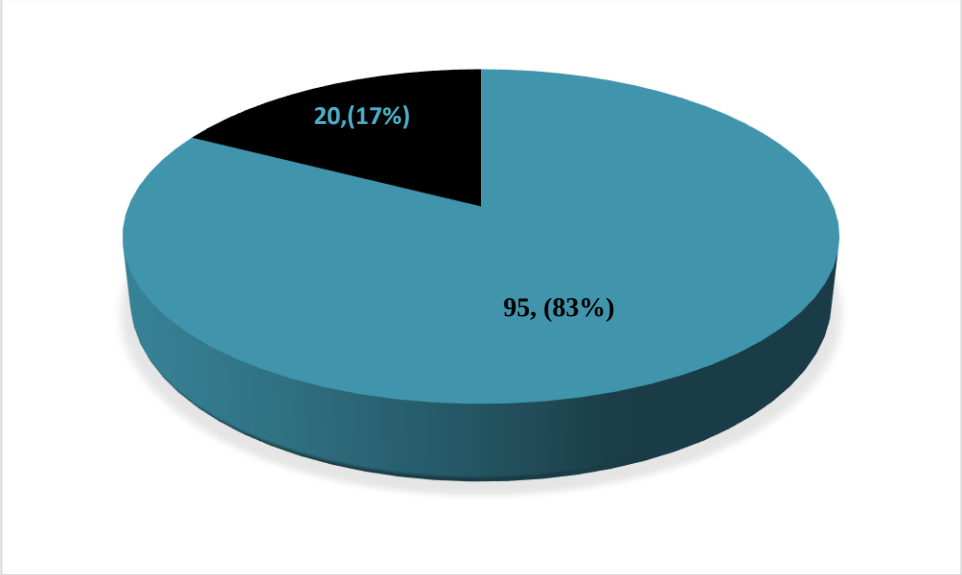

Figure-4.6: Frequency of Vertex Presentation among study population.

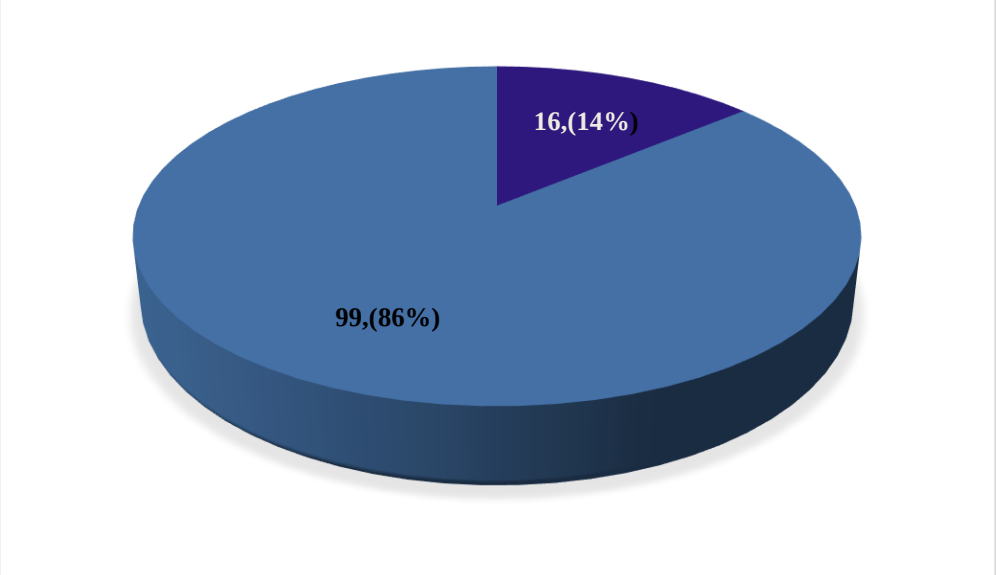

Figure-4.7: Frequency of Breech Presentation among study participants.

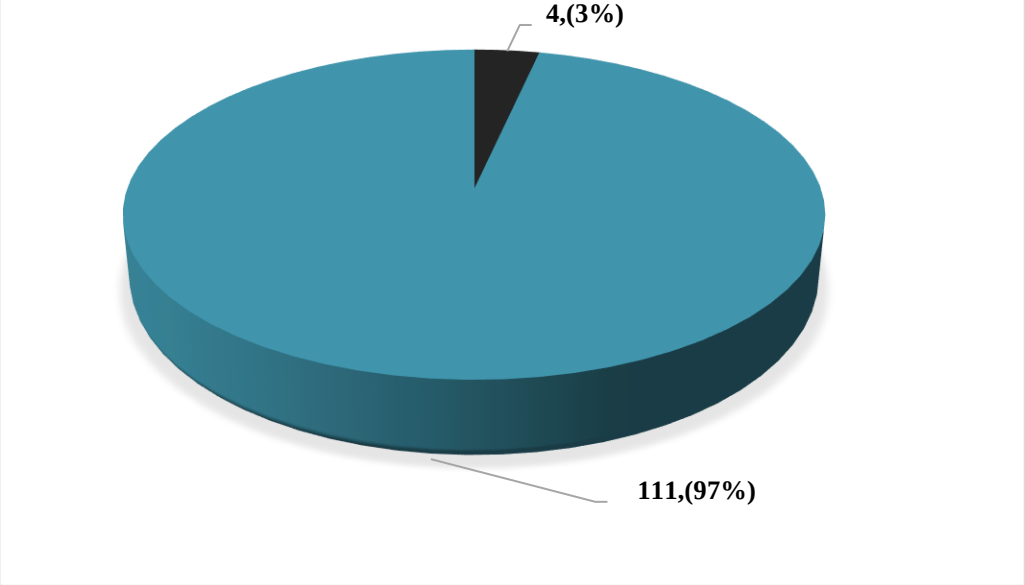

Figure-4.8: Frequency of Transverse Presentation among study participants.

Table-4.1: Gender distribution of study participants with minimum, maximum and mean age.

Gender	n (%)	Min Age (days)	Max Age (days)	Mean	SD
Male	59 (51.3%)	1	28	14.12	8.75
Female	56 (48.7%)	1	28	15.00	9.031
Total	115 (100%)	1	28	14.55	8.86

KEY: n: number of study participants; Min: minimum; Max: Maximum, SD: standard deviation
Test applied

Table-4.2: Type of hip distribution according to the Graf method ultrasound among study population.

