International Journal of Surgical Research 2014, 3(2): 22-26
DOI: 10.5923/j.surgery.20140302.02

Baseline Thickness of Proximal Femoral Epiphysis in the Diagnosis of Hip Diseases in Infants and Children in Nigeria

Abiodun A. A.[1], Falana B. A.[2,*], Olatunbosun A.[3]

[1]Department of Anatomy and Cell Biology, College of Health Sciences, University Ile-Ife, Nigeria
[2]Department of Anatomy, College of Health sciences, Osogbo, Nigeria
[3]Department of Anatomy, College of Health Sciences, University of Ilorin, Nigeria

Abstract **Backgroung/Introduction:** This study investigated the baseline for the epiphyseal plate thickness of femoral head in infants and children in Nigeria. This was with a view to establishing the longitudinal growth rate, and monitoring the hormonal influence on longitudinal growth rate in infants and children studied, with a view to diagnosing effectively pathological conditions associated with it. **Materials and Methods:** Plain anteroposterior pelvic radiographs collected from the radiological department of the University Teaching Hospital Ilorin Kwara State Nigeria were used for this study. The film focal distance (FFD) was 100cm, and the retrieved radiographs were mounted on x-ray "View Box" and the measurement of the epiphyseal plate taken by measuring the vertical distance or height between the ossified epiphyses of the femoral head and neck. The epiphyseal plate is seen as the space between the ossified epiphysis of femoral head and neck. Other parameters recorded include the age and sex of the patients. The result was statistically analysed. **Results:** Results of the study showed no significant difference in both sexes as compared with age ($p>0.05$). The thickness was significant with values greater in males than in females ($p<0.05$). It was also observed that there is an earlier closure of the epiphyseal plate of femur in females when compared to that of males. The thickness when compared with age in both sexes have no significant difference for both the left and right sides ($p>0.05$). **Conclusions:** It was concluded that there is significant difference in the mean of the epiphyseal plate thickness of the femoral head between the male and the female infant and children, and these baseline thickness for different age groups will be useful in diagnosis of disorders and injuries like perthes disease and slipped upper femoral epiphysis which are common at a particular age group with the diseases affecting epiphyseal plates.

Keywords Epiphyseal plates, Infant & children perthes disease Slipped upper femoral epiphysis

1. Introduction

The epiphyseal plate (growth plate) is a hyaline cartilage plate in the metaphysis at each end of a long bone. The plate is found in children and adolescents, also found in adults, who have stopped growing, the plate is replaced by an epiphyseal endochondral ossification responsible for the initial bone development from cartilage in utero and infants and the longitudinal growth of long bones in the epiphyseal plate. The plate's chondrocytes are under constant division by mitosis. These daughter cells stack, facing the epiphysis while the older cells are pushed towards the diaphysis. As the older chondrocytes degenerate, osteoblasts ossify the remains to form new bone. In puberty increasing levels of estrogen, in both females and males, leads to increased apoptosis of chondrocytes in the epiphyseal plate. Depletion of chondrocytes due to apoptosis leads to less ossification and growth slows down and later stops when the entire cartilage have become replaced by bone, leaving only a thin epiphyseal scar which later disappears. Once the adult stage is reached, the only way to manipulate height is modifying bone length via distraction osteogenesis.

Proximal femoral growth disturbance is a major complication associated with ischemic osteonecrotic conditions, such as Legg-Calvè-Perthes disease. The extent of ischemic damage and the mechanisms by which ischemic injury to the growing femoral head produces growth disturbance of the proximal femoral growth plate remain unclear.

Disruption of the epiphyseal vasculature did not lead to diffuse growth plate damage in the majority of the ischemic femoral heads. [30] established the use of microfracture technique for the treatment of full thickness articular

* Corresponding author:
benedict.falana@uniosun.edu.ng (Falana B. A.)
Published online at http://journal.sapub.org/surgery
Copyright © 2014 Scientific & Academic Publishing. All Rights Reserved

cartilage lesions of the knee especially in high impact athletes. The distribution of chondrocytes throughout the total thickness of articular cartilage from the femoral condyles of infants, children and adults has been studied using serial sections cut parallel as well as perpendicular to the articular surface. The thickness of the articular cartilage was estimated in fixed sections in the work of [20-26] but reports on the deleterious effect of these fixatives has also been documented, thereby limiting the study to data interpretation rather than exploring using routine laboratory techniques..In the standing position the femora are oblique but there is also variation according to sex (greater in women), age, and stature [8]. In X-ray radiographs of the femoral bones of the infant, the bone consists of all the structures as specified above in adult but less developed with the presence of the epiphyseal plates in various region including the femoral head, trochanters (great and lesser) and the distal end of the femur. Observation on developmental patterns of this supply in late fetal and early post natal periods modifies the above description through medial and lateral circumflex arteries at first contribute equally, two major branches of the neck [9] supply from the lateral circumflex diminishes and arterial circle is interrupted .

