Original Article

Accuracy of Fetal Foot Length Measurement in Estimation of Gestational Age and Fetal Weight in the Third Trimester of Pregnancy

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ABSTRACT

Background: Fetal foot length (FFL) is a biometric parameter that has been established for estimating the gestational age (GA). Accurate knowledge of fetal weight (FW) and GA assist Clinicians in the evaluation of fetal growth and predict neonatal outcomes. **Aims:** This study aims to predict the estimated FW and GA using the FFL in 26–40 weeks' gestation on antenatal ultrasound. **Materials and Methods:** In a retrospective study, we investigated the fetal measurements of FFL, femoral length (FL), and estimated FW in 100 pregnant women at 26–16 weeks' gestation who attended routine antenatal care. The fetal measurements were examined about the foot length. **Results:** The foot length was not a significance parameter to determine fetal gender (P = 0.6). There was no correlation of FFL with maternal socioeconomic status, parity, fetal gender, and maternal body mass index, P = 0.26, 0.84, 0.67, and 0.26, respectively. The FFL, FL, and estimated FW were strongly and linearly correlated with GA. The combination of FL, foot length, and estimated FW provide an accurate estimation of GA with minimum (standard error [SE] = 1.75). The combination of FL and foot length provide an accurate prediction of FW with SE of 320.52. The foot length and FL revealed similar values of SEs in estimated FW (R^2 = 0.85) for each. **Conclusions:** The FFL is linearly correlated with GA, FW, and FL. It is an accurate parameter to assess the GA and reliable for predicting the estimated FW. This is useful for assessing fetal growth and skeletal dysplasia.

KEYWORDS: *Accurate, fetal weight, foot length, gestational age, parameter*

INTRODUCTION

It is essential to obtain an accurate estimation of fetal weight (FW) since there several complications from the overweight of fetus during delivery and the puerperium. The identification of FW is essential in the detection of fetal growth disorders.[1,2] Sonographic estimation of FW is based on fetal biometric parameters such as femoral length (FL), biparietal diameter (BPD), abdominal circumference (AC), and head circumference. This estimation is calculated by regression models that include the combination of these biometric parameters. However, to the best of our knowledge, the fetal foot length (FFL) is not ordinarily used in the evaluation of FW and gestational age (GA).

The role of FFL in the estimation of GA has reported in several previous studies. Hong Soo studied the measurements of foot length and fetal biometrics in early pregnancy. He reported that FFL is an accurate parameter for estimating the GA in early pregnancy period.[3] However, a linear correlation between FFL and GA was reported in previous studies.[4,5]

The relationship between the FFL and FW was established in previous studies. It was reported that there was a significant relationship between foot

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length and neonates' weight.[6] The FFL is valuable in the clinical assessment of premature babies for conventional anthropometric parameters.[7] However, to the best of our knowledge, there are rare studies demonstrating the prediction of FW with the measure of FFL especially in the third trimester of pregnancy. Therefore, the study aims to highlight the role of FFL as an important fetal biometric parameter in the prediction of FW and estimation of GA and to validate that the FFT is similar to FL in the estimation of FW. Most of the previous studies demonstrated the role of FFL in the estimation of GA in first and second trimesters. However, the current study will explore whether the FFL has a significant correlation with FW, and is it a valid biometric diameter for estimating the FW in the third trimester.

Materials and Methods

This was a prospective cross-sectional study including normal healthy singleton pregnant Sudanese women in the third trimester (26–40 weeks) who were referred to ultrasound department for routine antenatal care. They were known for regular menstrual cycle and certain of their last menstrual period. The study conducted in Khartoum State from August 2016 to May 2017. The participants were selected utilizing simple, convenient systematic sampling. The inclusion criteria included the normal antenatal singleton pregnant in the third trimester (26–41 weeks) and women who are certain of their last menstrual period and estimated GA early by the ultrasound machine. Fetuses with foot anomalies were excluded from the study such as absence of foot, clubfeet, rocker-bottom foot: congenital vertical talus, polydactyly, syndactyly, and ectrodactyly. Fetal growth restricted multiple pregnancies and maternal pathologies were excluded from the study since they influence the morphology of fetal foot and in turn affect the sonographic measurement. The study was approved by the Institutional Ethical Committee of Al-rebat National University. Informed consent was taken from the participants.

