

Sonographic Correlation of Fetal Foot Length as a Reliable Parameter for Estimation of Gestational Age in the Second and Third Trimester of Pregnancy

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Abstract: Accurate estimation of gestational age is essential for appropriate antenatal care and fetal assessment. Standard ultrasonographic parameters may be affected in certain clinical situations, so that fetal foot length may serve as an additional reliable biometric marker. **Objective:** To determine the correlation between fetal foot length and standard biometric parameters, including femur length, biparietal diameter, and abdominal circumference, for the estimation of gestational age during the second and third trimesters of pregnancy. **Methods:** This cross-sectional study was conducted in the Department of Radiology, Holy Family Hospital, Rawalpindi, from 20 March 2023 to 19 September 2023. A total of 120 pregnant women in the second or third trimester undergoing ultrasonographic assessment were enrolled. Pregnancies complicated by oligohydramnios, polyhydramnios, intrauterine growth restriction, and skeletal dysplasia were excluded. Transabdominal ultrasonography was performed for all participants. Fetal foot length was measured and compared with conventional fetal biometric parameters, including femur length, biparietal diameter, and abdominal circumference, to assess their correlation with gestational age. Data were entered and analyzed using SPSS version 26. Descriptive statistics were calculated, and inferential analysis was performed using correlation testing. A p-value of less than 0.05 was considered statistically significant. **Results:** Among 120 participants, the mean maternal age was 28.28±4.37 years, while the mean gestational age was 27.33±4.99 weeks. The mean fetal foot length was 47.87±11.88 mm, the mean femur length was 51.29±12.58 mm, the mean biparietal diameter was 69.09±14.05 mm, and the mean abdominal circumference was 231.73±51.77 mm. Fetal foot length showed a significant positive correlation with gestational age and with other fetal biometric parameters ($p < 0.0001$). The correlation coefficient of fetal foot length was 0.867 with femur length, 0.850 with biparietal diameter, and 0.743 with abdominal circumference, all of which were statistically significant ($p < 0.0001$). **Conclusion:** Fetal foot length demonstrated a strong positive correlation with gestational age and standard fetal biometric parameters in the second and third trimesters. It may be considered a reliable supplementary parameter for gestational age estimation in routine obstetric ultrasonography.

Keywords: Abdominal Circumference; Biparietal Diameter; Femur Length; Foot; Gestational Age; Pregnancy Trimester

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Introduction

Gestation of the fetus in the mother's body is a physiological process of fetal development. Gestational age is used to define the developmental stage of the fetus in comparison to the duration of pregnancy (1). Evaluation of gestational age is the most important estimation performed as part of antenatal care to improve obstetric care throughout pregnancy and ensure appropriate fetal growth in relation to the time of conception. It also has a significant part in early identification of any abnormality, delayed fetal growth, risk of early delivery, and/or termination of pregnancy due to any cause (2).

Ultrasonographic assessment of gestational age has become an integral part of antenatal care worldwide. Various fetal biometric parameters are utilised to assess gestational age and match it to the time of conception. The choice of each parameter depends on the current trimester of pregnancy. In early pregnancy, the most commonly used foetal biometric parameters include gestational sac diameter and crown-rump length. In mid and advanced pregnancy, femur length (FL), abdominal circumference (AC), biparietal diameter (BPD), and head circumference (HC) are widely used (3). Utilising many predictors has been shown to enhance estimation accuracy. When evaluating growth patterns, it is important to include many epidemiological aspects. It is advisable to use specific development profile charts for each distinct group (4).

In some cases, the position of the baby can hinder accurate measurement of femur length, head circumference, biparietal diameter, and other commonly used parameters, making it difficult to assess gestational age and monitor fetal growth accurately. Sometimes, if the foetal head has an abnormally rounded shape, known as brachycephalic, or is elongated, known as dolichocephalic, then it results in inaccurate measurement of head circumference and biparietal diameter, which overestimates or underestimates the gestational age (5).

In cases when conventional parameters cannot accurately assess the gestational age, due to macrocephaly/microcephaly, macrosomic fetuses, growth-retarded fetuses, limb dysplasia, foetal Development retardation, or head engagement in the latter stages of pregnancy, an alternative reliable parameter, like fetal foot length, can be employed for assessment of gestational age (6). This parameter can also serve as an adjunct to the recognition of different karyotypic abnormalities and diseases (7). Fetal feet develop fully at 12 weeks of pregnancy; fetal foot length can be measured in the second or third trimester.

