

Research Article**Fetal Foot Length for Assessment of Gestational Age: A Comprehensive Study in North India****Vishnu Datt Pandey¹, Vishram Singh², G L Nigam³, Yasmeen Usmani⁴, Yogesh Yadav^{5*}**¹Lecturer, Department of Anatomy, LLRM Medical College, Meerut, UP, India²Professor & Head, Department of Anatomy, Santosh Medical College, Ghaziabad, UP, India³Assistant Professor & Head, Department of Anatomy, LLRM Medical College, Meerut, UP, India⁴Assistant Professor, Department of Radiodiagnosis, SVBP Hospital, LLRM Medical College, Meerut, UP, India⁵Associate Professor, Department of Anatomy, Rama Medical College, Hapur, UP, India***Corresponding author**

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Abstract: Appropriate assessment of gestational age is paramount in obstetric care. Making appropriate management decisions requires accurate appraisal of gestational age. Accurate pregnancy dating may assist obstetricians in appropriately counseling women who are at risk of a preterm delivery about likely neonatal outcomes and is also essential in the evaluation of fetal growth and the detection of intrauterine growth restriction. The purpose of this study is to find out the other parameters such as foot length which can be used to determine the gestational age either more accurately or can be used in other conditions where the previous parameters are unreliable and can also be used as an adjunct in the diagnosis of many karyotypic defects and syndromes. This study is a part of Ph. D thesis of first author under supervision of the second author. Ultrasonographic measurement of Foot Length of 100 pregnant women was done in the Radio diagnosis Department. Sonographically we measured foot length from 15 to 36 weeks of gestation. In our study the earliest age at which fetal foot length could be seen sonographically was found to be 15 weeks of gestation and mean foot length is 17.5 ± 1.29 and mean sonographic foot length at 36 weeks of gestation is 64.4 ± 3.28 . From regression analysis a strongly significant relationship has been observed between fetal foot length and gestational age.**Keywords:** Gestational age, Fetal foot length, Ultrasonographically age estimation

INTRODUCTION

Appropriate assessment of gestational age is quintessential in obstetric care. Making appropriate management decisions require accurate knowledge of gestational age. Accurate knowledge of gestational age may assist obstetricians in appropriately counseling women who are at risk of a preterm delivery about likely neonatal outcomes and is also essential in the evaluation of fetal growth and the detection of intrauterine growth restriction. Accurate pregnancy dating is also important in the interpretation of biochemical serum screening test or for counseling patients regarding the option of pregnancy termination [1]. Since clinical data such as the menstrual cycle or uterine size often are not reliable, the most precise parameter for pregnancy dating should be determined by the obstetrician by ultrasound. Ultrasound is an accurate and useful modality for the assessment of gestational age in the first and second trimester of pregnancy and, as a routine part of prenatal care, can modify obstetric management and improve antepartum care. For last 30 years, many equations regarding the relationship between fetal biometric parameters

{gestational sac mean diameter, crown rump length, femur length (FL), biparietal diameter (BPD) and abdominal circumference (AC)} and gestational age have been described. It has been proven that early antenatal ultrasound is an objective and accurate means of establishing gestational age [1].

If the head is unusually rounded (brachycephalic) or unusually elongated (dolicocephalic), BPD measurements would overestimate or underestimate gestational age. Variation in AC measurements in macrosomic and growth-retarded fetuses occurs due to differences in liver size and width of subcutaneous tissue has been observed [18]. Femur achondroplasia leads to underestimation of FL and therefore, of gestational age.

In 1920, Streeter had shown that fetal foot has a characteristic pattern of normal growth and proposed that the fetal foot could be used to estimate gestational age [2].

Boehm [3] had described the development of the foot in 4 stages:

- Stage one (second month): The foot is in ninety degrees equinus and adducted.
- Stage two (beginning of third month): The foot is in ninety degrees equinus, adducted, and markedly supinated.
- Stage three (middle of third month): The foot dorsiflexes at the ankle, but a mild degree of equinus is still present and marked supination persists. The first metatarsal remains adducted. This stage corresponds to the fetal period of development.
- Stage four (beginning of fourth month): The foot pronates and reaches a position of mid-supination. A slight metatarsus varus remains. The equinus is not present [3].

Campbell *et al.* [4] had evaluated the fetal femur/foot length ratio and observed it to be a useful parameter to differentiate fetuses having dysplastic limb reduction from those whose limbs are short because of constitutional factors or intrauterine growth retardation.

Warren M Hern *et al.* [5] used foot length as the independent variable, scatter plots and regression analysis. They showed that the foot length to have a linear relationship to knee-to-heel length with a correlation of 0.985; a curvilinear relationship to biparietal diameter, the increase in biparietal diameter decreasing with foot length; a curvilinear and almost exponential relationship with fetal weight, fetal weight increasing dramatically with foot length; a linear relationship to placental weight, with considerable variance in placental weight; and a more or less linear relationship to amniotic fluid volume.