The procedure of imaging the fetal foot length

Ultrasound examinations were performed using a Toshiba power Vision 6000 Ultrasound Machine (Tokyo, Japan) using 3.5 MHz frequency curvilinear probe. The pregnant women were scanned in the supine position. Single FFL measurements were measured from the skin edge covering the calcaneus to the distal end of the longest toe (the first or second toe) on either the plantar or the sagittal view. The FL was measured from upper diaphysis to lower point of the diaphysis. The women were investigated by tow expert Sonologists to reduce the interobserver errors.

Statistical analysis

The data were analyzed using SPSS statistical software program (version 16, Chicago, USA). Pearson correlation test was used to analyze the quantitative data and to find a correlation of foot length with GA, EFW, and FL. Spearman test correlation was used find the correlation between the qualitative variables such as correlation of FFL with maternal socioeconomic status, parity, and gender of fetuses.

Results

One hundred pregnant women at 26–40 completed weeks of pregnancy were enrolled. It was found there was no correlation of FFL with maternal socioeconomic status, parity, fetal gender, and maternal body mass index [Table 1]. The FFL has a linear positive correlation with GA (weeks) [Figure 1]. A positive linear correlation existed between the estimated FW against GA [Figure 2].

There was no significant difference between male fetuses and female's ones regarding the foot length (P = 0.6) [Table 2]. The sonograms demonstrated the sonographic measurements of FFLs [Figures 3 and 4]. The FFL reveals a significant linear correlation with GA and FW [Tables 3 and 4]. Maternal socioeconomic status and fetal gender were not significant factors influencing the FFL [Tables 1 and 2].

Table 1: Correlation of fetal foot length with maternal demographic variables and fetal gender

Variable	Correlation coefficient	Significance
Socioeconomic status	−0.114	0.26
Parity	−0.020-	0.84
Occupation	0.037	0.72
Gender of fetus	−0.044	0.67
Maternal BMI	−0.113	0.26

BMI: Body mass index

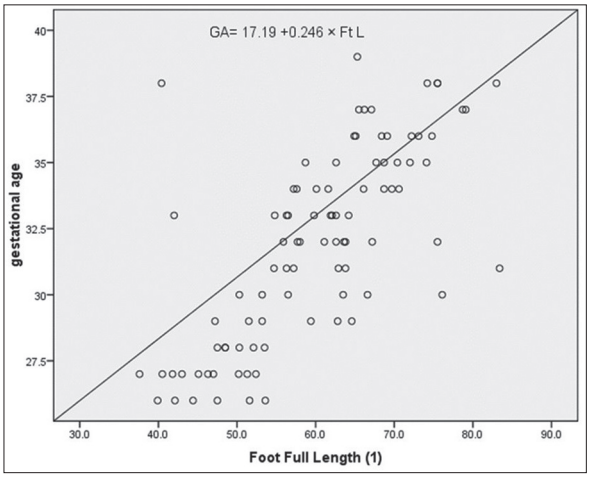

Figure 1: Correlation of fetal foot length with gestational age

Table 2: Comparison of foot length with fetal gender

Gender of fetus	Foot length Mean±SD (mm)	SE	*P*
Male	58.77±12.54	1.93	0.60
Female	57.41±12.73	1.70	

SE: Standard error, SD: Standard deviation

Table 3: Regression models of relationship between gestational age with fetal foot length, femoral length, and fetal weight

Fetal biometrics	Equations	*R*	Adjusted R^2	SE
FFL	GA=17.19 + 0.246 × FFL	0.72	0.52	2.56
FL	GA=13.85 + 0.296 × FL	0.84	0.70	2.01
FW	GA=23.85 + 0.004 × FW	0.87	0.76	1.81
FFL, FL, and FW	GA=21.29+0.163 × FL + 0.003 × FW−0.093 × FFL	0.87	0.78	1.75

