ORIGINAL ARTICLE

Determination of Gestational Age by Tibial Length using Ultrasound in A Nigerian Tertiary Hospital

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ABSTRACT

BACKGROUND: Determining fetal gestational age accurately is important to good obstetric care and outcome. Methods like measurement of symphysio-fundal height have been used but not accurate. With the advent of ultrasound, various fetal biometric parameters e.g. BPD, FKL, and fetal limbs are now being used.

AIMS AND OBJECTIVES: The aim of this study is to ultrasonographically evaluate the usefulness of fetal tibial lengths as an alternate to femur lengths in predicting gestational age from the second to third trimesters.

MATERIAL AND METHODS: A total of 500 pregnant Nigerian women between the GA of 13 to 41 week had ultrasound scan evaluation done at the fetal assessment unit of a Teaching Hospital. Fetal biometric parameters BPD, FL, and TL were measured and recorded against the calculated gestational age from the last menstrual periods.

RESULTS: There was a strong relationship between TL and EGA with a significant positive linear correlation (r= 0.915 P<0.05). For FL, r= 0.900 and for BPD r=0.906, all related to GA. The study has also shown a good correlation between TL and the other measured variables. For TL and FL, r=0.889 while TL and BPD r=0.867, making TL a substitute limb for limb measurement and as a pointer to a skeletal anomaly or delayed bone growth or dwarfs. The mean TL ranged from 13.47 mm at 13 week to 74.64 mm at 41 weeks of gestation.

CONCLUSION: This study has been able to justify the tibia as an important substitute for femur in the prediction of GA especially where the femur is susceptible to errors. (*Int J Biomed Sci* 2019; 12 (4): 104-111)

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INTRODUCTION

Assessment of Fetal Gestational Age (GA) is an important requirement for proper antenatal care (ANC) and outcome. This would prevent neonatal prematurity and reduce maternal mortality and morbidity that may result from undue induction of labour (1). As a result of this, adequate determination of GA with correlation to the various growing fetal body parts has evolved (2). The need for an accurate determination of GA has become necessary due to poor ability to keep dates in a developing country like Nigeria, even by literate women, making last menstrual period an unreliable means of determining GA. Methods that have been employed include plain abdominal radiography of the fetus in utero usually after the first trimester and ultrasonography. The hazards of X-radiation to organogenesis has made radiography obsolete (3).

Diagnostic imaging using ultrasonography has helped reduce hazards and widened the scope of GA determination using various growing fetal parts as parameters. Commonly used are Biparietal Diameter (BPD) (4), Femur length (FL), Abdominal Circumference (AC), Head Circumference (HC), Crown Rump Length (CRL), Fetal limb (humerus, radius, and ulna, tibia/fibula) (4, 5). Gestational Sac Diameter (GSD) (6), Crown Rump Length (CRL), and others such as ocular, binocular, interocular, fetal foot length (7), fetal renal length (8), ossification centers (Distal femur epicondyle, proximal tibia epicondyle) (9) have also been used.

Despite this wide variety of parameters, literature has established that a combination of parameters is best to increase accuracy in GA (2), which is widely practiced today. Ogunsina *et al* (2) and other reseachers (10) recommended BPD, AC, FL, HC for better accuracy.

Recent Practice now supports this method but the use of fetal limb has incorporated the femur length as the most commonly used limb measurement due to reproducibility and ease of identification (5). However, some studies have shown some possible errors in its use from 18 weeks GA to the third trimester (5, 11). Despite its widely accepted use, its easy variability at some gestational ages may mar its use in detecting skeletal anomalies like dwarfs in utero. Other studies done by some other authors like Exacoustor *et al* (11) has shown the tibia and fibula as the most consistently growing bones two weekly, with a minimal decreased rate in the second to third trimesters.

Khalid Shehzad *et al* (12) in Pakistan used various fetal biometric parameters and showed in the limbs that the femur is the fastest growing bone on a weekly bases and the tibia two weekly and most consistent in rate. This has predisposed the femur to possible errors and not reliable in early detection of skeletal anomalies.

Queenan *et al* (5) were also able to show that the femur showed some evidence of mild physiological bowing often after the 18 weeks of gestation which could make it prone to some errors. The attraction to the use of the tibial length (TL) is not only for gestational age but also for detecting skeletal long bone anomalies and dwarfs initiated this study.

Fernando *et al* (13) used the tibia in detecting dwarfs and tibia hypoplasia. Zeba Khan *et al* (14) and Fezekas and Kosa (15) also carried out studies in India and Hungary to determine a nomogram for the fetal limbs in their environment.