Graf type		Mature/physiology Immature hips (n, %)	Pathological Hips (n, %)	Total Hips	*p*-value
Gender	Male	81 (35.21%)	37 (16.08%)	118 (51.30%)	0.870
	Female	78 (33.91%)	34 (14.78%)	112 (48.69%)	
Total		159 (69.13%)	71 (30.86%)	230 (100.0%)	

KEY: n number of study participants. *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*). *p* value ≤ 0.01 is highly significant (**).
Test applied: Pearson's Chi- Square.

Table-4.3: Frequency distribution of different ethnic groups among study participants.

Ethnicity	Number (n)	Percentages
Urdu Speaking	37	32.17%
Punjabi	29	25.21%
Sindhi	28	24.34%
Pathan	14	12.17%
Bengali	7	6.09%
Grand Total	115	100%

KEY: n: number of study participants.

Table-4.4: Association between Ethnic groups and Pathological Immature/Pathological hips among study population.

Ethnicity	Mature/physiological immature hips	Pathological immature/pathological hips	*P* -Value
Urdu speaking	59 (25.65%)	15 (6.52)	0.021*
Punjabi	41 (17.82%)	17 (7.39%)	
Sindhi	35 (15.21%)	21 (9.13%)	
Pathan	14 (6.08%)	14 (6.08%)	
Bengali	10 (4.35%)	4 (1.73%)	
Total	159 (69.13%)	71 (30.86%)	

KEY: n: is number of hips of study participants; *p* value ≤0.05 is significant, *p* value ≤ 0.05 is significant difference (*) *p* value ≤ 0.01 is highly significant (**). Test applied: Pearson's Chi- Square.

Table- 4.5: Frequency distribution detailed hip types according to the Graf method ultrasound.

Graf type	Mature/ physiological Immature hips (n, %)	Pathological immature/ Pathological hips (n, %)	Total Hips	*P*-Value
Type-Ia Mature hips	88 (38.26%)	0.0 (0.0%)	88 (38.26%)	0.001**
Type-IIa+ Physiological Immature	71 (30.86%)	0.0 (0.0%)	71 (30.86%)	
Type-IIa- Pathological immature	0.0 (00.0%)	46 (20.0%)	46 (20.0%)	
Type-IIc Pathological hips	0.0 (0.0%)	18 (7.82%)	18 (7.82%)	
Type-D Pathological hips	0.0 (0.0%)	3 (1.30%)	3 (1.30%)	
Type-III Pathological hips	0.0 (0.0%)	2 (0.86%)	2 (0.86%)	
Type-IV Pathological hips	0.0 (0.0%)	2 (0.86%)	2 (0.86%)	
Total	159 (69.13%)	71 (30.86%)	230 (100.0%)	

KEY: n: is number of hips of study participants, *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant (**). Test applied: T test.

Table-4.6: BMI status among study populations.

BMI Status	n	Percentage
Underweight (< 18.5)	111	96.52%
Normal Weight (18.5 to 24.9)	4	3.48%
Over-weight	0	0.0%

KEY: n: number of study participants, BMI: Body mass index.

Table-4.7: Weight, Height & BMI of study Participants among both genders.

Variable	Gender	n	Minimum	Maximum	Mean	SD	*p*-value
Weight (Kg)	Male	59	1.5	6.16	2.956	0.712	0.267
	Female	56	1.3	4	2.839	0.518	
Height (Cm)	Male	59	36	55	46.22	4.039	0.364
	Female	56	40	55	45.60	3.206	
BMI (Kg/m^2)	Male	59	7.37	21.54	13.756	2.219	0.844
	Female	56	7.37	21.42	13.672	2.302	

KEY: n: number of study participants, BMI: Body Mass Index, SD: Standard Deviation. *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), p value 0.01 is highly significant (**).

Table-4.8: Distribution of Study participants according to Gestational Age.

Gestational Age	n	Percentage (%)
Term (37 to 40 weeks)	105 (210 hips)	91.30%
Pre- Term (Before 37 weeks)	7 (14 hips)	6.09%
Post-Term (41 to 43 weeks)	3 (6 hips)	2.61%

KEY: n: is number of study participants.

Table-4.9: Distribution of hip types among At Term neonates according to Graph method Ultrasound.

At Term	Ia	IIa+	IIa-	IIc	D	III	IV	Total	*p*-value
No	11 4.78 %	5 2.17 %	3 1.30 %	1 0.43 %	0 0.0 %	0 0.0 %	0 0.0 %	20 8.69 %	0.649
Yes	78 33.91 %	66 28.69 %	43 18.69%	17 7.39 %	2 0.86%	1 0.43%	3 1.30%	210 91.30 %	
Total	89 38.7 %	71 30.86 %	46 20.0 %	18 7.8 %	2 0.86%	1 0.43%	3 1.30%	230 100.0%	

KEY: *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), p value 0.01 is highly significant (**).

Table-4.10: Association between Pre-term babies & Graph method Ultrasound among study population.

Preterm	Ia	IIa+	IIa-	IIc	D	III	IV	Total	*P*-value
No	82 35.65%	68 29.56.%	43 18.69 %	17 7.9 %	2 0.9 %	1 0.43%	3 1.3 %	216	0.584
Yes	7 3.04 %	3 1.3 %	3 1.3 %	1 0.4 %	0 0.0 %	0 0.0 %	0 0.0 %	14 6.08 %	
Total	89 38.7 %	71 30.9 %	46 20. 0%	18 7.8 %	2 0.9 %	1 0.4 %	3 1.3 %	230 100.0 %	

KEY: *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant (**), Test applied Student T-test.

Table-4.11: Distribution of hip types in Post term study participants according to Graf method ultrasound.

Post-term	**Ia**	**IIa+**	**IIa-**	**IIc**	**D**	**III**	**IV**	**Total**	***P*-value**
No	86 37.39 %	70 30%	46 20%	18 7.82%	2 0.86%	1 0.43%	2 0.86%	224 96.95 %	0.782
Yes	3 1.3%	1 0.4%	0 0.0 %	0 0.0 %	1 0.4 %	1 0.4 %	0 0.0 %	6 2.60 %	
Total	89 38.7 %	71 30.9 %	46 20.0 %	18 7.8 %	3 1.3 6%	2 0.8 %	2 0.8 6%	230 100.0 %	

KEY: *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant (**), Test applied Student T-test.

