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Fetal Foot Length and Femur/ Foot Length Ratio: Significance in Nepalese Context.

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Abstract ***Aim:*** 1. To assess relationship between fetal foot length and gestation age and develop a nomogram. 2. To assess relationship between fetal foot length and femur length.
Meterials and Method: Cross sectional study. Fetal foot length was taken from the skin edge overlying calcaneus to the distal end of the longest toe on either plantar or the sagittal view in 860 singleton pregnant women between 15 and 40 weeks' gestation. Normal case was defined as normal sonographic findings during examination and normal infant examination at birth or both. Final study population constituted 779 healthy fetuses. The relationship between gestational age to foot length was analyzed by simple linear regression. Correlation of fetal foot length with gestational age and femur length were also obtained.
Results: A nomogram for fetal foot length was obtained. There is linear relationship between foot length and gestational age [foot length (mm)=2.494xGestational age (weeks)-15.46] with significant correlation (r=0.970 and p=0.000) and between foot length and femur length [foot length(mm)=1.049xfemur length (mm)+0.648] with significant correlation (r=0.980 and P=0.000). Femur length/ Foot Length ratio was 0.9 and 1.0 in most of the cases.
Conclusion: Nomogram was obtained for fetal foot length at various gestational ages in our population. There is linear relationship and good correlation between foot length and gestational age and foot length and femur length. Fetal foot length can be used as an alternative fetal parameter to assess gestational age. Femur length/ Foot Length ratio is fairly constant throughout gestation.

Keywords: Fetalfootlength,Gestation age

Introduction

Correct assessment of gestational age is a cornerstone of management of any obstetric case. Several anatomical parameters are useful in the assessment of gestational age. In early pregnancy, we use MSD[1,2,3] and CRL[4] to assess gestational age. In second and third trimesters, we use four main anatomic parameters viz; biparietal diameter[5], head circumference[6], abdominal circumference[7] and femur length[8]. These parameters are more than sufficient in any routine antenatal scan to assess the gestational age. Moreover in busy centers, we are unable to use multiple other parameters which consume a lot of time

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during sonogram and which do not yield any additional information. But there are situations where these parameters cannot be used, for example, hydrocephalus, anencephaly, short limb dysplasia and in third trimester pregnancy when the head is already engaged. In these situations, we have to use other parameters for the estimation of gestational age. One of the useful parameters is fetal foot length because it is easily assessed and measured easily.

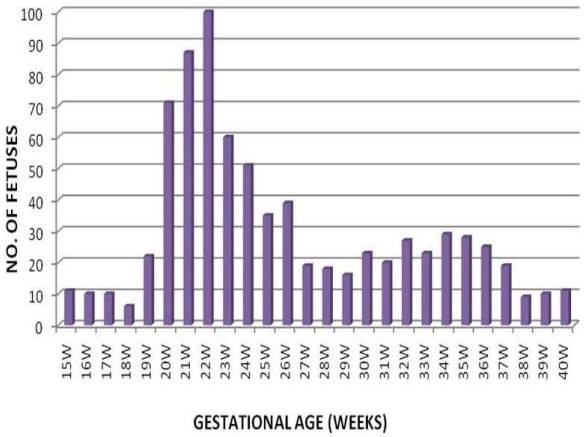

Figure 1: Frequency distribution of fetuses as per gestational age.

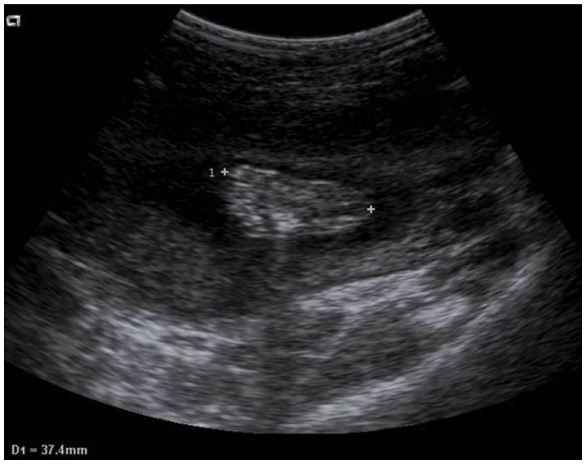

Figure 2: Plantar view of fetal view and measurement taken from the skin edge overlying the calcaneus to the distal end of the first toe (cursors). In this case of 20 weeks, the length is 37.4 mm.

