Original Article

The Prediction of Fetal Maturity and Gestational Age by Ultrasonic Measurement of Distal Femoral Epiphyseal Secondary Ossification Center

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Abstract

Objective: The aim of this study was to determine the diameters of the distal femoral epiphyseal secondary ossification center (DFOC) in the various gestational ages (GAs) as well as to create a novel equation, through which GA can be calculated from the measurement of DFOC. **Materials and Methods:** EDAN Digital ultrasonic diagnostic imaging system (model DUS 3 made by EDAN, Korea) and a 3.5MHz Convex transducer were used for the sonographic measurement. Ultrasonographic examinations were performed on 999 normal singleton pregnancies with GAs ranging from the 28th to the 41st weeks. Patients were recruited from the University of Calabar Teaching Hospital to Assurance Medical Diagnostic Center, where the ultrasonographic examinations were carried out. Images of the long axis of the fetal femur were taken. The DFOC was visualized as a small echogenic, ovoid structure lying adjacent to the distal femur. Three measurements of the DFOC diameter (in mm) were taken from outer to outer margins, and the largest diameter was recorded. Other measurements obtained include femur length, abdominal circumference biparietal diameter, head circumference, fetal weight (FW), and GA. **Results:** DFOC increased with GA. A strong positive relationship was observed between DFOC and GA with a correlation coefficient of $r = 0.85$. DFOC also increased with FW with a correlation coefficient of $r = 0.83$. The equation (GA = 30.84 + [1.25 × DFOC in mm]) relates GA to DFOC. **Conclusion:** The diameter of the distal femoral epiphyseal secondary ossification center is a useful parameter for estimating GA and assessment of fetal maturity in the third trimester.

Keywords: Diameter, epiphyseal, fetal, gestational age, maturity, ossification, ultrasound

Introduction

There are certain occasions during pregnancy when it becomes very necessary to know the maturity of the fetus. Such occasions could be diabetes, hypertension in pregnancy, placental insufficiency, antepartum hemorrhage, rhesus isoimmunisation, etc. These conditions threaten the life of the fetus *in utero*. On such occasions, the obstetrician may need to balance between the risk of intrauterine death and the hazards of prematurity and neonatal death. Uncertain gestational age (GA) and fetal maturity have been associated with adverse pregnancy outcomes including low birth weight, preterm delivery, and perinatal mortality independent of maternal characteristics[1] and hence extra-uterine viability and growth rate must be considered when defining fetal maturity. Accurate fetal maturity and GA assessment are essential in the evaluation of fetal growth and the detection of intrauterine growth restrictions.

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Most clinical methods used to assess GA and fetal maturity include; uterine size assessment, fundal height and quickening, but these methods have been reported to be suboptimal.[1] Up to 8 weeks, variation was observed in GA for any particular fundal height measurement taken during the second and third trimesters.[2] Sonographic estimations are derived from calculations based on fetal measurements and thus, serves as an indirect indicator of maturity and GA.[3] The use of multiple parameters had been noted to improve the accuracy of GA as well as reduces the effects caused by biological phenomena

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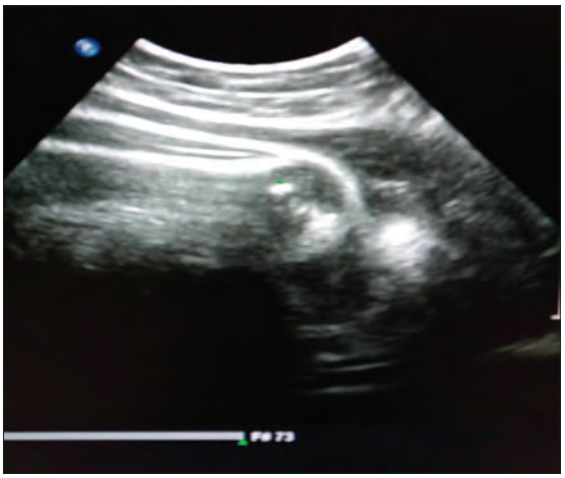