Table- 4.12: Distribution of study participants on the basis mode of the mode of the delivery.

Mode of Delivery	n	Percentage (%)
Normal Vaginal Delivery (NVD)	94	81.73%
Cesarean Section C/S	16	13.91%
Instrumental Delivery	5	4.3%

KEY: n: is number of study participants.

Table 4.13 Distribution of hip types among Normal Vaginal Delivery newborns according to Graph method Ultrasound.

NVD	Ia	IIa+	IIa-	IIc	D	III	IV	Total	*p*-value
No	14 6.08 % 	15 6.52 % 	10 4.3 % 	3 1.3 % 	0 0.00 % 	0 0.00 % 	0 0.0 0% 	42 18.26 % 	
Yes	74 32.1 7% 	56 24.34 % 	36 15.6 5% 	15 6.5 % 	3 1.3 % 	2 0.9 % 	2 0.9 % 	188 81.73 % 	0.847
Total	88 38.2 6% 	71 30.9 % 	46 20.0 % 	18 7.8 % 	3 1.3 % 	2 0.9 % 	2 0.9 % 	230 100.0 % 	

KEY: NVD: Normal Vaginal Delivery, *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant (**), Test applied Student T-test.

Table-4.14: Distribution of hip types among Cesarean Section newborns according to Graph method Ultrasound.

C/S	Ia	IIa+	IIa-	IIc	D	III	IV	Total	*P*-value
No	76 33.04%	6 2.60%	40 17.39%	16 6.95%	3 1.3%	2 0.9%	1 0.43%	198 86.08%	0.962
Yes	12 5.21%	11 4.78%	6 2.60%	2 0.9%	0 0.0%	0 0.0%	1 0.43%	32 13.91%	
Total	88 38.2%	71 30.9%	46 20.0%	18 7.8%	3 1.3%	2 0.9%	2 0.9%	230 100.0%	

KEY:C/S: Cesarean Section, *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant (**), Test applied Student T-test.

Table-4.15: Distribution of hip types among Instrumental Delivery newborns according to Graph method Ultrasound. Describes the association between Instrumental delivery and DDH.

ID	Ia	IIa+	IIa-	IIc	D	III	IV	Total	*p*-value
No	86 37.395%	67 29.13%	43 18.69%	18 7.82%	3 1.3%	1 0.43%	2 0.9%	220 95.65%	0.911
Yes	2 0.9%	4 1.7%	3 1.3%	0 0.0%	0 0.0%	1 0.43%	0 0.0%	10 4.34%	
Total	88 38.7%	71 30.9%	46 20.0%	18 7.8%	3 1.3%	2 0.9%	2 0.9%	230 100.0%	

KEY: ID: Instrumental Delivery, *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant (**), Test applied Student T-test.

Table-4.16: Distribution of study participants on the basis of mode of presentation at birth.

Presentation	n	Percentage (%)
Vertex		
Yes	96	83.48%
No	19	16.52%
Breech		
Yes	16	14 %
No	100	86.96%
Transverse		
Yes	4	3.48%
No	111	96.52%

KEY: n: is number of study participants.

Table- 4.17: Distribution of hip types among Breech Presentation newborns according to Graph method Ultrasound.

BP	Ia	IIa+	IIa-	IIc	D	III	IV	Total	*p*-value
No	80 34.8 %	65 28.3 %	38 16.5 %	10 4.3 %	2 0.9 %	1 0.43 %	2 0.9 %	198 97.3 %	0.002 **
Yes	8 3.5%	6 2.6 %	8 3.5%	8 3.5 %	1 0.43 %	1 0.43 %	0 0.0 %	32	
Total	88 38.7 %	71 30.9 %	46 20.0 %	18 7.8 %	3 1.3 %	2 0.9 %	2 0.9 %	230 100. 0%	

KEY: BP: Breech Presentation, *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant difference (**), Test applied Student T-test.

Table-4.18: Frequency distribution of hip types according to the Graf method ultrasound on the basis of Barlow's test.

Clinical Examination		Mature/physiological Immature hips (n, %)	Pathological immature/ pathological Hips (n, %)	Total Hips	*p* value
Barlow's test	**-ve**	159 (69.1%)	65 (28.3%)	224 (97.4%)	0.001**
	+ve	0 (0.0%)	6 (2.6%)	6 (2.6%)	
Total		159 (69.1%)	71 (30.9%)	230 (100.0%)	

KEY: n: is number of study participants. *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant difference (**), Test applied Student T-test.

Table-4.19: Frequency distribution of hip types according to the Graf method ultrasound on the basis of Ortolani's test.

Clinical Examination		Mature/Immature but Appropriate for Age Hips (n, %)	Pathological Hips (n, %)	Total Hips	*P* value
Ortolani's test	-ve	159 (69.1%)	65 (28.3%)	224 (97.4%)	0.001**
	+ve	0 (0.00%)	6 (2.6)	6 (2.6%)	
Total		159 (69.1%)	71 (30.9%)	230 (100.00%)	

KEY: n: is number of study participants. *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant difference (**), Test applied Student T-test.

Table-4.20: Distribution of hip types among first born newborn babies with graph method ultrasound.

First-born Babies		Mature/Immature but Appropriate for Age Hips (n, %)	Pathological Hips (n, %)	Total Hips	*P* value
No No		108 (47.0%)	66 (28.7%)	174 (75.65%)	0.001**
Yes		51 (22.2%)	5 (2.2%)	56 (24.34%)	
Total		159 (69.13%)	71 (30.9%)	230 (100.0%)	

Key: n is number of hips of study population, n: is number of study participants. *p* value > 0.05 is insignificant, *p* value ≤ 0.05 is significant difference (*), *p* value ≤ 0.01 is highly significant difference (**),
Test applied: Pearson's Chi- Square.

Table: 4.21 Risk factors distribution according to the Graf method ultrasound.

