



Original Research Article

CORRELATION OF BIOMETRIC PARAMETERS WITH THE GESTATIONAL AGE WITH SPECIAL EMPHASIS ON FOOT LENGTH OF THE FETUS DURING FIRST TRIMESTER

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ABSTRACT

Background: Precise estimation of gestational age (GA) in the first trimester is critical for prenatal care and management. Crown-rump length (CRL) is traditionally the gold standard in early pregnancy dating, but challenges remain when fetal position or maternal factors limit measurement accuracy. Fetal foot length (FT) has emerged as a promising complementary parameter for GA assessment. The objective is to study the correlation of biometric parametric parameters with the gestational age with special emphasis on foot length of the fetus during first trimester.

Materials and Methods: A cross-sectional study was conducted at Apollo Institute of Medical Sciences and Research, Hyderabad, with 50 gravid females at 12-14 weeks' gestation. Inclusion criteria were singleton pregnancy and regular menstrual cycles. All participants underwent transabdominal ultrasound, measuring CRL, biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), and Foot Length (FT). Correlations were assessed by Pearson's correlation coefficient, and significance determined at $p < 0.05$.

Results: FT showed a significant linear correlation with GA assessed by ultrasound ($R^2 = 0.77$, $p < 0.001$), comparable to CRL ($R^2 = 0.88$, $p < 0.001$). Combined CRL and FT measurements yielded an even higher correlation with GA ($R^2 = 0.93$, $p < 0.001$). Correlations of FT with other parameters were strong: BPD ($R^2 = 0.68$), HC ($R^2 = 0.70$), AC ($R^2 = 0.76$), FL ($R^2 = 0.58$) (all $p < 0.001$). FT was particularly useful when CRL measurement was inconclusive, and can be integrated into routine ultrasound examinations.

Conclusion: Foot length is a reliable supplementary parameter for GA estimation in early pregnancy, improving accuracy when combined with CRL. Integrating FT into routine ultrasound can enhance prenatal care, especially where CRL measurement is challenging. Larger multicentre studies are recommended to validate and standardize FT measurement.

Keywords: Gestational age, Fetal foot length, Crown-rump length, Ultrasonography, First trimester, Biometric parameters.

INTRODUCTION

In obstetrics care, accuracy in the assessment of the gestational age is of paramount importance. It helps the obstetrician to take decisions for proper management of the case. It also ensures about what counselling should be done for the woman. It is important in evaluating the growth of the fetus. Growth of fetus tells us about the chances of preterm delivery. If there are chances of preterm delivery, we can give appropriate counselling to the woman. Accurate estimation of gestational age helps us in assessment of possible neonatal outcomes which can be used as a basis for proper counselling of the woman. The woman can be given the option of therapeutic abortion if required based on correct determination of gestational age.^[1]

Ultrasound is the method of choice for accurate determination of the gestational age. Because the traditional method of last menstrual period depends upon the recall, there are chances of recall bias. Even the abdominal examination for size of the uterus may not often be reliable. In this backdrop, the ultrasound is the most accurate for determination of the gestational age as it provides direct evidence. Hence, during first and second trimester ultrasound is an accurate method. It is now done as a routine during the first and the second trimester of pregnancy. There are different biometric parameters like diameter of the gestational sac, length of the femur, circumference of the abdomen, crown rump length, biparietal diameter. The relation of these biometric parameters with the gestational age and many equations have been described over last 30 years. Not all of these parameters are accurate. For example, the biparietal diameter is affected if the head is abnormally rounded. In such a case, there can be overestimation or underestimation of the gestational age. Intrauterine growth retardation can affect the abdominal circumference measurements interpretations. If there is achondroplasia of the femur, it can lead to misinterpretation of length of the femur and thereby can lead to misinterpretation of the gestational age. Streeter in the year 1920, observed that the foot of the fetus shows patterns that match with the normal growth. He then proposed that the length of the foot of the fetus can be used for estimation of the gestational age.^[2]

