The African Journal of Medicine and Medical Sciences

Editors: T.A. Junaid
O. Bademosi and D.D.O. Oyebola

Volume 16
1987

BLACKWELL SCIENTIFIC PUBLICATIONS
Oxford London Edinburgh Boston Palo Alto Melbourne

Afr. J. Med. med. Sci. (1987) **16**, 47–52.

Assessment of foetal femur length by ultrasound in a normal Nigerian obstetric population

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Summary

In a group of Nigerian pregnant women at different gestational ages, 1097 foetal femur length measurements were taken using ultrasound. The measurement increased from a mean femur length of 15.9 mm at 14 weeks' gestation to 75.0 mm at 40 weeks' gestation. The growth pattern showed an asymptotic curve with faster growth in the early part of pregnancy. The standard deviation widened towards 40 weeks of gestation. There was a statistically significant correlation ($r = 0.9887$; $P < 0.001$) between gestational age and femur length. In the first half of pregnancy the femur length was significantly smaller than in studies reported for Caucasians. The finding may be related to the habit of late booking for antenatal care in our patients.

Résumé

Dans un groupe des Nigérianes enceintes aux âges de gestation différents, la longueur des 1,097 fémurs foetaux a été mesurée par moyen d'ultrasons. La longueur moyenne de fémur a cru de 15.9 mm à 14 semaines de gestation à 75 mm à 40 semaines de gestation. Le graphique de croissance dessinait une courbe asymptote avec une croissance plus rapide pendant la période initiale de gestation. La déviation normale a élargi vers 40 semaines de gestation. La corrélation entre l'âge de gestation et longueur de fémur était statistiquement importante ($r = 0.9889$; $P < 0.001$). Dans la première moitié de gestation, la longueur de fémur était beaucoup plus petite que celle rapportée pour les caucasiens. Ce fait peut résulter de l'habitude de nos patients a s'inscrire tardivement pour la consultation prénatale.

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Introduction

The determination of the gestational age of the foetus in a patient who does not know her last menstrual period (LMP) is one of the most frequent problems facing obstetric practice in developing countries. This is largely due to ignorance of the importance of the LMP in obstetric calculations and not due to illiteracy alone, as educated women also fail to recall the LMP when questioned.

Using ultrasound, the foetal biparietal diameter has proved to be a valuable measurement in estimating gestational age in both the developed (Campbell & Newman, 1971) and the developing world (Osefo & Chukudebelu, 1983). Considerable differences have been noted between the biparietal diameter charts for developed countries and those from Nigeria.

The technical difficulties that arise with the biparietal diameter measurements are due largely to malposition and engagement of the foetal skull. Cranial abnormalities also cause difficulty with interpretation of readings. For these reasons other foetal measurements are used. Of the foetal limb bones used, the femur (Queenan, O'Brien & Campbell, 1980; O'Brien & Queenan, 1981; Kirkpatrick, Dramaix Wilmet & Struyven, 1981) is increasingly being used to assess foetal growth, gestational age and to detect foetal limb abnormalities (Yeh *et al.*, 1982; Hobbins, Bracken & Mahoney, 1982).

The aim of this study was to determine the normal range of ultrasound femur length measurement at each week of pregnancy for a Nigerian population and to determine the correlation between gestation and foetal femur length in that population.

Patients and methods

From 14 to 40 weeks of gestation 947 patients were studied using a Philips SDR 1000 ultrasound machine with a 3 mHz transducer calibrated at a frequency of 1540 m/sec. Measurements were taken with electronic calipers. The patients had known last menstrual period dates and singleton, uncomplicated pregnancies. Delivery of a normal healthy baby occurred within 2 weeks of the expected date of delivery.

The foetal femur length was measured by the method described by O'Brien & Queenan (1981). The entire length of the femur was located and measurements were taken of the calcified shaft from lateral condyle to tip of greater trochanter (Fig. 1). The femoral head was excluded from measurement. Using low gain settings, sharp clearly defined ends of the femur were located and the intervening distance measured. Several separate readings were taken until two satisfactory and similar readings were found. Care was taken to visualize the entire length of the shaft and to avoid tangential pictures, which foreshorten the femur length. Superimposition of bones, which artificially lengthen the measure length, was also avoided. All measurements were taken by A.O.M.

The statistical analysis of the data utilized the method of least squares for fitting the linear regression equation and the Student's *t*-test for the comparison of two mean values.