Graf type		Mature/Immature but Appropriate for Age Hips (n, %)	Pathological Hips (n, %)	Total Hips	*P* value
Oligohydramnios	No	150 (91.739%)	68 (3.04%)	218 (94.78%)	0.759
	Yes	9 (5.21%)	3 (0.00)	12 (5.21%)	
Total		159 (96.95%)	71 (3.04%)	230 (100.00%)	

Key: statistically significant results *p* value≤0.05* is significant (*), p value ≤ 0.01 is highly significant (**)
Test applied: Pearson's Chi- Square

CHAPTER: 5 DISCUSSION & CONCLUSION

For past several decades, babies have been screened for hip instability in order to limit the occurrence of late-presentation of DDH. However, there is no agreement on the best approach. A good screening technique should be simple to use, widely available, inexpensive, and agreeable to the patient. It should also be sensitive and specific enough to discover the problem. Broadly, screening for DDH involves use of clinical examination of hip, radiological investigations, or combination of both. Till now, there is no program introduced to eliminate incidence of late-presenting DDH.

Because of the advent of hip ultrasonography, the natural history of the pathology has undergone a complete transformation. This has made it possible for an early detection, which enables more appropriate and potent management of DDH (Buonsenso et al., 2020).

Universal ultrasound screening (without risk factor) is practiced in European countries such as Italy, Austria, Switzerland, Germany and, Slovenia (Kilsdonk et al., 2021).

On the evaluation of DDH an international Consensus in June 2019 stated that there was a strong agreement in approval of universal ultrasound screening, that is cost-effective and, using the Graf technique, would not result in under or over treatment (Buonsenso et al., 2020).

Studies from Austria and Germany showed a decrease in surgery rates and complications of DDH, also cost effective, when universal ultrasound screening was compared with lack of ultrasound screening (Kilsdonk et al., 2021).

A positive family history of the condition, breech presentation, a female gender, premature birth, swaddling, and limited fetal movements including oligohydramnios, high birth weight, twin/ multiple pregnancies, first born, polyhydramnios, torticollis, and high altitude are considered as common risk factors (Harsanyi et al., 2020).

Individual practitioners rely on risk factor-based screening in the absence of a national screening program. Newborns with one or more DDH risk indicators are evaluated clinically

and/or sonographically to verify hip instability. Awareness of these risk factors, as well as knowledge of suspected hip abnormalities is required to prevent DDH.

As the number of risk factors increases, so does the chance of DDH. However, the existence of a risk factor does not always imply the presence of DDH.

The Barlow's test, Ortolani sign, thigh folds, and limb length disparity were the most often used clinical evaluations. The most used technique is a combination of the Ortolani and Barlow test, which has a specificity of 95% in severe cases of type III and type IV. Both their execution and expense are simple. However, in less severe cases of type IIA- and type D they are unable to detect irreducible dislocation and have a lower sensitivity (28%). Sensitivity declines to 0% for cases of physiological immature cases such as type IIa+.

Subluxable hip and dysplasia without dislocation is not identified by these clinical tests and often worsen and manifest later. The clinical examination such as Ortolani's and Barlow's tests, thigh gluteal folds, difference in leg length and restricted abduction in newborn babies is not observed providing a difficulty even to an experienced pediatrician. Hence physiological immature hips and minor pathological hips are harder to detect resulting in increased incidence of cases worldwide. This tendency is particularly pronounced in countries where the universal ultrasound screening is not practiced.

It has been observed in the current study that Graf method ultrasound is more efficient in detecting immature/ early pathological hips as compared to clinical examination. It is more sensitive and specific and detects both morphological aberration and instability. It is the ideal radiological method for detecting DDH in infants younger than six months of age while the femoral head is still cartilaginous. It is also non-invasive and safe, without any hazard to the new born babies.

In the current study 115 newborns, i.e., 230 hips were examined by clinical as well as Graf method ultrasonography. The study included 59 male and 56 female newborns. Graf method ultrasound showed that out of 230 hips examined, 71 were pathological making it 30.86% of total hips.

The study highlighted the importance of Graf method ultrasound as a screening tool in our population as 71 hips (30.86%) out of 230 hips were observed as pathological majority of which were missed on clinical examination alone. The clinical examination which comprised of Barlow's and Ortolani's maneuvers were positive in only 6 hips (2.6%), which were high grade

pathological hips according to Graf method ultrasound, indicating that minor types of DDH are easily missed on clinical examination alone. Major known risk factors identified in the current study were ethnicity, breech presentation and first-born babies.

Findings similar to the present study were observed by Tan et al (2019) in a study conducted in Singapore, who observed 92 (26.43%) cases of pathological hips among 348 neonates (Tan et al., in 2019).

On the other hand, contradictory results were observed in a study conducted in 2020. 3952 newborns were analyzed out of which only 48 (1.2) babies were diagnosed as pathological immature/pathological hips (Buonsenso et al., 2020).

It is estimated that 75 percent of DDH can be attributed to female sex alone, independent of any other known risk factors. This highlights the need of performing a thorough physical examination on each and every newborn in order to diagnose DDH (Hines et al., 2019). This could be because the maternal corpus luteum releases a hormone (relaxin) in early pregnancy that causes the ligaments of the hip joint to loosen, making the pelvis wider. Since females are more sensitive to relaxin hormone, this could cause female babies to develop "DDH" (Ayanoğlu et al., 2021). In the current study we could not find significant difference in gender distribution in occurrence of DDH. One possible explanation for this could be the socioeconomic status of the study population. Lower socioeconomic families value male babies more than females, thus attention is paid only to the “son” and they are brought to the hospital because parents are more concerned about the well-being of their boys than their girls and choose not to take their daughters to the hospital until and unless there is an emergency. But contradictory results are observed in a number of studies. A study conducted in Turkey revealed a significantly higher proportion of female gender as compared to male gender in association with an increased risk of developmental dysplasia of the hip in neonates (Onay et al., 2019).

We observed significant association of DDH among Pathan and Sindhi ethnicities as compared to Urdu speaking, Punjabi and Bengali. The practice of tight swaddling of infants is common among Pathans and Sindhis, which might be the cause. Similarly, a study carried out in Maxico revealed strong association between ethnicity and hip dysplasia (Mendez-Dominguez et al., 2022).

First born babies are considered as one of the risk factors in development of hip dysplasia (Treiber et al., 2021). We observed significant correlation between first born babies and DDH.

The reason could be limited fetal mobility due to less space in smaller uterus in primigravid mothers.