The foot of the fetus development has been detailed into four steps by Boehm. Stage one which is in second month where we can see that the foot is adducted and 90° equinus. At the starting of third month, stage two is described in which the findings are that of stage one plus there is marked supination. Around the mid of third month, in stage three, in addition to mild equinus and marked supination, there is dorsiflexion of the foot. In this stage, the first

metatarsal is seen as adducted. At the start of the fourth month, it is stage four, in which there is pronation of the foot and mid-supination. The equinus is absent.^[3]

With this background, present study was carried out to study the correlation of biometric parameters with the gestational age with special emphasis on foot length of the fetus during first trimester.

MATERIALS AND METHODS

Study Design and Participants: This cross-sectional study included 50 gravid females attending routine first-trimester antenatal ultrasound at Apollo Institute of Medical Sciences and Research, Hyderabad. Inclusion criteria were singleton pregnancy between 12–14 weeks' gestation and a regular 28-day menstrual cycle. Exclusion criteria included irregular cycles or inability to clearly visualize the entire fetal foot on ultrasound.

Ultrasonographic Technique: Transabdominal ultrasonography was performed using Philips Affiniti 70 and Affiniti 50 machines equipped with a 2–6 MHz curvilinear probe. Biometric parameters—CRL, BPD, HC, AC, FL, and FT—were measured as per standard guidelines. FT was measured from the posterior aspect of the heel to the tip of the longest toe in plantar view.

Ethics: Institutional ethics committee approval was obtained (IEC Application No.: EC/NEW/INST/1527/2022/08/15). All participants provided informed consent after a full explanation of the study and confidentiality safeguards. The study conformed to the principles of the Declaration of Helsinki

Statistics: Statistical analysis was performed using SPSS v24. Descriptive statistics described all patient and biometric variables. Pearson's correlation coefficient was used to assess relationships between FT and GA (by ultrasound and LMP), as well as with other parameters (CRL, BPD, HC, AC, FL). Statistical significance was set at $p < 0.05$.

RESULTS

Foot length was strongly correlated with the gestational age when studied using the ultrasound. However, when last menstrual period was used, there was very weak correlation though statistically significant. The correlation of crown-rump length was stronger with the gestational age when compared to the foot length. When the foot length and the crown-rump length was combined, it was found to be very closely related to the gestational age compared to either the foot length or crown-rump length separately. [Table 1]

Table 1: Correlation Analysis of various parameters with gestational age

Parameters	Correlation coefficient	P value
Foot length vs. gestational age by ultrasound	0.77	0.0001
Foot length vs. gestational age by last menstrual period	0.23	0.01
Crown to rump length vs. gestational age	0.88	0.0001
Combined crown-rump length with foot length vs. gestational age	0.93	0.00001

Table 2: Correlation Analysis of various parameters against each other

Parameters	Correlation coefficient	P value
Foot length vs. crown-rump length	0.64	0.0001
Foot length vs. biparietal diameter	0.68	0.001
Foot length vs. head circumference	0.70	0.001
Foot length vs. abdominal circumference	0.76	0.001
Foot length vs. femur length	0.58	0.001

All the parameters were significantly correlated with foot length. The least correlated was femur length followed by crown-rump length, then followed by biparietal diameter. Head circumference was better than these and most strongly correlated parameter with the foot length was abdominal circumference. [Table 2]

DISCUSSION

In the present study, Foot length was strongly correlated with the gestational age when studied using the ultrasound. However, when last menstrual period was used, there was very weak correlation though statistically significant. The correlation of crown-rump length was stronger with the gestational age when compared to the foot length. When the foot length and the crown-rump length was combined, it was found to be very closely related to the gestational age compared to either the foot length or crown-rump length separately. All the parameters were significantly correlated with foot length. The least correlated was femur length followed by crown-rump length, then followed by biparietal diameter. Head circumference was better than these and most strongly correlated parameter with the foot length was abdominal circumference.