Figure 1: Sonogram showing measurement of DFOC

Table 1: Correlation of DFOC with other parameters for assessing gestational age, and fetal maturity

	GA	FW	FL	BPD	HC	AC
DFOC	0.85	0.83	0.84	0.83	0.83	0.81

DFOC: Distal femoral epiphyseal secondary ossification center , GA: Gestational age, FW: Fetal weight, FL: Femur length, BPD: Biparietal diameter, HC: Head circumference, AC: Abdominal circumference

(congenital anomalies and/or growth variations) or technical errors encountered in the measurement of a single structure.[3-5] To improve the accuracy of measurements, it is better to use an alternative indicator of GA and fetal maturity, rather than a suboptimal one if a certain indicator is not visualized or difficult to measure at that time.[1]

Materials and Methods

This prospective, analytical study was performed on 999 pregnant women undergoing routine obstetric scans in the third trimester of pregnancy from January 2015 to October 2016 in Calabar Metropolis. The study was conducted at the University of Calabar Teaching Hospital and Assurance Medical Diagnostic Center, Calabar, Cross River State, Nigeria. Participants selected were subjects with normal singleton pregnancies with GAs of 28–41 weeks. Participants with gestational diabetes and hypertension, cases of multiple gestation, polyhydramnios/oligohydramnios, alcoholic mothers, and fetuses with suspected intrauterine growth restriction were excluded from the study. All sonographic examinations were performed by a very experienced sonographer using EDAN Digital ultrasonic diagnostic imaging system (model DUS 3) with a 3.5MHz Convex transducer. Menstrual age was calculated from the First day of the last menstrual period. Confirmation of the last menstrual period was done by first-trimester or early second-trimester dating scans. These were utilized to assess GA. Fetal maturity was assessed using standard fetal biometric parameters. Standard fetal biometric parameters such as biparietal diameter (BPD), head circumference (HC), femur length (FL), abdominal circumference (AC) as well as estimated fetal weight (FW) were measured according to the standard protocols[6-8] and documented. The estimated FW was measured by the combination of AC, BPD, HC, and FL.[8] Pearson correlation equation was used to assess the relationship between DFOC and fetal biometric parameters, FW, and GA. The normality of the data was assessed using the Kolmogorov–Smirnov test $P < 0.05$ was chosen as the level of significance. Data were analyzed using the Statistical Package for the Social Sciences (SPSS Version 20, IBM Inc. Chicago, Illinois, USA).

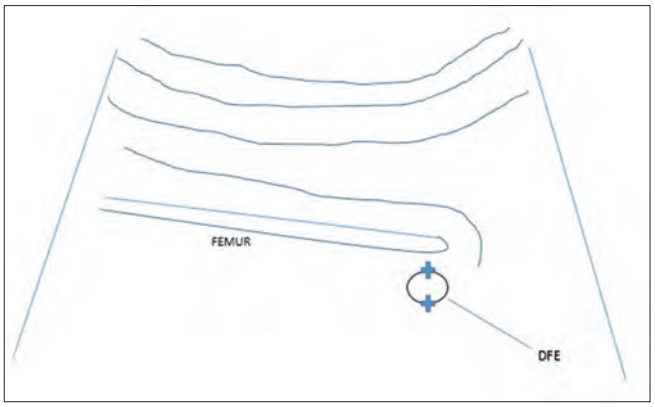

Figure 2: Sketched diagram showing how DFOC was measured

At the distal end of the femur, the DFOC was visualized as a small echogenic, ovoid structure lying adjacent to the distal femur as shown in figures 1 and 2. The diameter of this echogenic structure was measured as DFOC. Three measurements of the DFOC (in mm) were taken from outer to outer margins in an axial plane, and the largest diameter was recorded.

Results

The distal femoral epiphysis was not visualized until the 29th week of gestation. At this week, it was visualized in only 15% of the fetuses studied. This proportion increased drastically to 61% at GA of 32 weeks and 100% at GA of 37 weeks. The normality test shows that the data were normally distributed.