Streeter, in 1920, showed that the fetal foot has a characteristic pattern of normal growth.[9] He proposed that the fetal foot could be used to estimate gestational age. Mercer et al[10] in a study of two hundred twenty-three postpartum and 224 ultrasonograhic measurements between 11 and 43 weeks' gestation concluded that fetal foot length is a reliable parameter for use in assessment of gestational age. The study by Platt et al[11] also suggest that the measurement of fetal foot length with ultrasound gives a reliable assessment of anatomical fetal or neonatal foot length and is highly correlated to the menstrual age of the fetus. Mhaskar et al[12] performed one hundred and five ultrasonographic measurement of fetal foot length between 13 and 42 weeks gestation and found that ultrasonographic measurement of foot length is a reliable indicator of gestational age.

We have taken a step to define a nomogram for fetal foot length and its relationship with gestational age and femur length in normal second and third trimester pregnancies in our population.

Methods

For type I and type II errors of 5% and 20% respectively, total number of subjects (N) was given by the formula $32/ES^2$, where ES is the smallest effect size worth detecting. Because a correlation of 0.1 is equivalent to the effective size of 0.2, total minimal sample required was 800. Fetal foot length measurements were thus obtained prospectively in 860 singleton pregnant women between 15 and 40 weeks' gestation. The study was conducted in Dhulikhel Hospital, Kathmandu University Hospital over a 15 month period between May 2010 and July 2011. The inclusion criteria were normal sonographic findings during examination and normal infant examination

at birth or both. The cases with sonographic abnormalities such as IUGR, structural anomalies, oligohydramnios, polyphydramnios were excluded from the study. The cases where proper follow up was not found postnatally were also excluded from the study. Hence final study population constituted 779 healthy fetuses (Fig1). As the study was cross sectional in design, only one measurement was considered for patients having multiple visits.

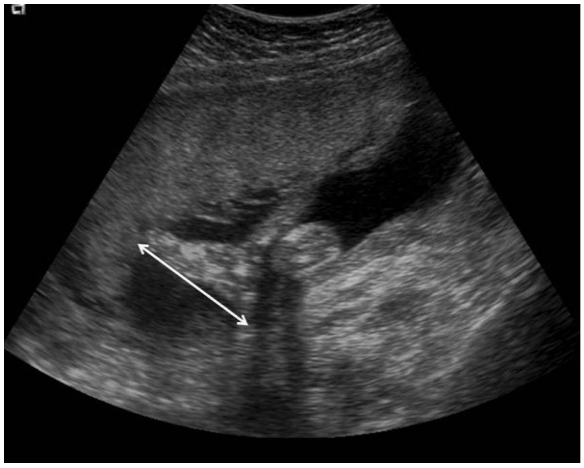

Figure 3: Sagittal view of fetal foot and its measurement (arrow).

Ultrasonographic measurements were made by a real-time system with a 3.5-MHz curvilinear transducer (ACUSON X150, Mountain View, CA 94043 USA). Gestational age (GA) was determined by two methods: firstly by knowing the first day of last menstrual period (GA by date) and secondly by sonographic measurement of four major parameters viz; Biparietal Diameter (BPD), Head circumference (HC), Abdominal Circumference (AC) and Femur Length (FL) and obtaining the final average GA (GA by measurement). If the two methods match closely within ±14 days, then gestational age by date was considered final GA. But if there is discrepancy of > 14days; GA by measurement was considered final GA.