Growth plate fractures of the distal femur are challenging to treat, with complications that require a secondary surgery 40% to 60% of the time [29]. These fractures often necessitate operative intervention, even in the youngest patients and even with minimal apparent displacement. Treatment varies with the Salter-Harris (SH) classification and with the extent of initial displacement, ranging from simple casting for nondisplaced SH I fractures to open reduction and internal fixation for almost all SH III and IV fractures. The load bearing articular tissues have a stiffness gradient that safely transmits loads from the articular cartilage to the trabecular bone. Engineered tissue constructs and biomaterials combined with the recipient site properties should approximate this gradient. Biomechanical properties of the recipient site are dependent on parameters such as cartilage thickness, cartilage glycosaminoglycan and water content, and calcified cartilage/subchondral bone characteristics. [16-18, 1] observed growth disturbance after distal femoral growth plate fractures in children. Distal femoral physeal fractures in children have a high incidence of physeal arrest, occurring in a mean of 40% of cases. The underlying nature of the distal femoral physis was the primary cause, but other factors have been postulated to contribute to the formation of a physeal bar [7]. In general, the closer a child is to reaching skeletal maturity, the less risk they have of their tibia or femur growing at an abnormal angle if their growth plate is injured. Very young children, who still have a lot of growing to do, have a greater risk of permanent damage if their growth plate is injured.

[4] Analysed histomorphometrically the human growth plate from birth to adolescence, in their study, development of trabecular bone racterized from growth plate cartilage in the human rib from birth to adolescence. The height of the proliferative and hypertrophic zones within the growth plate and the primary bone spongiosa decreased with increasing age, with the greatest change observed in the first year of postnatal life. Within these zones, an internal rearrangement of tissue structure occurred. The matrix volume fraction (either cartilage or bone) increased with age in each of the zones. A concomitant increase in cartilage septae thickness and bone trabecular thickness was observed. A decrease in cartilage septae number was seen in the proliferative zone and a decrease in bone trabeculae number was also observed in the primary spongiosa. However, no difference in cartilage septae number was noted in the hypertrophic zone, the region at which cartilage is transformed into bone. Together the proliferative and hypertrophic regions of the growth plate and the bone primary spongiosa appear to constitute the active growth region, with concomitant changes observed that result in longitudinal growth. In contrast, bone mineral volume in the secondary spongiosa was stable over the ages examined; however, trabecular architecture underwent consolidation as trabecular number decreased and trabecular thickness increased. The integration of the structural transformation from cartilage to bone is crucial in achieving the dual purposes of longitudinal growth and peak bone mass. The structure developed during childhood will have an important bearing on the response to bone-altering disease in later life.

Bearing all these variation in mind about the epiphyseal growth plates both in the children and adults this present study investigates the baseline thickness between infants and children only.

The absolute values for cartilage thickness depended on the method used, but in general total thickness was found to approximately double from late gestation to maturity. In the selected adult specimen, the cartilage was thickest just anterior and posterior to the main weight-bearing area of the condyles [19].

John Hunter studied growing chickens. He observed bones grew at the ends and thus demonstrated the existence of the epiphyseal plates. Hunter is considered the "father of the growth plate" [8].

Endochondral ossification: is one of the two essential processes during fetal development of the mammalian skeletal system by which bone tissue is created. Unlike intramembranous ossification, which is the other process by which bone tissue is created, cartilage is present during endochondral ossification. It is also an essential process during the rudimentary formation of long bones [11] the growth of the length of long bones [2] and the natural healing of bone fractures [3].

This tendency for bone to grow quickly in children explains why they often heal more quickly from fractures than adults do. It can also, unfortunately, put children at risk for cancers of the bone, because the rapid replication can allow cancer cells to spread quickly. In the standing position the femora are oblique but there is also variation in neck-shaft angle according to sex (greater in women), age, and stature [9]. The distal end comprises of two condyles, the medial and lateral condyles [9]. In plain radiographs of the femoral bones of the infant, the bone consists of all the structures as specified above in adult but less developed with the presence of the epiphyseal plates in various region including the femoral head, trochanters (great and lesser) and the end of the femur. The main blood supply to the femoral head is from the lateral epiphyseal artery.