SE: Standard error, FFL: Fetal foot length, FL: Femoral length, FW: Fetal weight, GA: Gestational age

Table 4: Regression models of relationship between estimated fetal weight with fetal foot length and femoral length

Fetal biometrics	Equations	*R*	R^2	SE
FFL	EFW = − 1348 + 54.054×FFL	0.87	0.76	398.94
FL	EFW = − 1657 + 58.28×FL	0.92	0.85	319.33
FFL and FL	EFW = −1661.3 + 54.561 × FL + 3.866 × FFL	0.92	0.85	320.52

SE: Standard error, FFL: Fetal foot length, FL: Femoral length, EFW: Estimated fetal weight

Discussion

The GA and FW are important critical issues that should be managed by a health professional to control anomalies and complications of fetal growth. The current study demonstrated the role of FFL in the estimation of GA and FW between 26 and 40 weeks' gestation since in this period the fetal growth is well developed. However, in some situations, the traditional fetal biometrics such as BPD, AC, and FL might be affected by hydrocephalus and anencephaly which distorts the fetal head. Therefore, in this period, the FFL is useful parameter because it is easily measured and assessed. In consistency, Pandey *et al*. reported that that FFL is particularly useful when other fetal biometrics do not accurately predict GA.[8] In this study, it was found that the FFL had a linear correlation with GA and FW between 26 and 40 weeks' gestation (P = 0.00). The correlation was the highest with FW, with the adjusted R^2 being 0.76. These results were consistent with the sonographic findings that the FFL reveals a linear relationship with the GA, even at early weeks of gestation.[9]

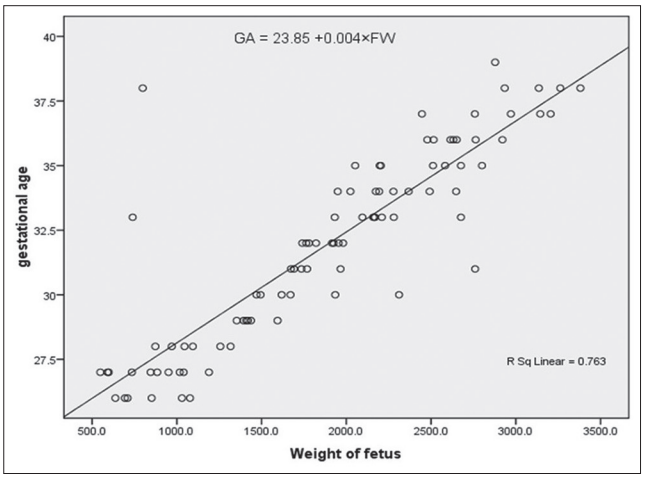

Figure 2: Correlation of fetal weight with gestational age

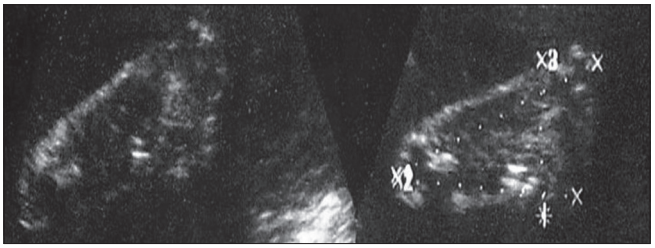

Figure 3: A sonogram shows a plantar view of fetal foot measurements. The gestational age is 35 weeks and fetal weight is 33.2

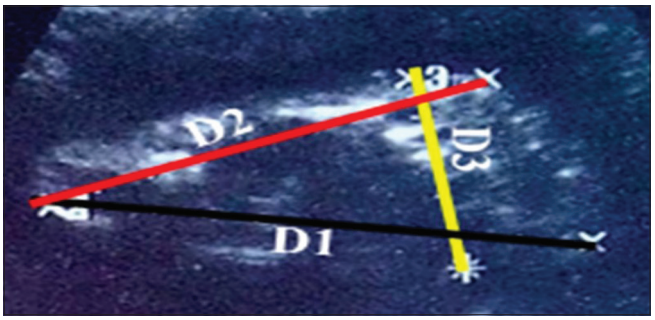

Figure 4: A sonogram shows a plantar view of fetal foot measurements. D1: length of the foot (78.7 mm), D2: width of the foot (67.8 mm). The gestational age is 37.9 weeks and fetal weight is 37.9