In our environment, there have been no studies correlating tibia length with GA in recent times. This has made it important to ascertain the normal tibial length in this environment as compared with that in the Caucasians. This study, therefore, seeks to provide a preliminary data upon which more extensive study will be carried out in the future. The result obtained from this study would also serve as a guide for the diagnosis in utero of dwarfs with limb shortness such as in achondroplasia.

It attempts to develop a nomogram for ultrasonographically measured tibia lengths between 13 to 41 weeks of gestation.

MATERIAL AND METHODS

Selection of patients

Population for the study was from women attending Antenatal Clinic referred to the Fetal Assessment Unit of University of Ilorin Teaching Hospital for ultrasonic evaluation of normal pregnancy. The period of study was twelve months from November 2006 to 2007.

Ethical approval and informed consent

Ethical approval for this study was obtained from the Ethical Review Committee of the Hospital. Approval and informed consent of every participating patient was obtained before the recruitment of each patient was commenced.

Sample size determination

The sample size was determined by Fischer's method:

$$n = \frac{Z^2Pq}{d^2}$$

Since there are no published data on the prevalence of normal fetal tibial length amongst Nigerians, 50% for the normal population was used to calculate the sample size.

From the above formula, therefore,

$$n = \frac{1.96^2 \times 0.5 \times (1 - 0.5)}{0.05^2} = 384.16$$

Using the formula for a sample size less than 10,000 as below:

$$n_f = \frac{n}{1 + (n / N)}$$

The final sample size calculated was 292. Since most patients were scanned only once during the pregnancy, a sample size of about 500 was considered to help develop a cross-sectional study of population.

Inclusion Criteria

This include:

• Singleton,

• Uncomplicated pregnancy and history of regular cycles with known last menstrual period.

Exclusion Criteria

This include:

• Patients unsure of LMP,

• Patients on a drug for chronic illnesses such as hypertension and diabetes that would affect fetal growth,

• Multiple gestations,

• Congenital anomalies (skeletal dysplasias and dwarfs).

• Patient with evidence of intrauterine growth retardation

• Macrosomic fetuses.

Methodology

Transabdominal ultrasound studies were performed using the available real-time ultrasonographic machine (Siemens Sonoline SX) with a 3.5-5.0 MHz sector transducer. The acoustic gel was used as a coupling medium. Patients were scanned in a supine position. Occasionally, a left lateral decubitus position was used to help relieve the compression effect of the gravid uterus on the inferior vena cava in cases of advanced pregnancy and prolonged scanning.

Scanning was done using the longitudinal, transverse, and sometimes oblique planes. Tibial length measurements were taken across the two blunt ends, a technique described by Queenan *et al* (5), after identifying the tibia and fibula.

Fetal lie and presentation were delineated first by a longitudinal plane scan using the fetal spine. The tibia and fibula bones appear as highly echogenic linear structures, parallel to each other and casting acoustic shadows distal to the buttocks. Both are shorter and thinner than the femur bone towards the late second and third trimesters. The tibia is medial in position and slightly thicker. They are both separated by an anechoic free space. Other landmarks to their specification are that they are equal in length, unlike the radius and ulna. Longitudinal and parallel measurements of the tibia were taken in a freeze frame in relation to the fibula. Tibia lengths were taken between the two blunt ends or between the medially cast acoustic shadows. Proximal tibia epiphysis seen at 29 wks to 36 wks was not included in the measurement (16).

The biparietal diameter (BPD) was measured from outer to inner edges in a transverse image of the fetal skull at the level of the thalamus and cavum septum pelludium as described by Campbell (17).

The femur length measurement was made from the major trochanter to external condyle according to the technique described by O' Brien *et al* (18).

Data collection and statistical analysis

Measured fetal Tibia lengths, Biparietal Diameter, Femur length were tabulated against derived estimated GA from predetermined last menstrual period (LMP). The data collected were expressed as mean and standard deviation (SD). The mean of each class of GA was compared with the GA in the table in Caucasians as was being used in our department.

Data was fed into the computer and analyzed with the Standard Package for Social Sciences (SPSS) version 11 software. Multivariate analysis was also done where necessary.

RESULTS

A total of 500 patients and 1500 measurements were made.

The mean age of women scanned was 30.00 ± S.D. 6.21 years and their mean parity was 2.00 ± S.D. 1.20 as shown in Table 1.

A Frequency table for different values of TL with a comparison with other biometric indices BPD and FL is shown in Table 2.