A small supply reaches the head along its ligament by the acetabular branches of obturator and medial circumflex arteries, these anastomose with the epiphyseal vessels [5]. Disruption of the epiphyseal vasculature did not lead to diffuse growth plate damage in the majority of the ischemic femoral heads [28].

The growth plates can clearly be seen on X-rays. Inspection of these areas is sometimes used to provide more information about bones. The plates fuse over at a stable and predictable rate, so someone with experience can examine a bone and make an estimate of its age. After about age 25, when the epiphyseal lines are fully formed, examination of this area of the bone can be less useful, as it may do little more than confirm that the bone belonged to a fully grown adult. It is possible to experience a fracture of the epiphyseal plate.

2. Materials and Methods

Plain anteroposterior radiographs of the pelvis were collected from the radiology department of the teaching hospital. The radiographs were mounted on the X-ray viewing box and dimension of the epiphyseal plate taken by measuring the vertical distance or height between the ossified epiphysis of femoral head and neck. It is important to know that two measurements were taken, one at the point of the widest diameter and the other at the lowest diameter. The mean is then determined. Measurements were taken for right and left femoral epiphyseal plates in both sexes. Other parameters recorded include:

i). Age and (ii) Sex of the patient.

3. Results

From the tables 4 and 5 below, (see appendix) it was observed that changes in the thickness of the growing plate may be as a result of the factors in table 5.

The femoral head growing plate thickness measured for infants and children shows that it ranges from 0.5mm-0.4mm and with mean values in male being 1.35±0.11 for both limbs and in female being 0.96±0.12. There are no changes in the value for both limbs. It closes earlier in male has compared with female. This baseline thickness values can also be used in diagnosis of disorders of proximal femoral epiphyseal plate among Nigerian infants and children.

4. Discussion

Though the distal femoral epiphyseal plate and epiphyseal plate of the proximal part of the tibia contribute immensely to the longitudinal growth in the lower limb [6]. Nevertheless, the femoral head epiphyseal plate thickness contributed to overall longitudinal growth of the limb [11].

Since femoral epiphyseal plate contributed to racial and sexual difference in height. It was observed in this study that there was an earlier closure of epiphyseal plate of the femur in female as compared with age in both sexes has no significant difference for both left and right sides (P>0.05).

The study observed that there is significant difference in mean of the epiphyseal or growth plate thickness of the femoral head between the female and male in infants and children because their values were found to be significantly higher in males than in females (P>0.05). This may be due to androgenic hormonal influence.

The difference were not significant in values of both sides i.e. right and left in each sex. The difference in mean value between male and female epiphyseal thickness of the femur and its early closure may have contributed to the earlier differences in vertical diameter of femoral head, in female and male reported in various regions of the country and also in other parts of the world which was reported to be significantly higher in males than females.

5. Conclusions

This study concluded that the baseline thickness for different age groups should be taken into consideration when making diagnosis of disorders affecting proximal femoral epiphyseal plate in Nigerian infants and children.

Appendix

Table 1. The comparison between the two sides in each sex for values of epiphyseal thickness in age

	Right	**Femur**	**Left**	**Femur**
Sex	**Male**	**Female**	**Male**	**Female**
Number of observation	54	46	54	46
Mean	7.28	7.98	7.28	7.98
Standard Deviation	5.13	4.85	5.13	4.85
SEM (±)	0.70	0.72	0.70	0.72

Actual Range of Age with Sex
Male……… 3 weeks to 16 years
Female…… 3 weeks to 14 years

Table 2. The difference between male and female values of epiphyseal thickness for right and left femoral head with age

	Right	**Femur**	**Left**	**Femur**
Sex	**Male**	**Female**	**Male**	**Female**
Number of observation	54	46	54	46
Mean	7.28	7.98	7.28	7.98
Standard Deviation	5.13	4.85	5.13	4.85
SEM(±)	0.70	0.72	0.70	0.72

P-Value: >0.05

Table 3. The difference between the male and female values of the epiphyseal thickness for the right and left femoral heads

	Right	Femur	Left	Femur
Sex	**Male**	**Female**	**Male**	**Female**
Number of observations	54	46	54	46
Mean	1.35	0.96	1.35	0.96
Standard Deviation	0.82	0.83	0.82	0.83
SEM(±)	0.11	0.12	0.11	0.12

P-Value: <0.05

It was noted that each of the two thicknesses is significant and greater in male than in female (P>0.05), the calculated value was noted to be greater than the tabulated value (tn at α=0.05=2.36)