It has been reported that foetal foot length correlates strongly with established parameters, including BPD, FL, and AC (8,9,10). Still, there is limited literature on estimating foetal foot length in our population to determine gestational age. The current study aimed to determine the correlation of standard parameters, including HC, BPD, FL, and AC, with foetal foot length in determining gestational age among the Pakistani pregnant population.



Methodology

A cross-sectional study was conducted at the radiology unit of Holy Family Hospital, Rawalpindi, from 20th March 2023 to 19th September 2023.

A sample size of 120 was calculated using the correlation sample size calculator, considering a correlation coefficient of 0.981 between fetal foot length and biparietal diameter to determine gestational age, 80% study power, and a 95% confidence level (Formula: $N = [(Z\alpha + Z\beta)/C]^2 + 3$).

The research participants were selected using a non-probability consecutive-sampling approach.

Pregnant females aged 18–45 years with a normal/uncomplicated singleton pregnancy, known pregnancy dates, and a pregnancy in the second or third trimester attending the radiology department for ultrasonographic assessment during the study interval were included. Pregnant females in the first trimester, and cases of oligohydramnios, polyhydramnios, intra-uterine growth retardation, and skeletal dysplasia were excluded.

Consecutive patients visiting the radiology department were assessed for eligibility before enrolment. Written informed consent was obtained from all eligible participants. Baseline demographic and clinical characteristics were recorded on the data collection form. Abdominal ultrasound was performed using the HS 2600 machine with a 3–4 MHz curvilinear transducer. The fetal foot was visualised ultrasonographically, and the image was frozen to measure foot length from the skin edge over the heel to the distal end of the longest toe, on plantar or sagittal views using

electronic calipers. Biometric parameters, FL, BPD, and AC, were also measured, and their correlations with fetal foot length were determined. Data were entered and analysed using SPSS version 26.0. Qualitative variables were summarised as frequencies and percentages, while quantitative variables were expressed as mean ± standard deviation. Pearson's correlation test was applied to assess the relationship between gestational age and fetal foot length, and between gestational age and femur length, BPD, and abdominal circumference. Statistical significance was set at $p \leq 0.05$.

Ethical approval was obtained from the Institutional Review Committee of Holy Family Hospital, Rawalpindi. Written informed consent was secured from all participants. Confidentiality and anonymity were maintained throughout the study.

Results

A sample of 120 patients was obtained, with a mean age of 28.28 ± 4.37 years. The majority (52.5%) were between 18 and 30 years old. The distribution of women shows that 35% and 41.6% belong to the middle and upper-middle socioeconomic status groups, respectively. Mean gestational age was 27.33 ± 4.99 weeks, mean foot length was 47.87 ± 11.88 mm, femur length was 51.29 ± 12.58 mm, biparietal diameter was 69.09 ± 14.05 mm, and abdominal circumference was 231.73 ± 51.77 mm, as shown in Table 1.

Table 1: Demographics and clinical characteristics of the study population (N=120)

Studied parameters		n / mean	% / SD
Age (n/%)	18–30 years	63	52.50
	31–45 years	57	47.50
Gestational Age (n/%)	<22 weeks	15	12.50
	22–28 weeks	52	43.33
	>28–37 weeks	53	44.17
	>37 weeks	0	0
Socioeconomic status (n/%)	Lower class	28	23.33
	Middle class	42	35.0
	Upper-middle class	50	41.67
Gestational age in weeks (mean/SD)		27.33	4.99
Foot length in mm (mean/SD)		47.87	11.88
Femur length in mm (mean/SD)		51.29	12.58
Biparietal diameter in mm (mean/SD)		69.09	14.05
Abdominal circumference in mm (mean/SD)		231.73	51.77

The correlation between fetal foot length and gestational age was 0.802 ($p < 0.0001$). Correlation between femur length and gestational age was 0.951, between biparietal diameter and gestational age was 0.957, and between abdominal circumference and gestational age was

0.909, all with $p < 0.0001$. The correlation coefficients (r) for foetal foot length with FL, BPD, and AC were 0.867, 0.850, and 0.743, respectively, all statistically significant ($p < 0.0001$), as shown in Table 2.

Table 2: Pearson correlation of gestational age and fetal foot length with standard fetal biometric parameters (N = 120)

Variables	Gestational Age (weeks)	Abdominal Circumference (mm)	Biparietal Diameter (mm)	Femur Length (mm)
Gestational age (weeks)	—	0.909**	0.957**	0.951**
p-value	—	<0.001	<0.001	<0.001
Fetal foot length (mm)	0.802**	0.737**	0.845**	0.860**
p-value	<0.001	<0.001	<0.001	<0.001

AC, abdominal circumference; BPD, biparietal diameter; FL, femur length ** Correlation is significant at the 0.01 level (2-tailed)

A positive correlation was found between the fetal foot length and other parameters in estimating the gestational age. The linear scatter

plot (Figure I) shows gestational age in the study population as a function of fetal foot length.