In the current study, we utilized the linear regression since it is used in all previous studies; and it is shown to yield similar estimates. A linear regression model was constructed to predict the GA from the FFL. The equation revealed a linear relationship between FFL and GA. This finding is consistent with Srivastava *et al*. who reported that GA has a strong correlation with FFL.[10] Wyk and Smith reported that foot length correlated well with GA (r = 0.919, $P < 0.001$).[11] Wong reported that FFL length is an accurate estimate of the GA in early pregnancy.[12] It was observed that the regression model of GA with FL is more accurate than the model of FFL. The standard error (SE) difference is not high (SE difference = 0.55). Therefore, the

combination of FFL with FL and FW provide a more accurate estimation of GA than using FFL alone. The regression model provides lesser SE than that of the FFL (1.75 vs. 2.56). Therefore, the addition of FFL to the other fetal biometrics improved the accuracy of GA. However, the conjunction of FFL with FL is important in the management of patients with premature labor to accurately predict GA.

The estimation of FW from fetal biometrics had been established in various studies. Wu *et al*. estimated the FW using BPD, FL, and HC and reported they were accurate and reliable for the assessment of FW.[13] In literature, different formulae have been established to estimate FW based on different fetal biometric parameters.[14] However, to the best our knowledge, no studies demonstrated the utilization of FFL to estimate the FW. Most of the studies focused on the role of FFL in the estimation of GA. In this study, we constructed a weight formula for the third trimester. The other fetal biometric parameters might be influenced by fetal growth retardation.[15] Therefore, the current study focused on display the role of FFL in estimating the FW in the third trimester of pregnancy. The accurate estimation of FW is required by Obstetricians and Clinicians to fetuses with growth restriction and macrosomia.[16,17] However, the estimation of FW with BPD, FL, and AC might be difficult in fetus with hydrocephalus, anencephaly, and postmortem destruction. Since the FFL has a characteristic pattern of normal fetal growth and shows gradual increase in length relative to the length of the embryo; therefore, it could be used to estimate the FW. In the present study, we found a strong linear correlation of FFL with FW. We constructed a regression model to predict the FW from the measurement of FFL.

The addition of FL to FFL in the regression model improved the accuracy of EFW. The difference in SE was 78.72. In literature, it was reported that a considerable variation was still existed in the systematic and random errors in estimation models of FW.[18] Our result agreed with Abdel Malik *et al*. who reported a significant relationship between FFL and EFW.[19] However, the accuracy of each EFW formula may change with various fetal biometrics in different ethnical populations. In general, the constructed model is accurate and reliable in the prediction of EFW in the third trimester of pregnancy. In literature, there was a lack of equations using the FFL as a parameter for calculating the FW. However, there were significant differences in growth of EFW among countries.[20]

Therefore, FFL can be used in conjunction with other fetal biometrics such as BPD and FL in the management of patients with premature labor to accurately predict GA and FW. A previous study reported that FFL can be utilized for GA estimation and updated to reflect the diversity of abortion patients worldwide.[21] Hence, the present study demonstrates that the sonographic measurement of FFL is a reliable indicator of GA and FW.

Although all findings of this study showed a strong correlation of FFL with GA and FW, our study faced some limitations. The sample size was not large enough. Further studies with large representative sample size were recommended. Further studies were recommended to confirm the utilization of fetal foot measurements for the estimation of FW, particularly in the third trimester.

Conclusions

The FFL is linearly correlated with GA, FW, and FL. It is an accurate parameter to assess the GA and reliable for predicting the estimated FW in the third trimester of pregnancy. The regression models of FFL with a combination of FL improve the accuracy of predicting EFW and GA. This is necessary to assess normal fetal development and detect skeletal dysplasia.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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