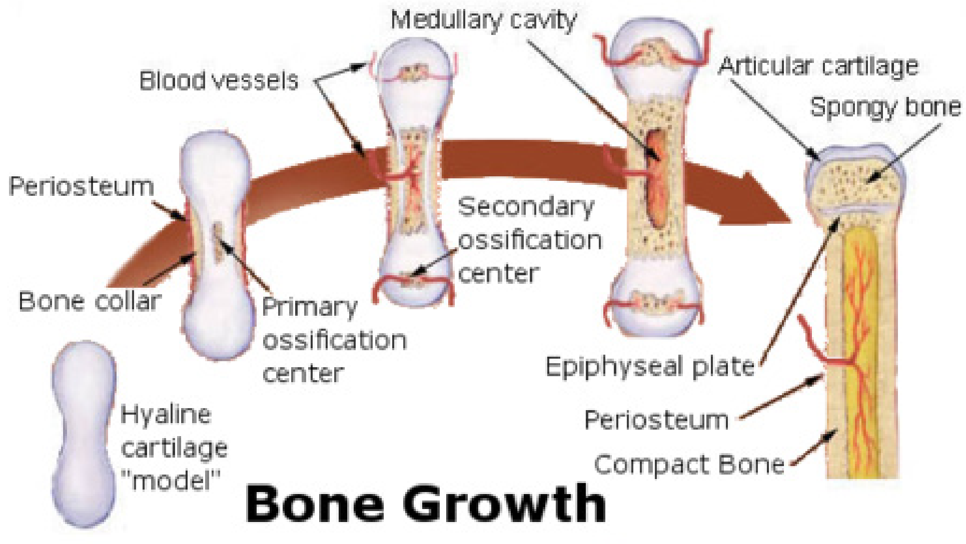
Actual range of thickness 0.5mm-4mm

Table 4. Range of values for epiphyseal thickness of femoral head in both male and female

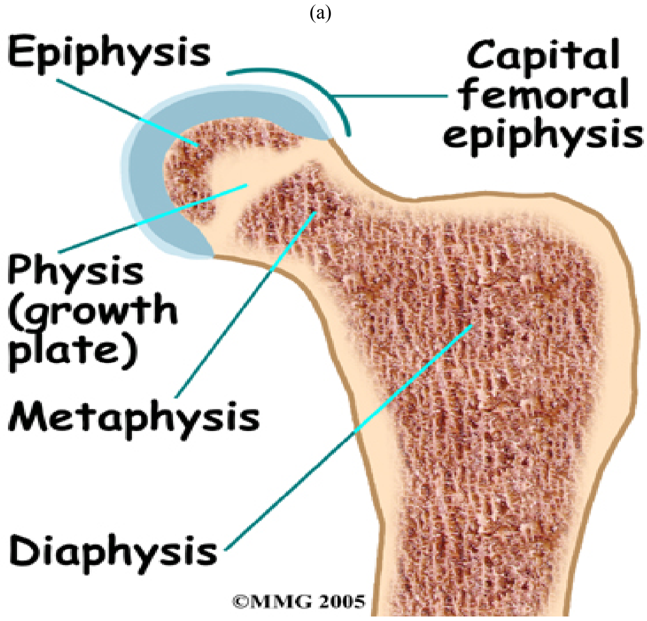
Age Group/ Years	Range mm
0-4	1-4
5-9	1
10-14	0.5-1
15-19	0.5

Table 5. Diagnostic calendar of Hip disorders

Age of Onset (year)	Probable diagnosis
O birth	Congenital dislocation
0-5	Infections
5-10	Perthes' disease
10-15	Slipped epiphyses



(a)



(b)

Figure 1. Showing schematic representation of Osteogenesis

REFERENCES

[1] Basener, CJ, Mehlman CT, Dipasquale, TG. Growth disturbance after distal femoral growth plate fractures in children: A meta-analysis. *J. Orthop Trauma 2009 (9): 663-7.*

[2] Brighton CT, Yoichi S, and Robert MH (1973), "Cytoplasmic structures of epiphyseal plate chondrocytes; quantitative evaluation using electron micrographs of rat costochondral junctions with specific reference to the fate of hypertrophic cells", *Journal of Bone and Joint Surgery*, 55-A: 771-784.

[3] Brighton CT, and Robert MH. (1986): "Histochemical localization of calcium in the fracture callus with potassium pyroantimonate: possible role of chondrocyte mitochondrial calcium in callus calcification", *Journal of Bone and Joint Surgery*, 68-A (5): 703-715.