The results show that DFOC diameter increases with GA ($r = 0.85$, $P < 0.02$) and weight ($r = 0.83$, $P < 0.03$) of the fetuses in all age groups [Table 1]. At term, the DFOC was seen in 100% of fetuses and ranges between 4.00 and 9.00 mm. The equation, GA = 30.84 + 1.25 × DFOC (mm) relates the GA with the DFOC. The diameter of DFOC had a strong positive correlation with other indices of fetal maturity and GA such as BPD (0.83), HC (0.83), FL (0.84), and AC (0.81) as shown in Table 1. The reference chart of GA according to DFOC diameter, is shown in Table 2. Data were analyzed with SPSS version 16.0, and $P < 0.05$ was set as the level of significance.

Discussion

The rationale in this study was to provide yet another parameter

Table 2: DFOC (mm) in various gestational age

Gestational age (weeks)	DFOC diameter (mean±SD)
28	0
29	0.09±0.41
30	0.32±0.23
31	0.40±0.22
32	0.61±0.34
33	1.32±1.21
34	2.30±1.33
35	2.72±1.45
36	3.41±1.54
37	4.33±1.28
38	5.62±1.40
39	6.43±1.31
40	7.27±1.43
41	8.46±1.66

DFOC: Distal femoral epiphyseal secondary ossification center, SD: Standard deviation

that can be used to assess fetal maturity and predict GA within the late period of gestation by direct measurement of a single structure. Fetal biometry has been used to predict GA and fetal maturity since the time of A-mode ultrasound.[9] Sonographic estimations of GA are derived from calculations based on fetal measurements.[3]

The results show that the mean DFOC diameters increase linearly as GA increases. DFOC had a very strong positive relationship (r = 0.85) with GA. In line with our results, a study conducted by Birang *et al*.[10] in the Iranian population produced a correlation coefficient of 0.8 between DFOC and GA. FW in the present study also increased linearly with DFOC diameters. A very strong positive correlation (r = 0.83, P = 0.000) was also noticed between DFOC and FW.

The DFOC was not visualized in the 28th week of gestation in our population. DFOC was also not visualized before the 28th week in the American population, with the mean age of DFOC appearance being 32–33 weeks.[10] Wu *et al*., also reported 29 weeks gestation for the first appearance of DFOC in China.[9] At term, the DFOC was seen in 100% of fetuses and ranges between 4.00 and 9.00 mm. The distal femoral epiphysis is identified by locating the echogenic epiphyseal structure near the distal portion of the femur, and its measurements are obtained in an axial plane along the mediolateral surfaces of the epiphysis from the outer-outer margins. During the third trimester, the most central and older cells of the distal femoral, proximal tibial and humeral epiphyses convert from a cartilaginous model into a bone. These centers are the secondary epiphyseal ossification centers and are visible on an ultrasound scan during the third trimester and enlarge centrifugally until the cartilaginous epiphyses become completely ossified at birth.[11] Epiphyseal ossification centers appear late in gestation when traditional biometric measurements are not accurate or reliable. The usefulness of this parameter at this stage of gestation is, therefore, unequivocal and promises to be a useful method of determining fetal maturity and GA in the third trimester.

Accurate determination of fetal maturity and GA can positively affect pregnancy outcomes. For instance, studies found a reduction in the need for post-term inductions in a group of women randomized to receive routine first-trimester ultrasonography compared with women who received only second-trimester ultrasonography.[12] Appropriate management of preterm labor and post-term pregnancies requires accurate knowledge of fetal maturity and GA. Many pregnancies considered to be preterm or post-term could be wrongly classified if necessary and useful information is not provided.

Conclusion

The diameter of the distal femoral epiphyseal secondary ossification center is a useful method of determining fetal maturity and GA in the third trimester. Future studies may focus on showing the relationship between GA and DFOC in complicated pregnancies.

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Conflicts of interest

There are no conflicts of interest.

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