Mercer *et al.* [6] reported fetal foot length as a reliable parameter for the estimation of gestational age and particularly useful when other parameters cannot accurately predict gestational age as in cases of hydrocephalus, anencephaly or short-limb dwarfism.

So, the purpose of this study is to determine the accuracy of fetal foot length in estimating gestational age and correlating it with the previously approved parameters such as biparietal diameter, femur length and abdominal circumference.

MATERIAL AND METHODS

The present study was conducted in the Department of Anatomy, Santosh Medical College & Hospital in coordination with the Department of Anatomy & Radio diagnosis Department of L.L.R.M. Medical College, Meerut and NMC Sky center attached to S.V.B.P. Hospital, L.L.R.M. Medical College Meerut. In pregnant women attending the OPD during 2nd and 3rd trimester for routine checkups. The present study was done in 100 normal pregnant women who were sure about their last menstrual period, had regular menstrual cycle, not experienced any vaginal bleeding since becoming pregnant; no one had taken oral contraceptives for at least 3 months before conception, having singleton apparently normal fetuses between 16 to 36 weeks of gestation and no medical pathology.

Ultrasonographic measurement of Foot Length was done without prior knowledge of gestational age and then the gestational age was confirmed by an early abdominal ultrasound by biparietal diameter, femur length and abdominal circumference. The standard methods of obtaining the foot length, biparietal diameter, femur length and abdominal circumference were employed.

RESULTS

The present study was conducted in 100 pregnant women between 15 to 36 weeks of gestation, attending the OPD for 2nd and 3rd trimester routine checkups, in the department of Radio diagnosis, L.L.R.M. Medical College and associated S.V.B.P. Hospital Meerut.

Sonographically we measured foot length from 15 to 36 weeks of gestation. In our study the earliest age at which fetal foot length could be seen sonographically was found to be 15 weeks of gestation and mean foot length is 17.5 ± 1.29 and mean sonographic foot length at 36 weeks of gestation is 64.4 ± 3.28 (Table 1). Along with foot length biparietal diameter (BPD), Femur length (FL), abdominal circumference (AC) also measured for comparison (Table 1, Fig. 2).

From regression analysis a strongly significant relationship has been observed between fetal foot length and gestational age (Fig. 1, Table 3).

$$y = 7.130 + 0.503 x$$

where,

$$y = \text{gestational age in weeks}$$

$$x = \text{foot length in mm}$$

Table 1: The Mean Values And Standard Deviation of Foot Length (Ftl), Biparietal Diameter (BPD), Femur Length (FL), and Abdominal Circumference (AC) at Weekly Intervals From 15 to 36 Weeks of Gestation.

GA	No. of Cases	Mean FTL ± SD	Mean BPD ± SD	Mean FL ± SD	Mean AC ± SD
15	4	17.50 ± 1.29	30.00 ± 1.41	15.75 ± 1.70	95.00 ± 3.82
16	4	19.75 ± 0.50	32.75 ± 1.89	20.50 ± 0.57	104.0 ± 2.82
17	4	20.00 ± 0.81	37.25 ± 0.95	23.25 ± 0.95	111.2 ± 6.99
18	5	22.60 ± 2.96	40.60 ± 0.89	27.80 ± 0.44	116.4 ± 4.09
19	4	25.75 ± 0.50	45.25 ± 0.95	30.50 ± 1.00	124.5 ± 2.51
20	6	26.66 ± 1.96	47.66 ± 0.81	33.33 ± 1.21	144.0 ± 4.19
21	4	28.00 ± 0.81	55.00 ± 0.81	34.00 ± 0.81	155.0 ± 2.58
22	5	30.20 ± 1.09	56.80 ± 0.83	37.20 ± 1.30	173.2 ± 2.77
23	4	32.50 ± 1.00	58.00 ± 0.81	40.66 ± 1.00	181.0 ± 2.58
24	5	34.80 ± 0.83	61.00 ± 1.41	42.60 ± 0.89	196.2 ± 3.63
25	4	35.75 ± 0.50	62.00 ± 1.41	45.50 ± 1.00	200.7 ± 4.85
26	5	35.80 ± 2.28	65.20 ± 1.64	49.20 ± 1.30	216.4 ± 5.77
27	4	36.25 ± 2.06	65.00 ± 1.15	51.50 ± 1.00	225.5 ± 5.00
28	6	37.33 ± 1.21	71.66 ± 3.07	54.00 ± 2.52	231.1 ± 11.5
29	5	41.20 ± 1.09	74.80 ± 0.83	54.40 ± 1.14	255.4 ± 5.45
30	5	43.40 ± 1.34	75.00 ± 1.00	57.40 ± 0.89	272.8 ± 3.34
31	4	45.50 ± 2.38	78.75 ± 0.95	58.75 ± 0.95	271.5 ± 5.97
32	5	47.00 ± 2.00	79.20 ± 0.83	62.40 ± 2.07	288.2 ± 9.70
33	4	49.00 ± 3.46	83.50 ± 2.51	63.00 ± 2.58	294.0 ± 3.74
34	4	51.25 ± 0.95	85.00 ± 0.81	66.25 ± 0.50	304.0 ± 4.32
35	4	58.75 ± 4.78	87.25 ± 1.50	69.25 ± 1.70	312.7 ± 3.40
36	5	64.40 ± 3.28	89.80 ± 1.48	72.60 ± 1.34	325.6 ± 6.22