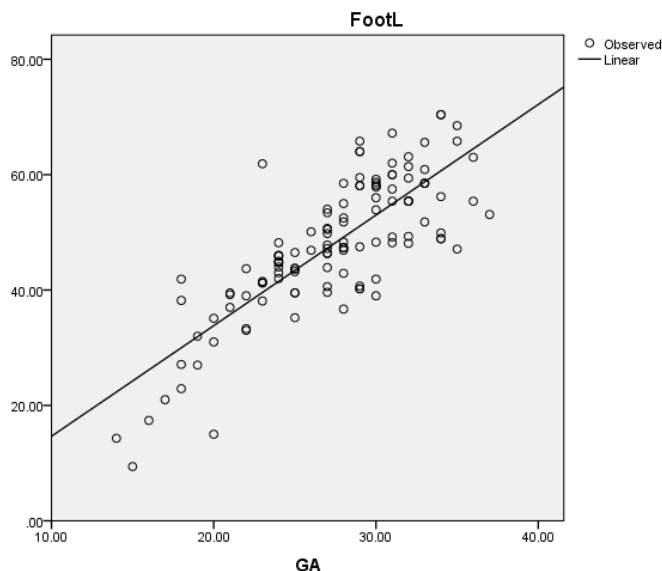


Figure I: Linear scatter plot shows gestational age based on foetal foot length. GA: Gestational age; FootL: fetal foot length (mm)

Discussion

The four parameters, femur length (FL), biparietal diameter (BPD), head circumference (HC), and abdominal circumference (AC), are commonly used to estimate gestational age and are often regarded as the most accurate indicators. Combined, they provide the highest level of precision in assessing gestational age (3). Femur length is a valuable biometric measurement commonly employed throughout the 2nd and 3rd trimester, exhibiting linear growth and most accurately assessed after 14 weeks of gestation (11).

Our study recruited 120 pregnant females with a mean age of 28.28 ± 4.37 years, a mean gestational age of 27.33 ± 4.99 weeks, a mean foot length of 47.87 ± 11.88 mm, a femur length of 51.29 ± 12.58 mm, a biparietal diameter of 69.09 ± 14.05 mm, and an abdominal circumference of 231.73 ± 51.77 mm. A positive and statistically significant correlation between fetal foot length and gestational age was observed, with correlation coefficients of 0.867, 0.850, and 0.743 for FL, BPD, and AC, respectively ($p < 0.001$).

In 2021, Ebraheem M et al. (8) evaluated gestational age using fetal foot length and concluded that it is a reliable parameter. In 2016, Mukhia R et al. (9) reported that foot length assessment is comparable to measurements of the femur and humerus for estimating gestational age. In 2021, Thennarasi K et al. (10) assessed gestational age using fetal hand and foot length during pregnancy. They reported that foot length correlates strongly with traditional measures such as head diameter, femur length, and abdominal circumference.

A study found an overall correlation coefficient for FL of 0.994 ($p=0.006$), with trimester-specific values remaining consistently high and statistically significant (12). Dagnev et al. reported a substantial positive relationship between gestational age and foot length ($r=0.865$, $p<0.0001$) (13), corroborated by studies in Indian regions showing a substantial positive association between foot length and gestational age (14-16). A study on the Pakistani population reported a strong correlation between gestational age and foot length ($r^2=81.7\%$) (17).

Tenali et al. observed a direct correlation between gestational age and foot length (18). Rakkappan and Kuppusamy found a coefficient of determination (r^2) of 65% in the relationship between foot length and gestational age (19). Joshi et al. discovered a strong association between foot length and gestational age ($r=0.970$, $p=0.0001$) and femur length ($r=0.980$, $p=0.000$) in 779 pregnant women in Nepal (20). Malik et al.

found the correlation between foot length and femur length was 0.91, and between foot length and foetal age was 0.94 (21). Collectively, these findings support the use of foot length as a standard supplementary method for determining gestational age.

Conclusion

This study demonstrates a significant link between fetal foot length and gestational age in the second and third trimesters, and a strong correlation between foetal foot length and other standard parameters — femur length, biparietal diameter, and abdominal circumference. Fetal foot length is an effective and reliable supplementary indicator of gestational age during pregnancy.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-HOFHISB-20-23)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

KS (PGR)

Manuscript drafting, Study Design,

NK (Professor)

Review of Literature, Data entry, Data analysis, and drafting articles.

HMAA (AP)

Conception of Study, Development of Research Methodology Design,

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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