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Estimation of Gestational Age by Sonographic Measurement of Foetal Foot Length–A Cross-Sectional Study

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Abstract | **Original Research Article**

Introduction: Gestational age assessment is of paramount importance in obstetric care. It helps in pregnancy management from the first trimester to delivery. The three basic methods used to help estimate gestational age are menstrual history, clinical examination, and ultrasonography. Traditionally biparietal diameter, femur length, head circumference, and abdominal circumference have been used to estimate gestational age. The purpose of this study is to find out whether foot length can be used to determine the gestation age more accurately and to explore the relationship of foetal foot length with other foetal measurements between 16 to36 weeks' gestation. ***Methods:*** 500 women with singleton viable normal pregnancy and willing to participate in the study were included. Ultrasonographic measurement of foot length and other parameters was done. Data were analyzed. ***Results:*** The mean foetal foot length at 16 weeks and 36 weeks was 21.59±1.79 mm and 71.88±2.61 mm respectively. A strong significant linear relationship between foot length and gestational age was observed. The foetal FT showed a significant linear correlation with biparietal diameter, femur length, head circumference, and abdominal circumference (P<0.0001). ***Conclusion:*** Foetal foot length shows a good correlation with gestational age (pearson's correlation coefficient = 0.97, p value<0.0001). Foetal foot length can thus be used as an alternative foetal parameter to assess gestational age especially in cases of wrong dates or when other routine parameters are not conclusive or did not accurately predict gestational age for e.g, in cases of hydrocephalus, anencephaly or short limb dwarfism.

Keywords: Foot length, Gestational age, and ultrasonography.

INTRODUCTION

The accurate assessment of gestational age is the cornerstone for antenatal care and pregnancy management from the first trimester to delivery. Accurate gestational age is essential to calculate estimated date of delivery, foetal viability, to predict the outcomes of birth as preterm, intrauterine growth restriction, term or post term [1, 2].

Uncertain gestational age has been associated with adverse pregnancy outcomes including low birth weight, spontaneous preterm delivery and perinatal mortality, independent of maternal characteristics.

The three basic methods used to help estimate gestational age (GA) are menstrual history, clinical examination, and ultrasonography. The first two are subject to considerable error and should only be used when ultrasonography facilities are not available.

Traditionally, determining the first day of the LMP is the first step in establishing the EDD. By convention, the EDD is 280 days after the first day of the LMP. LMP dating is a simple and low-cost method, for a woman having regular menstrual cycle of 28 days and may cause an inaccuracy of 1–4 weeks [3]. Symphysis-Fundal height measurement is most accurately measured around 20 weeks of gestation when the fundus is above the symphysis [4]. Clinical estimates of gestational age requires technical skills [5]. The date of feeling the first foetal movements (quickening) is far too unreliable to be useful.

Ultrasound scan is an accurate, cost-effective and useful modality for the assessment of gestational age in the first and second trimester of pregnancy. Ultrasound assessment of gestational age has become an integral part of obstetric practice in recent times. Multiple foetal anatomical parameters have been used for ultrasound evaluation of gestational age. The gestational sac diameter and CRL are used in first trimester for estimating gestational age [6].

From second trimester onwards biparietal diameter (BPD), head circumference (HC), abdominal

circumference (AC), femur length (FL) have been used to estimate gestational age [2, 6, 7]. These parameters are more than sufficient in any routine antenatal scan to assess the gestational age. But there are situations where measurement of these parameters have some limitations or cannot be used like hydrocephalus, anencephaly, hydrops foetalis, macrosomia, short limb dysplasia, femur achondroplasia. In these situations, we have to use other parameters for the estimation of gestational age. One of the useful parameters is foetal foot length (FT length) as it is easily assessed and measured [8-10]. In the normally developing foetus the foetal foot length increases with advancing gestational age. Very few studies have been done in our state to use foetal FT length to estimate gestational age. The purpose of this study is to find out whether foot length can be used to determine the gestation age more accurately. In this study, we also explored the relationship of foetal FT length with gestational age and to find relationship between foot length and the other foetal measurements (BPD, HC, AC and FL) between 16 to36 weeks' gestation. We have defined a nomogram for foetal foot length for our population.