According to literature, breech presentation is a common risk factor in the development of hip dysplasia. It has been seen that breech presentation places a significant amount of stress on the lower extremities and also prolonged strain on lower limbs during a breech delivery (Harsanyi., et al 2020). Our findings showed that breech presentation had highly significant association with development of dysplasia of hip. Highly significant association was found between breech presentation and DDH in a study conducted in Slovenia by Treiber et al (2021).

In the current study the Barlow's and Ortolani's maneuver results were positive only in the sever/unstable cases (Graf type lll & lV) of hip dysplasia. Clinical/physical examination (Barlow and Ortolani maneuvers) have missed cases of stable DDH due to poor sensitivity (Buonsenso et al., 2020). The Barlow and Ortolani maneuvers were not successful in identifying 66.7% of the hip joints that ultimately required surgical surgery (Paton et al., 2017). Clinical examination is considered insufficient for early diagnosis of DDH because the condition can be clinically occult (Hareendranathan et al., 2021). Physical examinations are recommended as the initial evaluation for each newborn. Although it has been observed that approximately half of the neonates would be missed in the initial examination (Chavoshi et al., 2021).

The current study could not find significant correlation between BMI and the hip dysplasia. It is likely that children's weight can affect their risk of developing acetabular dysplasia. A higher body mass index (BMI) may reduce the risk of developing acetabular dysplasia, while a lower BMI may contribute to the development of the condition. A study determined an inverse correlation between body mass index and acetabular dysplasia in children who had an age bracket of nine year (Chung, wk., et al 2021).

According to the findings of our study, premature infants born at less than 36 weeks of gestation had no significant impact in developing DDH. On the other hand, premature infants born at less than 36 weeks of gestation had a lower risk of developing DDH (Lang et al 2017). Literature also shows that the newborn babies who deliver post maturely are at risk of developing developmental dysplasia of hip. Strong association among post-mature babies and developmental dysplasia of hip were observed by Woodacre et al (2016) They concluded that babies who were born later than 38 weeks had a greater risk of developing DDH (Woodacre et al., 2016). However, our study did not reveal significant correlation.

According to literature there is evidence to suggest that having a caesarean section increases the risk of DDH. On the other hand, we did not fount significant results for Cesarean Section in our study. Similar results were revealed by Lankinen et al (2022) that caesarean section were not linked with DDH (Lankinen et al., 2022).

5.1 LIMITATIONS AND STRENGTHS OF STUDY:

5.1.1 Limitations

The epidemiological data was obtained from the population of Karachi only.
Sample size was small due to the limited duration of study.
The ethnic distribution was not equal.

5.1.2 Strengths

Graf method of ultrasound was used for the first time in Pakistan.
Both clinical tests, Barlow's as well as Ortolani's were performed and compared with ultrasound findings.
Different risk factors were correlated.
It will increase awareness about the advantages of Graf method ultrasound as an early diagnostic tool to reduce the rate of complications in cases of DDH.

5.1.3 *Future research directions / Recommendations*

Results of the study should be conveyed to the clinicians so that they can spread awareness to the common people about the advantages of Graf method ultrasound as an early diagnostic tool to reduce the rate of complications in our country.
Traditional swaddling should be avoided in hospitals, unfortunately it is still a common practice in hospitals.
Clinicians should educate the parents regarding consequences of traditional swaddling.

Clinicians should receive training in clinical examination (Barlow's and Ortolani's maneuvers) as junior clinicians are inexperienced with these techniques which should be done on every newborn at all hospitals.

Radiologists should have awareness about Graf Method Ultrasound.

Universal ultrasound screening should be implemented to avoid serious outcomes.

The present situation necessitates large-scale longitudinal cohort studies with subsequent follow-up research.

In-person and online training programs on DDH should be made available throughout the course of pediatrician residency training and afterwards for the pediatricians and specialists in neonatology.

5.2 CONCLUSION:

Current study demonstrated that a universal screening enabled us to identify DDH in a number of children who had normal clinical examinations and did not have risk factors, suggesting that a universal screening is preferable to a selective screening. A significant correlation was observed in the newborn subjects with breech presentation, first born (primigravida) and ethnicity for DDH with the ultrasound results of a pathological hip. On the other hand, ultrasound diagnosis of developmental dysplasia of the hip did not show significant correlation with female gender, preterm, or oligohydramnios

CHAPTER: 6 REFERENCES

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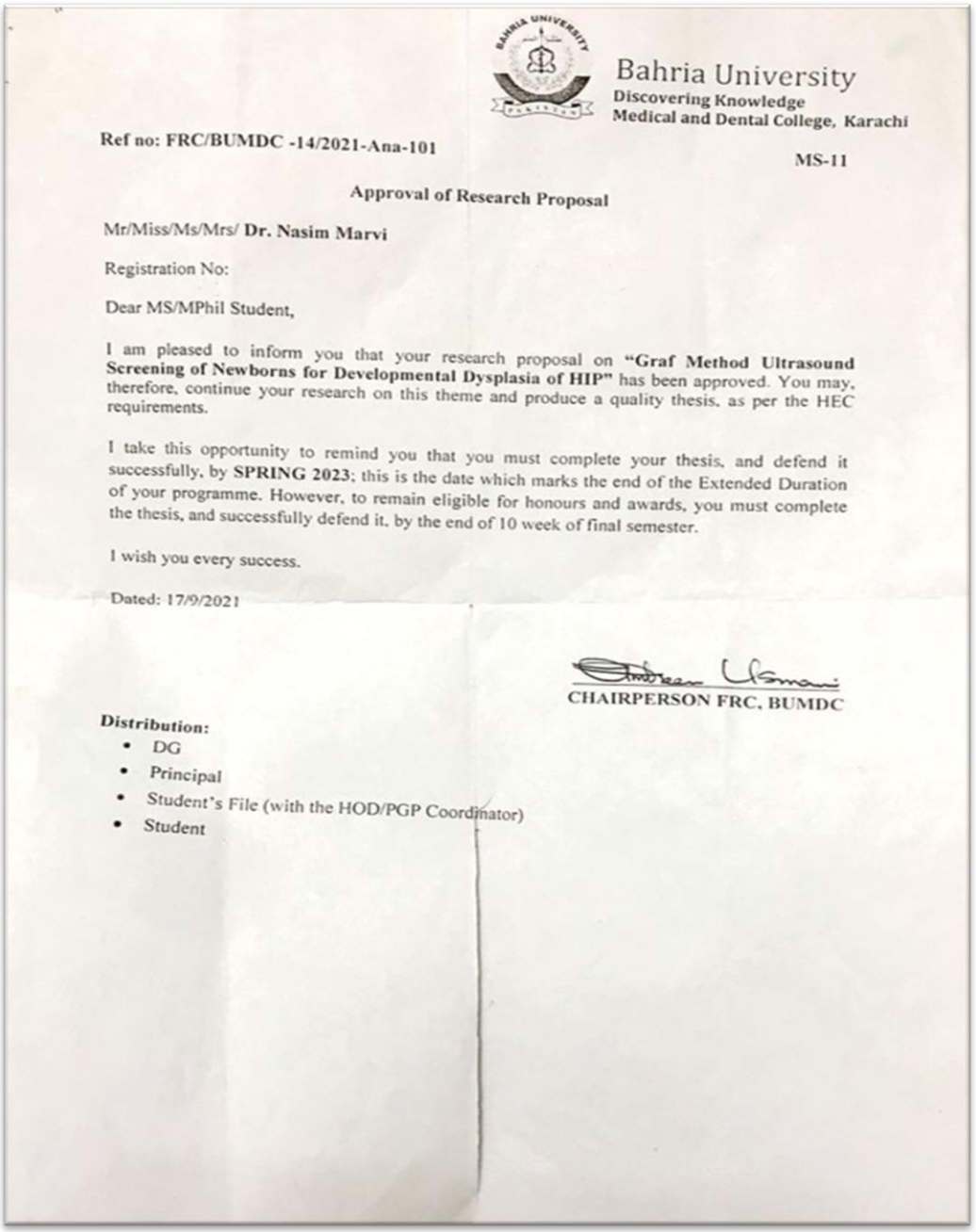
CHAPTER: 7 ANNEXURES