Pandey VD et al [4] carried out measurement of the foot length using the ultrasound. The sample size was 100 women who were pregnant. The study was carried out in the department of Radiodiagnosis. All the pregnant women were in the range of 15-36 weeks of gestation. We observed that 15 weeks was the best early possible gestational age where the foot length can be studied at the earliest using the ultrasound. At 15 weeks of gestation, the mean length of the foot was 17.5 ± 1.29 which increased to 64.4 ± 3.28 at 36 weeks of gestational age. We found a very strong relation between the gestational age and the foot length when they applied the regression analysis.

Wong HS et al [5] conducted a study, in which they reviewed 47 pregnant women of 10-16 weeks of gestation. Foot length was studied in relation to various measurements in the fetus and various ratios of the measurement. They noted that as the gestational age increased from 10 weeks of gestation to the 16 weeks of gestation, all the biometric

parameters including the foot length also increased. They also observed that the foot length had a very good correlation with all the biometric parameters. However, the foot length was found to have a weaker correlation with the crown to rump length when compared to all other biometric parameters. The ratio of the length of the femur with that of foot length was inversely related to the gestational age. Similarly, the ratio of the abdominal circumference with that of the length of the femur was also inversely related with that of the gestational age. The authors concluded that length of the foot of the fetus estimates the age of the gestation precisely during 10-16 weeks of gestation. They recommended to use the ratio of the gestational age specific.

Wong HS [6] compared the correlation of various fetal ultrasound measurements with that of the length of the foot of the fetus. This was done to find out which can be chosen as best estimate at 10-14 weeks of gestation. All these they have done in the first trimester of pregnancy. They found and noted that there was a linear correlation of all these biometric parameters with the gestational age. Poor correlation was found between femur length and gestational age and highest correlation was seen with foot length and gestational age. When some parameters like FL, BPD, AC and HC were combined and their correlation was tested with that of foot length, it was found that there was a good correlation. The correlation strength increased when the CRL was added to these parameters. We concluded that combination can be used to estimate the gestational age with more precision.

Ravisankar G et al [7] studied antenatal women with the gestational age of 17-25 weeks. The sample size was 150. All underwent ultrasound examination. They noted that there was a strong correlation existed between the foot length and the gestational age. Even there was strong correlation between femur length and the gestational age. They also found that "the femur-to-foot length ratio approximates 1, with a ratio below 0.92 serving as a reliable indicator for detecting most cases of dysplasia."

Kutlugül YÜKSEL et al [8] described the relation between foot length as measured by ultrasound and the gestational age. Sample size was 462. The range of gestational age selected was 15-42 weeks. All were singleton pregnancies and healthy. The authors found

a significant correlation between gestational age and the foot length. Thus, the foot length was found to be a reliable measure of gestational age. The authors concluded that it was a useful measurement.

Senthilkumar K et al,^[9] carried out a cross-sectional study in a hospital. The sample size was 170. They used parameters like last menstrual period, ultrasound done in the first trimester of the pregnancy and New Ballard Score to estimate the gestational age. Right side of the foot was used to measure the foot length. This was done immediately or within 12-24 hours of birth. Measurements were taken using standard techniques and protocol. The authors found a strong, positive and significant correlation between the gestational age and the foot length. Both the gestational age based on ultrasound measurement and that obtained by last menstrual period were found to be significantly correlated with foot length. They concluded that gestational age can be assessed by using the foot length.

Sharma V et al,^[10] carried out a cross-sectional study. The sample size was 150. All were singleton pregnancies. The gestational age was between 16-40 weeks. They used simple linear regression. They found a relationship between the FFL and GA.

Limitations

The main technical limitation was fetal position, occasionally precluding clear visualization and measurement of FT. Repeat scanning was required in such cases

CONCLUSION

Foot length is a reliable supplementary parameter for GA estimation in early pregnancy, improving accuracy when combined with CRL. Integrating FT into routine ultrasound can enhance pre natal care,

especially where CRL measurement is challenging. Larger multicentre studies are recommended to validate and standardize FT measurement.

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