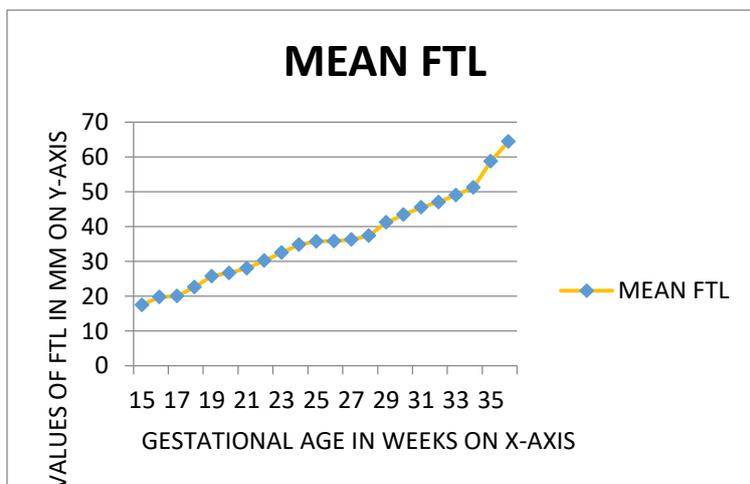


Fig. 1: The graph plotted the mean values of foot length against gestational age which shows linear increase in FTL as pregnancy progresses from 15 to 36 weeks of gestation

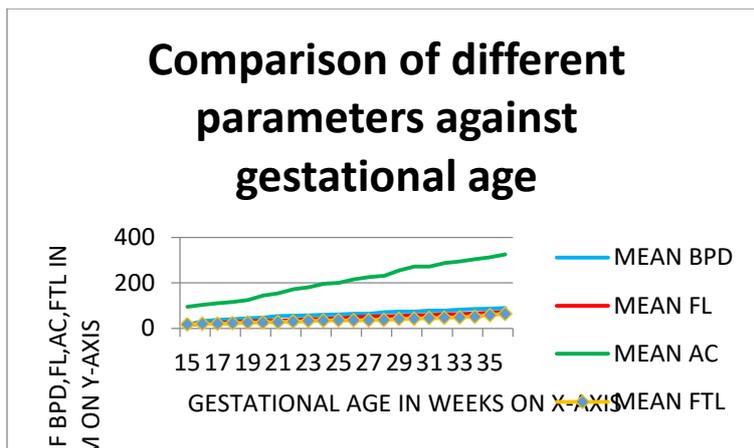


Fig. 2: The graph plotted the mean values of FTL, BPD, FL, AC against gestational age and compare the linear increase in different parameters as pregnancy progresses from 15 to 36 weeks of gestation

Table 2: Comparison between Values of Present Study with Previous Studies

GA	Present Study (2013)	Family Practice Notebook	Molly S. Chatterjee et al (1994)	Andrzej M. bulandra et al (2003)	Rajesh Bardale et al (2008)	Jowita Wozniak et al (2009)
15	17.50 ± 1.29	18	20	19.75±1.05	21.4±0.88	-
16	19.75 ± 0.50	20	22	18.94±1.92		10.3±2.8
17	20.00 ± 0.81	23	25	22.63±2.47	32.1±0.54	-
18	22.60 ± 2.96	26	27	24.70±1.96		-
19	25.75 ± 0.50	29	30	29.19±2.62		-
20	26.66 ± 1.96	33	32	30.90±4.91		17.8±3.8
21	28.00 ± 0.81	36	35	35.38±2.91	42.6±0.45	-
22	30.20 ± 1.09	39	37	39.01±2.05		-
23	32.50 ± 1.00	42	40	43.16±3.91		-
24	34.80 ± 0.83	45	42	45.80±4.51		-
						26.6±6.6