(A) BUMDC- FRC APPROVAL LETTER



Bahria University
Discovering Knowledge
Medical and Dental College, Karachi

Ref no: FRC/BUMDC -14/2021-Ana-101

MS-11

Approval of Research Proposal

Mr/Miss/Ms/Mrs/ **Dr. Nasim Marvi**

Registration No:

Dear MS/MPhil Student,

I am pleased to inform you that your research proposal on **"Graf Method Ultrasound Screening of Newborns for Developmental Dysplasia of HIP"** has been approved. You may, therefore, continue your research on this theme and produce a quality thesis, as per the HEC requirements.

I take this opportunity to remind you that you must complete your thesis, and defend it successfully, by **SPRING 2023**; this is the date which marks the end of the Extended Duration of your programme. However, to remain eligible for honours and awards, you must complete the thesis, and successfully defend it, by the end of 10 week of final semester.

I wish you every success.

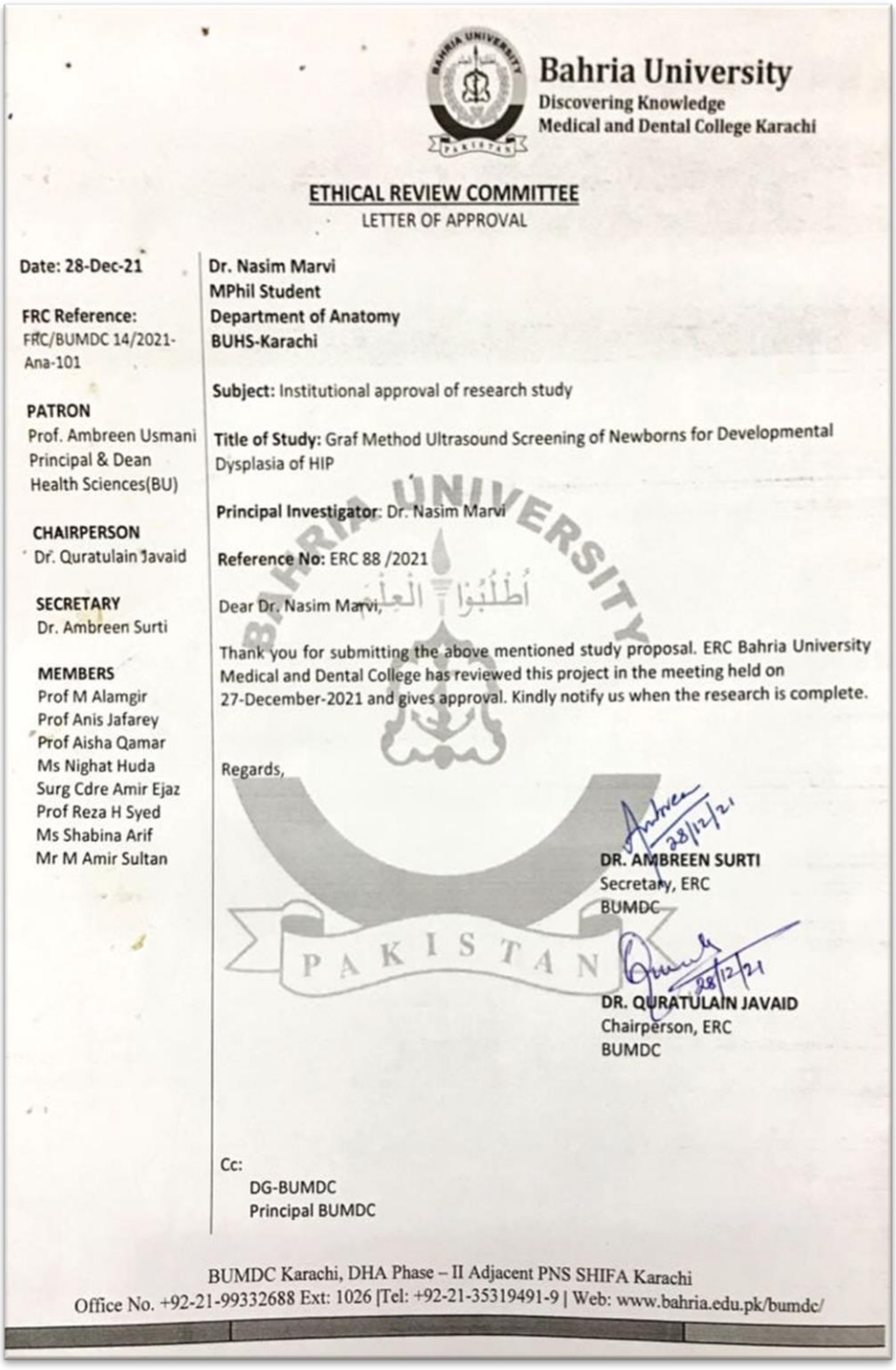
Dated: 17/9/2021

CHAIRPERSON FRC, BUMDC

Distribution:

- *DG*
- *Principal*
- *Student's File (with the HOD/PGP Coordinator)*
- *Student*

(B) BUMDC –ERC APPROVAL LETTER



Bahria University
Discovering Knowledge
Medical and Dental College Karachi

ETHICAL REVIEW COMMITTEE
LETTER OF APPROVAL

Date: 28-Dec-21

FRC Reference:
FRC/BUMDC 14/2021-Ana-101

PATRON
Prof. Ambreen Usmani
Principal & Dean
Health Sciences(BU)

CHAIRPERSON
Dr. Quratulain Javaid

SECRETARY
Dr. Ambreen Surti

MEMBERS
Prof M Alamgir
Prof Anis Jafarey
Prof Aisha Qamar
Ms Nighat Huda
Surg Cdre Amir Ejaz
Prof Reza H Syed
Ms Shabina Arif
Mr M Amir Sultan

Dr. Nasim Marvi
MPhil Student
Department of Anatomy
BUHS-Karachi

Subject: Institutional approval of research study

Title of Study: Graf Method Ultrasound Screening of Newborns for Developmental Dysplasia of HIP

Principal Investigator: Dr. Nasim Marvi

Reference No: ERC 88 /2021

Dear Dr. Nasim Marvi,

Thank you for submitting the above mentioned study proposal. ERC Bahria University Medical and Dental College has reviewed this project in the meeting held on 27-December-2021 and gives approval. Kindly notify us when the research is complete.

Regards,

28/12/21

DR. AMBREEN SURTI
Secretary, ERC
BUMDC

28/12/21

DR. QURATULAIN JAVAID
Chairperson, ERC
BUMDC

Cc:
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(C) CONSENT FORM (ENGLISH

WRITTEN INFORMED CONSENT FORM OF PATIENT

Graf Method Ultrasound Screening of Newborns for Developmental Dysplasia of Hip. The purpose is prevention and early diagnosis of developmental dysplasia of the hip (DDH).

Clinical examination and ultrasound investigation will be conducted to evaluate the hip joint anatomy, from the OPD and admitted patients in the hospital (National Institute of Child Health [NICH], Fazaia Ruth Pfau Medical College [FRPMC] hospitals, Zubaida Medical Center, and Bantva Anis Hospital).There is no risk, as ultrasound examination is a noninvasive procedure, and seriously sick babies will not be included. The project will evaluate measurements/information for early diagnosis of developmental dysplasia of the hip in neonates less than one month of age which will lead to early diagnosis and cost-effective treatment, reducing the rate of surgical interventions in the diagnosed patients. Data will be kept strictly confidential and will be used only for the benefit of the community, publications, and paper presentations.

Your participation in this study is voluntary. It is up to you to decide whether or not to take part in this study. If you decide to take part in this study, you will be asked to sign a consent form. After you sign the consent form, you are still free to withdraw at any time and without giving a reason. Withdrawing from this study will not affect the relationship you have, if any, with the researcher. If you withdraw from the study before data collection is completed, your data will be returned to you or destroyed.

I have read and I understand the provided information and have had the opportunity to ask questions. I understand that participation of my son/daughter is voluntary and that I am free to withdraw at any time, without giving a reason and without cost. I understand that I will be given a copy of this consent form. I voluntarily agree for participation of my son/daughter to take part in this study. I also agree to give all relevant information needed, in full and to the best of my knowledge to the researcher. It is clarified to me that no incentive, financial assistance, or reimbursement will be provided to me for participation of my ward in the study whereas I do have the right to withdraw from the study at any time.

I am advised to contact Dr. Nasim Marvi on mobile number 0336-8172559
or visit _____ hospital in case of query/ emergency related to my child's disease.

Name of Participant: _____S/o or D/o_____
Signature of participant's parent: _____

Name of Researcher: Dr. Nasim Marvi
Signature of Researcher: _____
Date: _____

(C) CONSENT FORM (URDU)

مریض کی تحریری باخبر رضامندی فارم

گراف مرتبہ بپ کےٹویلپمنٹ ڈسپلاسیا کے لئے نوزائیدہ بچوں کی الٹراساؤنڈ اسکریننگ.
طالعے کا مقصد کولہے کے ڈویلپمنٹ ڈسپلاسیا کی روک تھام اور ابتدائی تشخیصب ہے.

کولہے کے جوڑ وں کی جسمانی ساخت کا جائزہ لینے کے لئے طبی معائنہ اور الٹراساؤنڈ تحقیقات کی جائیں گی. او پی ڈی سے اور اسپتال میں داخل مریضوں کو شامل کیا جائے گا (این آئی سی ایچ، زبیدہ میڈیکل سینٹر، روتھ پی ایچ اے اسپتال اور بنتوا النیس اسپتال)۔ الٹراساؤنڈ معائنہ ایک محفوظ طریقہ کار ہے جس سے بچوں کو کوئی خطرہ نہیں ,اور سنگین بیماربچوں کو شامل/ نہیں کیا جائے گا. یہ پروجیکٹ ایک ماہ سے کم عمر کے نوزائید بچوں میں کولہے کے ڈویلپمنٹ ڈسپلاسیا کی جلد تشخیص کے لئے معلومات کا جائزہ لے گا جس سے جلد تشخیص اور کم لاگت سے موثر علاج ہوگا، تشخیص شدہ مریضوں میں آپریشن کی شرح میں کمی آئے گی. ڈیٹا کو سختی سے خفیہ رکھا جائے گا اور اسے صرف تحقیقی مضمون کے کے لئے استعمال کیا جائے گاجس سے لوگوں کو فائدہ پہنچ سکے .