METHODS

This was a hospital based descriptive cross-sectional study done in the Department of Obstetrics and Gynaecology, S.M.S. Medical College and attached hospitals, Jaipur, Rajasthan from April 2017 to November 2018, (after taking the approval from Institutional Review Board and Ethical committee).

Sample size was calculated at 95% confidence levels assuming Standard Deviation of 4.78mm in foetal foot length as found in reference study at 35 weeks, at the absolute allowable error (precision) of 0.5mm, minimum of 351 cases were required as sample size which was enhanced and rounded off to 500 cases as final sample size to improve the precision in the study.

500 women with viable singleton pregnancy between 16 weeks to 36 weeks of gestation and who were willing to be enrolled in the study were included in the study. Women with unknown LMP, irregular menstrual cycle, congenital malformation of foetus, associated medical disorders were excluded from the study.

Transabdominal ultrasound was performed as part of antenatal assessment. Various foetal measurements such as BPD, HC, AC, FL were measured. The foetal foot length was measured from skin edge overlying heel to the distal end of the longest toe, either 1st or 2nd toe, on either the plantar or sagital view by electronic calipers. All data entered in to MS excel sheet and analysed.

The relationship between gestational age in weeks to foetal foot length in millimeters was analyzed by simple linear regression. For a given gestational age, predicted values were obtained for the 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 95^{th} percentiles to develop a nomogram. Correlation of foetal foot length with BPD, HC, AC and femur length was also determined by using linear regression analysis. P value of less than 0.05 was considered as significant.

RESULTS

Majority of the women (44.8%) were between 25 to 30 years. Maternal age ranged from 20 to 40 years with mean age of 27.03 ± 4.23 years. Majority of the women belonged to lower and middle socioeconomic status (96.8%) whereas only 3.2% women belonged to upper socioeconomic status. 51.6% women belonged to rural area. (Table 1)

Table 2 shows ultrasonographic measurement of foetal foot length in mm (mean ± SD) for a given gestational age between 16 to 36 weeks. It demonstrates a linear relationship between foetal foot length and gestational age. The mean sonographic foot length at 16 weeks is 21.59±1.79 mm and at 36 weeks of gestation is 71.88±2.61 mm.

Simple linear regression analysis shows a strongly significant linear relationship between foot length and gestational age. (Graph 1)

Where, gestational age (weeks) Y= 0.3900 x foot length (X) + 7.462; with high degree of correlation coefficient (r^2=0.970 and P=<0.0001)

The mean foetal foot length at 16 weeks and 36 weeks was 21.59±1.79 mm and 71.88±2.61 mm respectively. The mean biparietal diameter at 16 weeks and 36 weeks was 36.13±0.99 and 88.88±2.87 respectively. The mean head circumference at 16 weeks and 36 weeks was 127.85±4.79 and 331.64±22.97 respectively. The mean femur length at 16 weeks and 36 weeks was 21.75±1.67 and 70.18±3.84 respectively. The mean abdominal circumference at 16 weeks and 36 weeks was 108.88±4.45 and 311.71±19.57 respectively.(Table 3) When plotted on a graph all parameters showed a linear relationship with gestational age. (Graph 2)

In the table 4, we have developed a nomogram for foetal foot length in millimetres. Table 5 summarizes relationship of foetal foot length with gestational age, BPD, HC, AC and femur length. The foetal FT showed a significant linear correlation with GA, BPD, HC, AC and FL (P<0.0001). The correlation was the highest with FL, with the adjusted R^2 being 0.9697, followed by GA (0.9616), BPD (0.9435), HC (0.943) and was the least with AC (0.9423).