Table 3: Predicted Values of Various Parameters (FTL, BPD, FL, AC)

Parameters	Intercept		Slope		R Square	Adjusted R Square	P Value
	Estimate	Standard Error	Estimate	Standard Error			
Foot Length	7.130	0.882	0.503	0.023	0.960	0.958	<0.0001
Biparietal Diameter	5.440	0.628	0.323	0.014	0.949	0.949	<0.0001
Femur Length	7.564	0.352	0.391	0.007	0.993	0.993	<0.0001
Abdominal Circumference	7.325	0.298	0.087	0.001	0.995	0.995	<0.0001

DISCUSSION

In the present study fetal foot length showed good correlation with gestational age with correlation coefficient 0.960 with p<0.0001. Goldstein I, Reece EA, Hobbins JC *et al.* [7] found a significant correlation between fetal foot length and gestational age (r = 0.9, p less than 0.0001) and between fetal foot length and femur length (r = 0.9, p less than 0.0001) however in the present study correlation coefficient between fetal foot length and gestational age (r=0.960, p<0.0001) and between fetal foot length and femur length (r=0.948, p<0.0001) was found to be higher, thus making the present study more reliable.

The variation in values in our study are lower or higher as shown in Table 2 is due to significant racial and socioeconomic differences between individuals of the present study and that of previous studies. Table-2 shows the comparison between the values of Fetal Foot Length of present study with standard values of Family Practice Notebook maintained by Scott Moses, MD, a board-certified Family Physician practicing in Lino Lakes, Minnesota [8] with previous studies done by Molly S. Chatterjee *et al.* [9], Andrzej M. Bulandra *et al.* [10], Rajesh Bardale *et al.* [11] and Jowita Wozniak *et al.* [12].

Similar evaluation of the relationship between fetal foot length and the menstrual age was performed by Platt LD *et al.* [13]; models were best described by a linear equation. An R² value of 0.94, with a standard error of the estimate of 0.204, was obtained for menstrual age versus fetal foot length. When the model for fetal foot length and menstrual age was compared with present study, close agreement was seen. Our results suggest that the measurement of fetal foot length with ultrasound gives a reliable assessment of anatomical fetal foot length and is highly correlated to the menstrual age of the fetus.

R. Mhaskar *et al.* [14] in 1989 demonstrated a strong correlation on comparison of linear regression of foot length versus gestational age with an r² value of 0.84 (P < 0.001) which is comparatively much lesser than the present study showing r² value of 0.960 (p<0.0001) although both studies are consistent.

Molly S. Chatterjee *et al.* [9] in 1994 similarly showed significant linear relationship between fetal foot length and gestational age (R²= 0.89, p<<0.0001).

Ji E K [15] in 2001 concluded that fetal foot length during the second trimester of a normal pregnancy in Korean women is a reliable parameter for use in the assessment of gestational age. The normogram depicted in his study serve as a useful adjunct in the screening of chromosomal abnormality or skeletal dysplasia among Koreans.

Andrzej M Bulandra *et al.* [10] in 2003 found the value of the correlation index between foot length and femur length was 0.91, while between foot length and humerus length was 0.96 and between foot length and fetal age was 0.94 in close association with our study.

A. Smolin *et al.* [16] in 2008 investigate the influence of fetal gender on the foot length throughout gestation. After controlling for gestational age the difference between male and female is 0.304 mm and is not significant (P = 0.59). Therefore he concluded that the absence of statistically significant correlations between foot length measurements throughout gestation and fetal gender indicate that sonographic reference value for fetal foot length may be suitable regardless of fetal gender.

M.C. Lutterodt *et al.* [17] in 2009 correlated foot length linearly to embryonic and fetal age, and was unaffected by gender, environmental tobacco smoke, maternal smoking and alcohol consumption.

On comparing the results of the present study with that of previous researches we concluded that the present study is concordant with that of previous studies. Nevertheless high correlation coefficient

(0.960) and comparatively lesser standard error (1.3) make this study more reliable.

Since the present study also compared the foot length with the more recognizable previously used parameters such as biparietal diameter, femur length and abdominal circumference, a higher association was found between femur length, abdominal circumference with that of gestational age as compared with foot length and biparietal diameter.

CONCLUSION

In the normally developing fetus the fetal foot length increases with advancing gestational age. Fetal foot length is a good marker for gestational age especially in cases of femur achondroplasia, dolichocephaly or brachycephaly and in cases who are not sure about their L.M.P. Fetal foot length can be used as an investigational tool in the determination of gestational age in the late second and third trimesters of pregnancy. Fetal foot length was particularly useful when other parameters did not accurately predict gestational age, e.g., in cases of hydrocephalus, anencephaly or short-limb dwarfism.

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