اس مطالعے میں آپ کی شرکت رضاکارانہ ہے۔ یہ آپ پر منحصر ہے کہ اس مطالعہ میں حصہ لینا ہے یا نہیں۔ اگر آپ اس مطالعہ میں حصہ لینے کا فیصلہ کرتے ہیں، تو آپ سے رضامندی فارم پر دستخط کرنے کو کہا جائے گا. رضامندی فارم پر دستخط کرنے کے بعد، آپ کسی بھی وقت اور کوئی وجہ بتائے بغیر دستبردار ہونے کے لئے آزاد ہیں۔ اس مطالعے سے دستبرداربونے سے محقق کے ساتھ آپ کے تعلقات پر کوئی اثر نہیں پڑے گا. اگر آپ ڈیٹا اکٹھا کرنے سے پہلے مطالعہ سے دستبردار ہو جاتے ہیں، تو آپ کا ڈیٹا آپ کو واپس کر دیا جائے گا ضایع کر دیا جائے گا.

میں نے پڑھا ہے اور میں فراہم کردہ معلومات کو سمجھتا ہوں اور مجھے سوالات پوچھنے کا موقع ملا ہے۔ میں سمجھتا ہوں کہ میرے بیٹے /بیٹی کی شرکت رضاکارانہ ہے اور میں کسی بھی وقت، بغیر کسی وجہ کے اور بغیر کسی قیمت کے دستبردار ہونے کے لئے آزاد ہوں۔ میں سمجھتا ہوں کہ مجھے اس رضامندی فارم کی کاپی دی جائے گی۔ میں رضاکارانہ طور پر اپنے بیٹے /بیٹی کی شرکت سے اتفاق کرتا ہوں کہ وہ اس مطالعے میں حصہ لیں . میں تمام متعلقہ معلومات، مکمل طور پر اور اپنی معلومات کے مطابق محقق کو دینے پر بھی اتفاق کرتا ہوں۔ مجھے واضح کیا گیا ہے کہ مجھے مطالعے میں میرے بچے کی شرکت کے لئے کوئی ترغیب، مالی امداد یا معاوضہ فراہم نہیں کیا جائے گا جبکہ مجھے کسی بھی وقت مطالعہ سے دستبردار ہونے کا حق حاصل ہے۔

مجھے مشورہ دیا گیا ہے کہ ڈاکٹر نسیم ماروی سے موبائل نمبر 0336-8172559 پر رابطہ کریں یا میرے بچے کی بیماری سے متعلق استفسار /ایمرجنسی کی صورت میں _____ہسپتال سے رابطہ کریں۔
شرکا کا نام:_____ والد/والدہ: ----------
شرکا کے والدین کے دستخط:----------

محقق کا نام :ڈاکٹر نسیم ماروی
محقق کا دستخت----------

تاریخ__----------

(D) SUBJECT EVALUATION PERFORMA

SUBJECT'S EVALUATION FORM

Date: _____ Hospital's Name: _____

Patient ID: _____ Patient's Name: _____

Age: _____ Gender: _____

Height (in cm): _____ Weight (in pounds): _____ BMI: _____

Health status_____ Ethnicity: _____Maternal age_____

Gestational age at the time of delivery:

At Term	YES	☐	NO	☐
Preterm	YES	☐	NO	☐
IF YES (weeks) _____				
Post Term	YES	☐	NO	☐
IF YES (weeks) _____				

Mode of delivery:

Cesarean section	YES	☐	NO	☐
NVD	YES	☐	NO	☐
Instrumental VD	YES	☐	NO	☐

Presentation:

Vertex	YES	☐	NO	☐
Breech	YES	☐	NO	☐
Transverse	YES	☐	NO	☐

Maternal Parity:

Primigravida	YES	☐	NO	☐
Multigravida	YES	☐	NO	☐

Medical obstetric history:

Co- morbidities: _____

Oligohydramnios YES ☐ NO ☐

Polyhydramnios YES ☐ NO ☐

Family history of DDH: YES ☐ NO ☐

Co-existing anomalies:

Musculoskeletal deformities YES ☐ NO ☐

Lower-limb malformations YES ☐ NO ☐

CLINICAL EXAMINATION OF NEONATE:

1. Difference in leg lengths (in cm) _____

2. Shortening of the femur with hips and knees flexed (Galeazzi sign):

_____

3. Asymmetry of the thigh or gluteal folds:

_____

4. Barlow's test: _____

5. Ortolani's test: _____

ULTRASOUND OBSERVATIONS OF HIP JOINT:

2. The alpha angle of the hip joint Right: _____ Left: _____

4. Beta angles of the hip joint Right: _____ Left: _____

5. Position of the femoral head, evaluating the stability of the hip, and examining the acetabular morphology (Harcke's method) _____

_____

(E) HOSPITAL / INSTITUTE ULTRASOUND REPORT

NATIONAL INSTITUTE OF CHILD HEALTH
Rafiqui Shaheed Road, Karachi, Ph. 99201261-3 Ext 257
DEPARTMENT OF RADIOLOGY

NAME:	DATE:
ULTRASOUND BOTH HIP JOINTS	

ULTRASOUND FINDINGS:

- Both head of femori visualized in the acetabulum.
- Both α and β angles are within the normal range.
- Angles of rt. hip:
  - α angle: °
  - β angle: °
- Angles of lt. hip:
  - α angle: °
  - β angle: °
- No sonographic evidence of DDH noted.
- No evidence of any collection or soft tissue edema noted at the time of scan.
- Scan appears normal.
- Xray both hip joints is advised for further evaluation.

DR. MAHAIRA

(F) TURNITIN PLAGIARISM CHECK REPORT

PLAGIARISM CHECK

ORIGINALITY REPORT

8%	3%	8%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	link.springer.com Internet Source	1%
2	Danilo Buonsenso, Antonietta Curatola, Ilaria Lazzareschi, Giuseppina Panza et al. "Developmental dysplasia of the hip: real world data from a retrospective analysis to evaluate the effectiveness of universal screening", Journal of Ultrasound, 2020 Publication	1%
3	Daniel J. Westacott, Daniel Butler, Emma Shears, Stephen J. Cooke, Andrew Gaffey. "Universal versus selective ultrasound screening for developmental dysplasia of the hip", Journal of Pediatric Orthopaedics B, 2018 Publication	1%
4	"Skeletal Injury in the Child", Springer Science and Business Media LLC, 2000 Publication	1%
5	Ritesh Arvind Pandey, Ashok N. Johari. "Screening of Newborns and Infants for Developmental Dysplasia of the Hip: A	1%