Table-1: Demographic profile of the women

Demographic profile	Number	Percentage
Age (years)		
20-25	142	28.4
25-30	224	44.8
>30	134	26.8
Mean age 27.03 ± 4.23		
Religion		
Hindu	307	61.4
Muslim	193	38.6
Socio-economic status		
Lower	238	47.6
Middle	246	49.2
Upper	16	3.2
Literacy status		
Illiterate	159	31.8
Literate	341	68.2
Residence		
Rural	258	51.6
Urban	242	48.4

Table-2: Foetal foot length (mm) according to gestational age (weeks)

GA (weeks)	No. of Foetuses	Lower limit –Upper limit (mm)	Mean FTL (mm) ± SD
16	8	18.5-24.0	21.59±1.79
17	8	23.0-26.0	24.93±1.17
18	47	25.0-30.0	27.82±1.25
19	76	27.0-35.0	30.52±1.74
20	63	28.0-38.0	32.65±2.45
21	39	32.0-39.0	36.54±2.01
22	25	35.0-40.0	38.32±1.11
23	37	39.0-46.0	42.08±2.01
24	21	41.0-47.0	44.05±2.20
25	15	44.0-57.0	46.80±3.34
26	12	38.0-50.0	45.83±4.41
27	8	50.0-53.0	52.00±1.07
28	9	50.0-55.0	52.78±2.22
29	17	55.0-60.0	57.29±1.72
30	13	51.0-60.0	57.62±2.26
31	14	59.0-65.0	61.86±2.14
32	21	48.0-67.0	62.10±6.07
33	17	60.0-75.0	65.53±4.14
34	14	64.0-73.0	68.14±3.28
35	19	62.0-72.0	68.24±2.51
36	17	65.0-77.0	71.88±2.61

Table-3: The Mean Values and S D of FT l, BPD, HC, FL and AC from 16 to 36 weeks of gestation

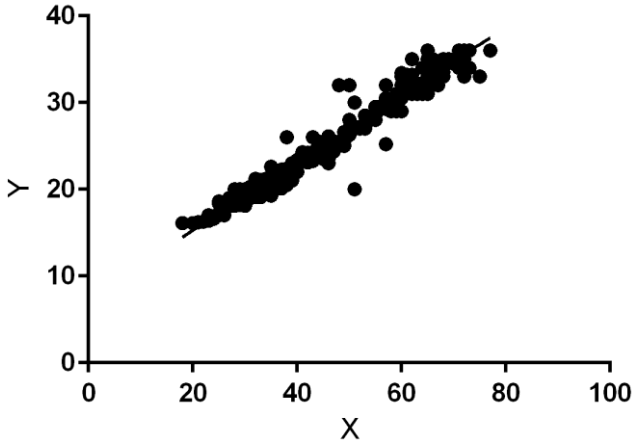
GA	No. of cases	Mean FTL ± SD	Mean BPD ± SD	Mean HC ± SD	Mean FL ± SD	Mean AC ± SD
16	8	21.59±1.79	36.13±0.99	127.85±4.79	21.75±1.67	108.88±4.45
17	8	24.93±1.17	38.75±0.71	137.66±2.61	25.38±0.52	117.75±3.58
18	47	27.82±1.25	41.45±1.19	150.74±5.03	27.72±1.25	131.15±6.58
19	76	30.52±1.74	44.83±2.44	163.30±6.82	30.50±1.76	142.76±7.60
20	63	32.65±2.45	48.27±3.32	173.82±9.68	32.57±2.53	148.54±7.98
21	39	36.54±2.01	51.10±2.39	186.18±6.24	36.13±2.05	166.33±8.35
22	25	38.32±1.11	53.72±2.87	193.71±7.63	38.32±1.10	173.48±5.87
23	37	42.08±2.01	58.27±2.06	208.46±11.75	41.51±1.41	184.81±9.69
24	21	44.05±2.20	59.43±1.54	220.79±5.39	44.05±2.20	192.10±11.58
25	15	46.80±3.34	62.67±3.15	226.84±12.62	48.00±2.75	206.40±18.62
26	12	45.83±4.41	67.92±1.93	238.02±16.06	44.50±7.93	205.92±13.69
27	8	52.00±1.07	70.13±0.35	256.39±1.25	49.69±0.37	221.50±0.76
28	9	52.78±2.22	71.33±3.43	261.50±4.76	52.11±3.52	235.11±8.24
29	17	57.29±1.72	72.29±5.22	270.46±21.92	55.71±3.33	249.12±9.77
30	13	57.62±2.26	78.00±1.47	267.51±31.57	58.35±1.14	238.31±37.90
31	14	61.86±2.14	79.71±2.84	292.75±8.71	62.29±1.98	265.21±9.05
32	21	62.10±6.07	79.76±2.99	297.41±16.35	63.81±6.50	262.57±20.81
33	17	65.53±4.14	83.65±2.69	325.94±19.28	64.76±2.28	295.06±19.13
34	14	68.14±3.28	86.14±2.50	326.63±10.68	67.50±1.74	297.43±12.92
35	19	68.24±2.51	86.89±3.33	330.29±13.64	66.63±4.35	303.21±11.77
36	17	71.88±2.61	88.88±2.87	331.64±22.97	70.18±3.84	311.71±19.57