The changes in fetal BPD starts from a mean of 25.40 ± 2.530SD mm at 13 week to 100.01 ± 241.592SD mm at 41 weeks giving a mean growth of 66.38 mm for this period. The fetal FL also grew from a mean of 13.60±0.632SD

Table 1. DISTRIBUTION BY AGE AND PARITY

Variable	Frequency	Percentage
Maternal Age		
15-24	67	13.4
25-34	347	69.4
35-44	77	15.4
45-54	7	1.4
≥55	2	0.4
Parity		
0	63	12.6
1	260	52.0
2	88	17.6
3	45	9.0
4	31	6.2
5	9	1.8
6	3	0.6
7	1	0.2
Total	500	100

Mean for Maternal Age is 30.00 ± S.D. 6.208, Mean for Parity is 2.00 ± S.D. 1.205.

Table 3. SHOWING THE COMPARATIVE MEAN TL VALUES FROM DIFFERENT OTHER STUDIES

Fetal GA in weeks	Zeba Khan *et al*	Queenan *et al*	Present Study
13	-	12.10	13.47
15	-	17.80	18.60
16	15.50	22.20	22.10
17	-	23.40	24.17
19	-	28.30	26.75
20	46.00	30.70	29.75
21	-	33.90	32.30
22	-	37.30	33.89
24	37.5	-	39.40
28	48.75	-	47.42
32	55.50	-	53.70
36	64.00	-	59.85
40	68.50	-	67.80

mm at 13 week to 78.00 ± 8.210SD mm at 41 week with a mean growth of 50.05 mm. The mean fetal TL increased from 13.47 ± 0.516SD mm at 13 week to 72.64 ± 7.814SD mm at 41 week with a mean growth of 20.11 mm.

A comparison table of the present study of the mean TL and those done by Zeba *et al* and those obtained by Queenan *et al* are also shown in Table 3.

The standard deviation (SD) of the recorded mean values for BPD, FL, and TL were calculated as shown in Table 4 and correlated. In order to assess the linear relationship between the estimated GA and the various biometric measurements of BPD, FL, and TL a significance test P value was also was set at P values≤ 0.05 is significant while > 0.05 is not significant.

Figure 1 illustrates the relationship between TL, BPD, FL and estimated GA. There is a steady increase in TL from about the 19th week to 41 week with a mean growth rate of about 2 mm weekly. A maximum mean growth value of 72.64 mm was obtained.

A comparative study of BPD, FL, and TL against estimated GA showed an initial correspondence between the FL and TL until about the 16th week of gestation where they varied. There was also a slight variation in the FL with an initial tip down at about the 20th week (31.75 mm) and an increase again at the 21st week (34.74 mm) up to the 37th week on to 40th week when compared to the TL whose growth was consistent until its peak at 41 week (72.64 mm).

A stronger correlation of TL to EGA was noted with an rvalue 0.915 while BPD and FL were r=0.906 and 0.900. However, correlated mean variables showed a good correlation between TL and BPD r=0.867, P ≤0.05 and TL and FL r=0.889, P ≤0.05as shown in Table 4.

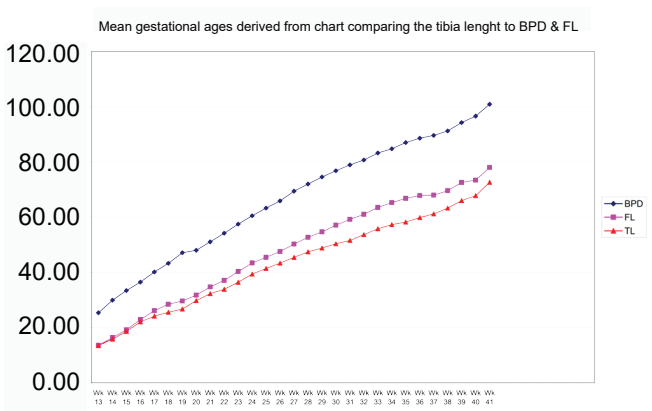

Figure 1. A Line Graph of Mean gestational ages derived from chart comparing the TL to BPD and FL.

Table 2. SHOWING THE MEAN ESTIMATED GA AND THE TL OBTAINED FROM PATIENTS ON ANC IN UITH ILORIN COMPARED WITH THAT OF BPD AND FL