[4] Byers S, Moore AJ, Byard RW, Faz. Quanlarri NL (2000) Quantitative histomorphometric analysis of the human growth plate from birth to adolescence. *Bone 2000, (4): 495-501.*

[5] Crock H.V (1965). A review of the anatomy of the arteries supplying the upper end of the human femur. J. Anat. (2):77-88.

[6] Faucet D.W (1994). A textbook of histology 12th edition Chapman and Hall. 194-218.

[7] Garret BR Hoffman EB, Carrara H. The effect of percutaneous pin fixation in the treatment of distal femoral physeal fractures*. J. Bone Joint Surg Br. 2011(5):689-94. doi: 10.1302/0301-620X.93B5.25422.*

[8] Hamilton W.J. textbook of human anatomy. McMillian Publishers (1987) Ltd 117-120.

[9] Ogden J.A Changing Pattern of Proximal femoral vascularity J. Bonest Sur.1974 56A:941-950.

[10] Seinsheimer F, Sledge CB. Parameters of longitudinal growth rate in rabbit epiphyseal growth plates. J Bone Joint surg., am. 1981, 63(4): 627-630.

[11] Netter, Frank H. *Musculoskeletal system: anatomy, physiology, and metabolic disorders*. Summit, New Jersey: Ciba-Geigy Corporation 1987 ISBN 0-914168-88-6, p. 130.

[12] Gilmore RS and Palfrey AJ Chondrocyte distribution in the articular cartilage of human femoral condyles. 1988 *J.Anat*. 157: 23-31.

[13] Byers S, Moore AJ, Byard RW, Faz. Quanlarri NL (2000) Quantitative histomorphometric analysis of the human growth plate from birth to adolescence. *Bone* 2000. (4): 495-501.

[14] Basener CJ, Mehlman CT, Dipasquale TG Growth disturbance after distal femoral growth plate fractures in children: a meta-analysis *J.Orthop Trauma* .2009 (9): 663-7.

[15] Ducheyne et al., *J. Biomech.,* 1977, 10:747-762.

[16] Hall et al., *J. Bone Joint Surg.* 1980, 3:408:413.

[17] Treppo et al., *J. Orthop Res.,* 2000, 18:739-748.

[18] Gilmore, RS Palfrey AJ. A Histological study of human femoral condylar articular cartilage. *J Anat*.1987; 155:77-85.

[19] Gilmore RS, and Palfrey AJ. Chondrocye distribution in the articular cartilage of human femora codyles *J Anat.* 1988;157:23-31.

[20] Barnett CH, Cochran W, Palfrey AJ, Age changes in articular cartilages of rabbits. *Ann Rheum Dis.* 1963;22:389-400.

[21] Davies DV, Barnett CH, Cochrane W, Palfrey AJ. Electron microscopy of articular cartilage in the young adult rabbit. *Ann Rheum Dis*. 1962;21:11-22.

[22] Engfieldt B, Hjertquist So, The effect of various fixatives on the preservation of acid glycosaminoglycan in tissues. *Acta Pathol Microbiol Scand.* 1967;71(2):219-232.

[23] Roy S, Meadrim G. Chondrocyte ultrastructure in the adult human articular cartilage. *Ann Rheum Dis*. 1968;27(6): 544-558.

[24] Stockwell RA. The interrelationship of cell density and cartilage thickness in mammalian articular cartilage. J Anat.1971; 109(pt3):411-421.

[25] Wilsman NJ, Van Sickle DC. Cartilage canals, their morphology and distribution. *Anat Rec*.1972;173(1):79-93.

[26] Seinsheimer .F. Sledge C.B. Parameters of longitudinal growth rate in rabbit epiphyseal growth plates. *J Bone Joint surg., Am*. 1981, 63(4): 627-630.

[27] Netter, Frank H. *Musculoskeletal system: anatomy, physiology, and metabolic disorders*. Summit, New Jersey: Ciba-Geigy Corporation 1987 ISBN 0-914168-88-6, p. 130.

[28] Kim *et al.,* Effects of disruption of epiphyseal vasculature on the proximal femoralgrowth plate *J Bone Joint Surg Am*. 2009;91(5):1149-58.

[29] Wall EJ, May MM. Growth plate fractures of the distal femur. *J. Pediatr Orthop*. 2012 Suppl 1:540-6.

[30] Mithoefer et al., High impact athletics after knee articular cartilage repair. A prospective evaluation of the microfracture technique. The Amer. J.Sports Medicine 34:1413-1418.