Table-4: Nomogram of foetal foot length (in mm) according to percentile distribution

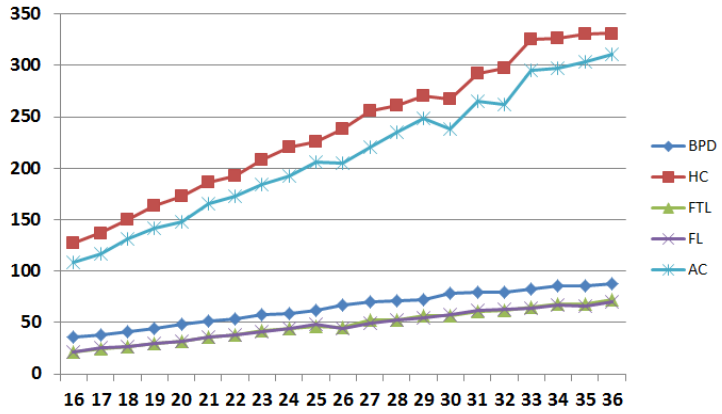
Foot length (in millimetres) according to percentile distribution								
GA (weeks)	No. of Foetuses	5^{th}	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}	95^{th}
16	8	18.5	18.5	20.5	21.6	23	24	24
17	8	23	23	24.2	25	26	26	26
18	47	26	26	27	28	29	29	30
19	76	27.8	28	30	30	32	33	33
20	63	29	29	32	32	34	36	37
21	39	33	33	35	37	38	39	39
22	25	37	37	38	38	39	40	40
23	37	39	40	41	42	43	46	46
24	21	41	41	42	44	46	47	47
25	15	44	44	44	46	49	49	57
26	12	38	38	43	47.5	49	50	50
27	8	50	50	51.5	52	53	53	53
28	9	50	50	50	53	55	55	55
29	17	55	55	56	57	59	59	60
30	13	51	57	57	58	59	59	60
31	14	59	59	60	62	63	65	65
32	21	48	50	57	61	63	65	66
33	17	60	60	62	66	68	72	75
34	14	64	64	65	68	71	73	73
35	19	63.5	63.5	66	69	69.5	71.25	72
36	17	65	71	71	71.4	73	77	77

Table-5: Summary of relationship of foetal foot length with GA, BPD, HC, AC and FL