EGA Weeks	No of Measurement (f)	Variables	Mean ± S.D. of TL, BPD, FL calculated from the chart in mm	T	p-value
13	15	BPD	25.40 ± 2.530	18.984	0.000
		FL	13.60 ± 0.632	3.674	0.003
		TL	13.47 ± 0.516	3.500	0.004
		GA	13.00 ± 0.00		
17	6	BPD	40.17 ± 1.169	48.541	0.000
		FL	26.17 ± 0.983	13.984	0.000
		TL	24.17 ± 0.408	43.000	0.000
		GA	17.00 ± 0.000		
21	23	BPD	51.09 ± 1.881	76.717	0.000
		FL	34.74 ± 1.137	57.957	0.000
		TL	32.30 ± 0.635	85.38	0.000
		GA	21.00 ± 0.000		
25	14	BPD	63.29 ± 0.469	305.567	0.000
		FL	45.43 ± 1.158	66.015	0.000
		TL	41.43 ± 0.514	119.696	0.000
		GA	25.00 ± 0.000		
29	18	BPD	74.56 ± 0.511	378.001	0.000
		FL	54.67 ± 0.907	119.996	0.000
		TL	48.83 ± 0.383	219.425	0.000
		GA	29.00 ± 0.000		
33	33	BPD	83.24 ± 0.614	470.130	0.000
		FL	63.55 ± 0.109	160.639	0.000
		TL	55.79 ± 0.857	152.708	0.000
		GA	33.00 ± 0.000		
41	11	BPD	100.01 ± 2.415	1.821	0.000
		FL	78.00 ± 8.210	14.947	0.000
		TL	72.64 ± 7.814	13.428	0.000
		GA	41.00 ± 0.000		

Table 4. CORRELATIONS BETWEEN VALUES OF EGA, TL, BPD, AND FL

Correlations						
			TL	FL	BPD	EGA
Spearman's rho	TL	Correlation Coefficient	1.000	0.889**	0.867**	0.915**
		sig. (2-tailed)	.	0.000	0.000	0.000
		N	500	500	500	500
	FL	Correlation Coefficient	0.889**	1.000	0.922**	0.900**
		sig. (2-tailed)	0.000	.	0.000	0.000
		N	500	500	500	500
	BPD	Correlation Coefficient	0.867**	0.922**	1.000	0.906**
		sig. (2-tailed)	0.000	0.000	.	0.000
		N	500	500	500	500
	EGA	Correlation Coefficient	0.915**	0.900**	0.906**	1.000
		sig. (2-tailed)	0.000	0.000	0.000	.
		N	500	500	500	500

**Correlation is significant at the 0.01 level (2-tailed).

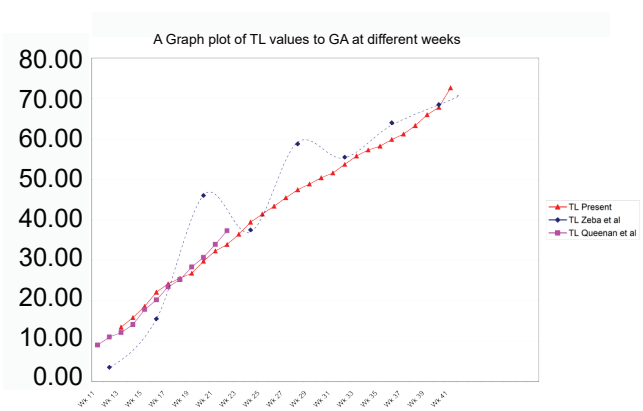

Figure 2. Line graph of TL values from various studies to GA at different weeks.

Comparative TL values from other studies at different EGAs in weeks with those of the present study were done (Figure 2). The values of the present study were shown to be more in concordance with those done by Queenan *et al*.

DISCUSSION

Gestational age in the early trimester can be accurately determined by GSD and gestational sac volume, Fetal CRL and in the second to third trimesters a combination of biometric indices to improve accuracy (2, 6). These could be BPD, FL, or TL as fetal limbs, HC, AC, FKL, etc.

The inclusion of the fetal limbs over the years made the FL the most widely accepted measurement due to its reproducibility and ease of identification of the femur (2).

TL measurements provide an obvious added advantage if substituted for FL because apart from its reliability in dating, it aids as a marker for dwarfs and skeletal anomalies. These would sensitize the obstetrician at the right time for intervention if need be.

A comparison of the present study with those of Zeba *et al* (14) (in an Indian population comparable to Nigerian population) and those done by Queenan *et al* (5) (in England, London a Caucasian population) Table 3, showed that the TL between 13 to 41 week in Nigerian fetuses had a lower value to those of the Indians ($r=0.904$, $P<0.05$) and higher and approximated to the Caucasian value ($r=0.994$, $P<0.05$). However, a concordance with a growth rate between the 4th to 6th months was noted as documented by Zeba *et al* (14).

Variations may be due to racial reasons and the higher social status of the women included in this study which was hospital-based and not a true representation of the society at large.

Queenan *et al* (5) also reported a diagnosis at 16weeks of a diastrophic dwarfism syndrome using the fetal limb and the tibia classical but this study did not emphasize on

skeletal anomaly or was any reported.