Results

Table 1 shows the summary indices of the 1097 femur length measurements obtained from the 947 patients. While 150 of these patients had two measurements at different times during pregnancy, the remaining 797 patients had single measurements. The femur length grew from a mean of 15.9 mm at 14 weeks to 75.0 mm at 40 weeks, giving a mean growth of 59.1 mm for the period. The general pattern shows a steady increase in femur length with gestational age. This growth pattern illustrated in Fig. 2 was rapid initially and became slower with increasing gestational age resulting in an asympotic curve. The 95% confidence limits for femur length at each gestational age presented in Fig. 2 showed that the variability in femur

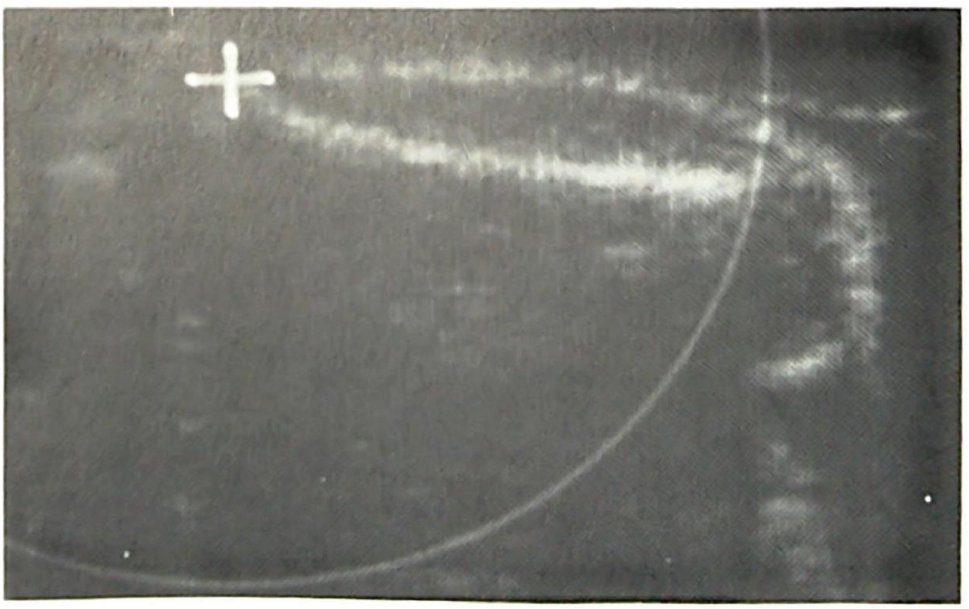

Fig. 1. Ultrasound image of the foetal femur length.

Table 1. Comparative mean (± 2 s.d.) femur length values in mm for the present study and that of O'Brien and Queenan (1981)

Weeks of gestation	Present Study		O'Brien & Queenan			
	No. readings	Mean (± 2 s.d.)	No. readings	Mean (± 2 s.d.)	*t* values	*P*
14	23	15.9 (2.2)	31	16.6 (2.5)	−2.139	0.05
15	24	17.8 (3.4)	28	19.9 (2.3)	−5.28	0.001*
16	21	20.4 (3.0)	28	22.0 (3.0)	−3.095	0.01
17	23	23.4 (3.2)	35	25.2 (2.9)	−4.44	0.001*
18	21	27.0 (2.4)	30	29.6 (3.1)	−0.45	0.001*
19	22	30.1 (4.0)	32	32.4 (3.1)	−4.757	0.001*
20	30	33.0 (4.2)	27	34.8 (2.5)	−3.876	0.001*
21	31	36.0 (3.4)	29	37.5 (4.1)	−3.09	0.001*
22	24	38.9 (3.8)	23	40.9 (3.9)	−3.561	0.001*
23	31	41.3 (4.6)	33	43.5 (3.6)	−4.276	0.001*
24	40	43.1 (3.4)	38	46.4 (3.5)	−8.447	0.001*
25	26	46.4 (3.2)	33	48.0 (4.6)	−3.016	0.001*
26	33	48.1 (4.0)	39	51.1 (5.0)	−5.551	0.001*
27	44	51.2 (4.6)	37	53.0 (3.2)	−4.011	0.001*
28	31	53.6 (4.8)	39	54.4 (4.1)	−1.503	0.001*
29	46	56.1 (4.4)	28	57.3 (4.3)	−2.295	0.05
30	45	58.5 (4.2)	48	58.7 (3.8)	−0.482	0.5
31	45	60.1 (4.8)	50	61.5 (4.5)	−2.934	0.01
32	34	61.6 (5.2)	52	62.8 (4.2)	−2.356	0.05
33	48	63.7 (4.8)	41	64.9 (4.6)	−2.397	0.05
34	66	66.0 (4.0)	41	65.7 (4.4)	−0.726	0.4
35	64	67.8 (4.4)	59	67.7 (4.8)	−0.241	0.5
36	70	69.1 (4.8)	56	69.5 (4.6)	−0.947	0.5
37	65	71.2 (4.6)	51	70.8 (4.3)	−0.956	0.5
38	63	72.0 (5.0)	46	71.8 (5.6)	−0.392	0.5
39	46	74.3 (6.0)	34	74.2 (5.1)	−0.157	0.5
40	81	75.0 (5.2)	28	75.4 (5.6)	−0.638	0.5