X axis	Y axis	Regression Formula	Correlation Coefficient	p value
Foot length	GA	Y = 0.3900 x X + 7.462	0.9616	<0.0001
	BPD	Y = 1.081 x X + 12.63	0.9435	<0.0001
	HC	Y = 4.222 x X + 34.97	0.9435	<0.0001
	AC	Y =4.044 x X + 18.55	0.9423	<0.0001
	FL	Y = 0.9848 x X + 0.5554	0.9697	<0.0001



Graph-1: Relationship between foetal foot length (mm) and gestational age (weeks)



Graph-2: The Mean Values and S D of FT length , BPD, HC, FL & AC from 16 to 36 weeks of gestation

DISCUSSION

In this study 500 women with viable singleton pregnancy were evaluated by ultrasongraphy so as to find use of foetal foot length to estimate gestational age. Age distribution of women in our study was consistent with that observed in the study of B Abdel Malik *et al.* [11]. The mean age of the women in our study (27.03 ± 4.23 years) was lower than that observed by Hong Soo Wong [12] in his study (32.2±4.3yers) and higher than that (24.7 years) observed by Hebber S *et al.* [9] Distribution of the women according to socio-economic status in our study was comparable to that observed by B Abdul Malik *et al.* [11]. 51.6% women in our study belonged to rural area. From this observation it is clear that there is increase awareness among rural population about antenatal care and importance of hospital deliveries. This happened due to implementation of Janani Shishu Suraksha Yojna by the Government.

The mean sonographic foot length at 16 weeks is 21.59±1.79 mm and at 36 weeks of gestation is 71.88±2.61 mm. Similar results were observed by Pandey V D *et al.* in [7] observed that the mean foot length at 16 weeks was 19.75 ±0.50 and at 36 weeks of gestation was 64.4 ± 3.28. The mean values of foot length at various gestational age obtained in our study were almost identical to those of Yuksel *et al.* [13], Goldstein *et al.*[14] and Platt *et al.* [15].

Simple linear regression analysis shows a strongly significant linear relationship between foot length and gestational age. The result of our study is consistent with other studies done in the past by K S

Joshi *et al*. [8], Vishram Singh *et al*. [2], and Pandey V D *et al.* [7]. From our study and other studies done in the past we can conclude that the ultrasonographic measurement of foot length is a reliable indicator of gestational age.

When plotted on a graph FT length, FL, BPD, HC & AC showed a linear relationship with gestational age. Our results were in agreement with results of Pandey VD *et al.* [7].

We have developed a nomogram for foetal foot length in millimetres which is almost comparable to that developed by Meirowitz *et al*. [10], Lyn S. Chitty [16], Joshi *et al.* [8] and Hebber *et al*. [9]. We therefore recommend foetal foot length be considered for evaluation of gestational age when other routine parameters as described above are not conclusive.

The foetal FT showed a significant linear correlation with GA, BPD, HC, AC and FL (P<0.0001). The correlation was the highest with FL, with the adjusted R^2 being 0.9697, followed by GA (0.9616), BPD (0.9435), HC (0.943) and was the least with AC (0.9423). Our results were consistent with the study done by Hong Soo Wong [12] and the foetal FT showed a linear correlation with GA, BPD, HC, AC and FL. He observed the highest correlation with HC, with the adjusted R^2 being 0.950, followed by BPD (0.945), AC (0.943), FL (0.937) and was the least with GA (0.816).

CONCLUSION

During normal development of the foetus the foetal foot length increases with advancing gestational age. Foetal foot length shows a good correlation with gestational age (pearson's correlation coefficient = 0.97, p value<0.0001). In addition, foetal foot length shows a linear correlation with other foetal biometric parameters such as BPD, HC, FL and AC. Foetal foot length can thus be used as an alternative foetal parameter to assess gestational age especially in cases of wrong dates or when other routine parameters are not conclusive or did not accurately predict gestational age for e.g, in cases of hydrocephalus, anencephaly or short limb dwarfism.

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