Variations in measurement time could also be attributed to low birth weight in Nigerian fetuses compared with the Caucasians (19).

Other reason could be the type of study (longitudinal or cross-sectional). Zeba *et al* (14) did a cross-sectional study while Queenan *et al* did a longitudinal study this could however not explain the similarities with the present study. The number of operators (single or multiple), Estimation of values (e.g GA rounded or exact) and also the quality of the machine used.

Though the femur is easier to assess during fetal limb measurement, the tibia identification and measurement may prove some difficulty and needs experienced hands to overcome certain geometric hindrances observed like bone overlap.

In the event of this study, it must be acknowledged that difficulty in identifying the tibia was occasionally encountered especially in cases of breech presentation. This also leads to discrepancies in measurement and reduction of its reliability. This was however overcome with repeated measurements taken in different planes and angles as advocated by Queenan.

At 18weeks of gestation BPD mean value was 43.29 mm while FL had a mean value of 28.43 mm and TL showed 25.57 mm. This point is significant when a comparative study of Queenan *et al* (5) was considered and physiological bowing was noted in Caucasians. Exacoustor *et al* (11) from this point was able to diagnose skeletal anomalies, however, none of this was noted in this present study.

The mean values for BPD at 5th and 10th month were 48.00 mm and 96.60 mm and for TL 29.75 mm and 67.80 mm while FL was 31.75 mm and 73.40 mm respectively. A comparative study to that done by Zeba *et al* (14), Warren *et al* (20) and Fekoza *et al* (15) in Indians, Americans and Hungarians respectively showed that the values were in more accordance with those of Warren and Fekoza as documented by Zeba *et al*. This could be due to racial factors.

This study has shown that using the fetal limb bones measurement of either TL or FL as additions to other biometric fetal indices is accurate in the determination of gestational age in the second to third trimesters with the TL showing a higher correlated value r=0.915 while FL, r=0.900. Also, the consistency in growth of the tibia with little variation has put it as a marker for detection of skeletal anomalies and dwarfs (Figure 3).

Despite all this advantage, this study has not conclusively replaced the use of femur length as a combined limb with other biometric indices like BPD and AC in predicting GA (Figure 4). However, the use of tibial length would serve as an early pointer to any form of skeletal long bone anomalies or dwarfs in utero.

CONCLUSION

This study has been able to justify the tibia as an important fetal limb that can substitute the femur in the prediction of GA especially where the femur is susceptible to errors. It also showed a good correlation between the tibia length and gestational age in our own population (r=0.915 P<0.05).

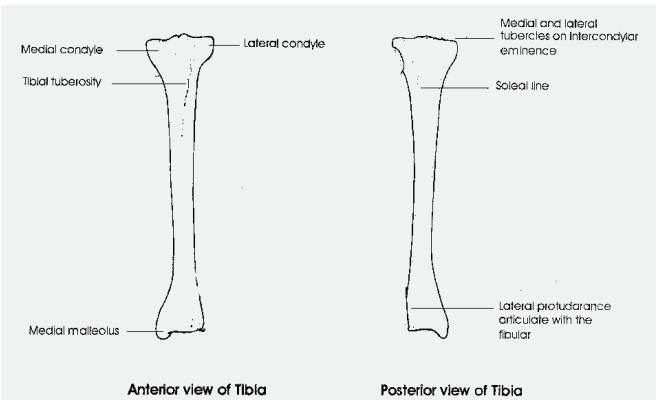

Figure 3. Schematic diagram of the tibia.

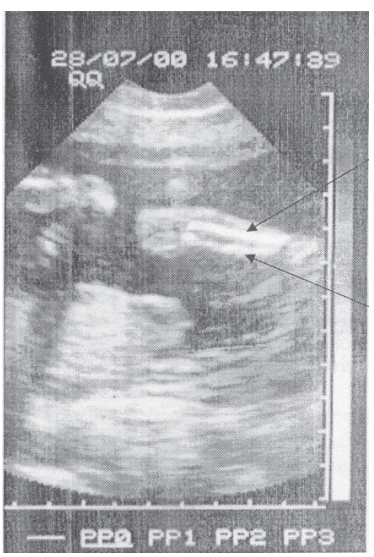

Figure 4. Trans abdominal ultrasound of the fetus in utero showing the Tibia and Fibular.

It also established the normal range of ultrasound measurements of tibia lengths each week of pregnancy from 13th week to 41st week of gestation.

However, the values cannot adequately serve as a chart for dating pregnancy in Nigeria until more studies with larger data are carried out.

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