t = Student's *t*-test; *P* = significance of level of difference between readings of each gestational age for the two studies; * = significant difference.

length increases with increasing gestational age. The smoothened curve is represented in Fig. 3.

Based on a random sample of 360 paired measurements, the relationship between femur length and gestational age showed a significantly positive linear correlation ($r = 0.9887$; $P < 0.001$). The subsequent linear regression model fitted by the least squares approach produced the equation:

$$y = 6.62 + 0.418x,$$

where y = gestational age and x = femur length (Fig. 4). An examination of the residuals of the equation gave a mean residual of 1.09 days and a standard deviation of 0.9 days taking the observed and predicted values as paired observations. This was, however, found to be statistically not significant ($t = 1.214$; $P > 0.3$). When femur length was taken as the dependent variable (y) and gestational age as the independent variable (x) the linear regression equation was found to be:

$$y = -14.31 + 2.34x.$$

The summary of the estimates of the regression parameters are presented in Table 2.

Discussion

This study has shown that femur growth in the patients studied followed the asymptotic pattern as found by other workers among patients in the developed world (O'Brien & Queenan, 1981; Kirkpatrick *et al.*, 1981).

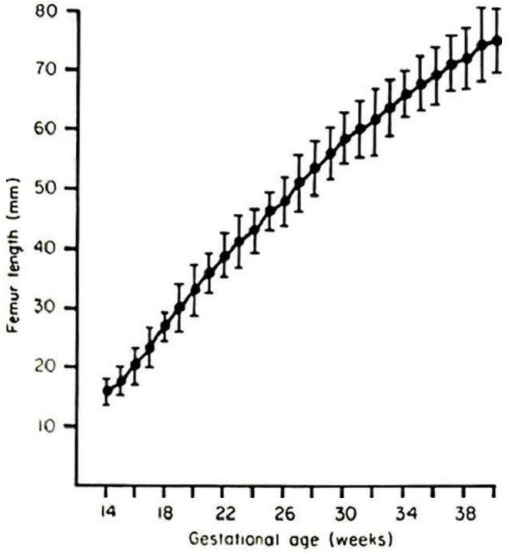

Fig. 2. Ultrasound mean foetal femur lengths (± 2 s.d.) at each gestational age from 14 to 40 weeks.

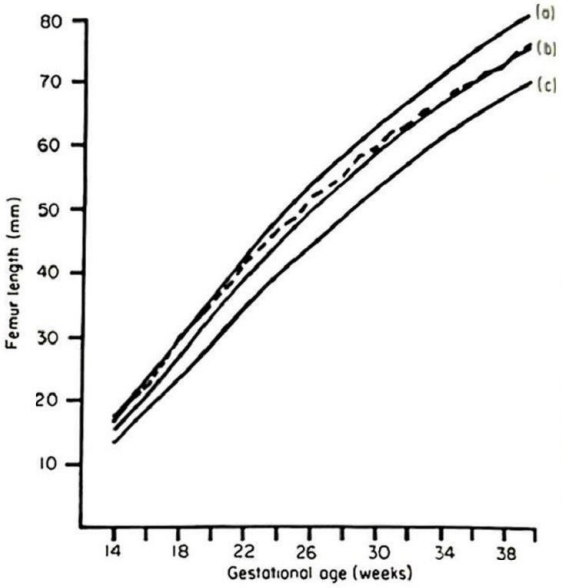

Fig. 3. A smoothened curve of mean femur length with upper and lower tolerence limits for each week of pregnancy from 14 to 40 weeks. (a = 95% limit, b = mean, c = 5% limit). (– – –) Represents the mean values for the data from O'Brien and Queenan (1981).

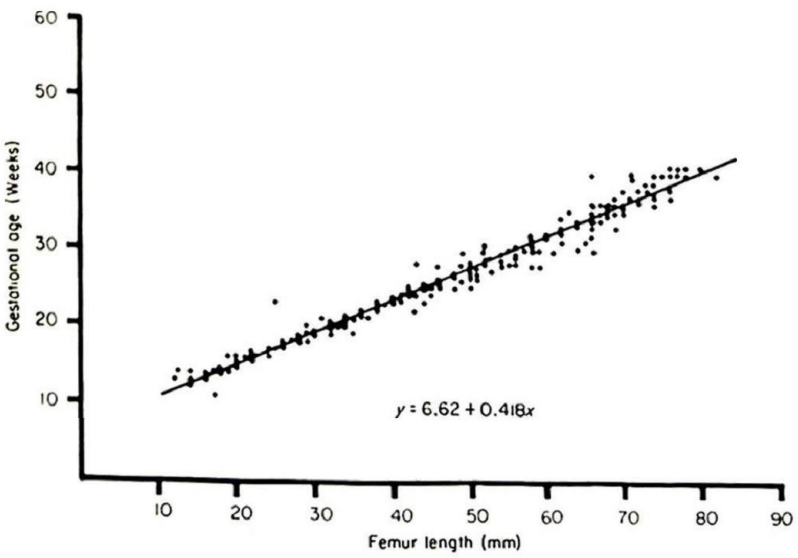

Fig. 4. Regression line for estimating gestational age from ultrasound measurements of foetal femur length

Table 2. Parameter estimates of the linear regression model ($y = a + bx$) between gestational age and femur length

Parameters	y = Gestational age x = femur length	y = Femur length, x = gestational age
Intercept only (a)	6.62	−14.31
Slope (b)	0.418	2.34
Standard error (y/x)	1.177	2.784
Standard error of a	0.1821	0.546
Standard error of b	0.0034	0.019
Correlation coefficient	0.9887	0.9887

y (gestational age) = 6.62 + 0.418x (femur length).
y (femur length) = −14.31 + 2.34x (gestational age).

A comparison of the average femur length at each age of gestation with those of Caucasians (O'Brien & Queenan, 1981) presented in Table 1 and Fig. 3, showed that the Nigerian foetuses studied had a significantly lower femur length ($P < 0.01$) below 27 weeks of gestation. After this week differences became smaller and statistically not significant ($P > 0.5$). It was also noted that the differences were of the order of only 2 mm when significant differences were recorded. The smaller mean femur lengths found in this study before 27 weeks of gestation may reflect a racial, genetic or local factor, as in the case of biparietal diameter (Osefo & Chukudebelu, 1983; Okupe, Coker & Gbajumo, 1984). One local factor of relevance is that the first attendance at antenatal clinic is often in the sixth or seventh month. It is often only from this time that regular mineral and vitamin supplements are taken and it is also only from this time that any dietary advice is given. It is possible that the foetus responds to this mid-pregnancy nutritional improvement by a growth rate, which tends to correct any previous tendency towards stunting of the femur length.

The mean birth weight in this study is lower than the 3.4 kg usually found in Caucasian studies (Campbell & Newman, 1971) although O'Brien and Queenan (1981) did not record mean birth weight in their mixed American and Hispanic population. It is not possible to comment on the effect of birth weight on femur lengths although Odita *et al.* (1982) found a correlation using X-ray femur lengths on newborn babies. Femur lengths may also be influenced by maternal and paternal height.

The standard deviation in this series is quite wide and represents the fact that this was a cross-sectional study with broad selection criteria. The latter was to provide a data base reflecting the community. The standard deviation generally increased towards term, which reflects the trend found by others (Queenan *et al.*, 1980; O'Brien & Queenan, 1981; Kirkpatrick *et al.*, 1981).

The high correlation between femur length and gestational age found is similar to that found elsewhere (Queenan *et al.*, 1980; O'Brien & Queenan, 1981). An estimate of gestational age for a given femur length was found to have the best precision between 18 weeks and 36 weeks of gestation where the error was generally less than 4 days. At the extreme ages of gestation, the precision was less good as deviations as high as 9 days were recorded. The two linear regression equations derived in this study were different from that found in other studies (Queenan *et al.*, 1980; O'Brien & Queenan, 1981) probably because of differing data bases.

Those workers also found that between 25 weeks and 35 weeks the error in estimation of the gestational age from a given foetal femur length was less than 5 days, with less reliability outside this range.

The foetal femur length is a useful additional measurement in the assessment of the foetus by ultrasound. While standard charts may be used it is useful that each centre develops its own normal charts, which will take account of racial,

ethnic and environmental factors. For our own local population the regression equation developed here can be useful for prediction purposes.

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(*Accepted* 3 *February* 1986)