In addition to these measurements, detailed evaluation of fetus was done from head to toe. Fetal foot length was taken from the skin edge overlying the calcaneus to the distal end of the longest toe (the first or second toe) on either the plantar or the sagittal view (Fig 2 and 3). The statistical analyses were performed by SPSS software version 11.5. The relationship between gestational age in weeks to fetal foot length in millimeters was analyzed by simple linear regression. For a given gestational age, predicted values were obtained for the 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 95^{th} percentiles to develop a nomogram. Correlation of fetal foot length measurements with GA and FL was also obtained alongwith FL/Foot Length ratio.

Results

Simple linear regression analysis shows linear relationship between foot length and gestational age [foot length (mm) = 2.494xGestational age (weeks)-15.46] with high degree of correlation (r=0.970 and P=0.000) (Fig4). A nomogram was obtained with the predicted values at 5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 95^{th} percentiles (Table 1). There is also a linear relationship between foot length and femur length [foot length (mm) =1.049xfemur length (mm) +0.648] with high degree of correlation (r=0.980 and P=0.000) (Fig5). Table 2 summarizes relationship of fetal foot length with gestational age and femur length. Femur/ Foot Length ratio was fairly constant throughout gestation (Fig6). In approx. 50.9% (396 cases, n=779) of cases the ratio is ≥0.9 and in approx. 40% (312 cases, n=779) of cases the ratio is 1. In 5% (40 cases, n=779), the ratio was less than 0.9. In remaining 3.9% (31 cases, n=779), the ratio was 1.1 (Fig7). Accordingly, the mean Femur/ Foot length ratio was 0.9 (SD 0.08).

Discussion

Correct assessment of gestational age is one

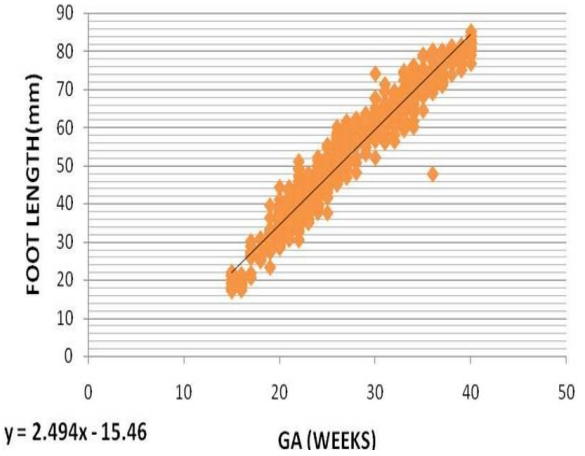

Figure 4: Relationships between fetal foot length (mm) and gestational age (weeks).

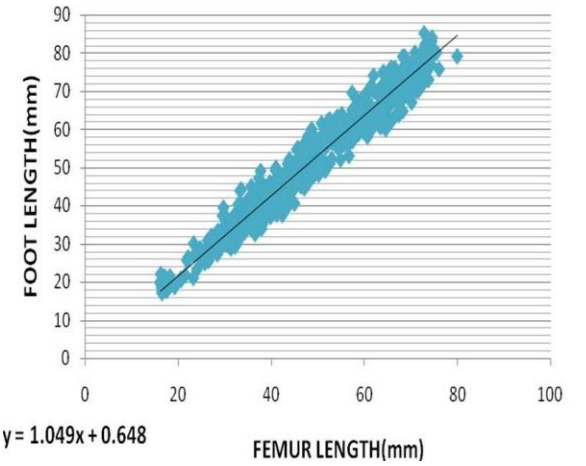

Figure 5: Relationship between fetal foot length (mm) and femur length (mm).

of the crucial events in the management of obstetric case. Gestational age can be assessed by knowing the first day of last menstrual period and by knowing the uterine height on examination. But these are subjected to considerable errors especially when a lady cannot recall LMP and in cases of multifetal gestation, oligo/polyhydramnios etc. Today most of the obstetricians depend on ultrasound for correct assessement of gestational age. Almost all fetal measurements change with gestational age.[13] Accordingly several parameters are described in the literature to evaluate gestational age. But routinely we use MSD, CRL, BPD, HC, AC and FL depending upon

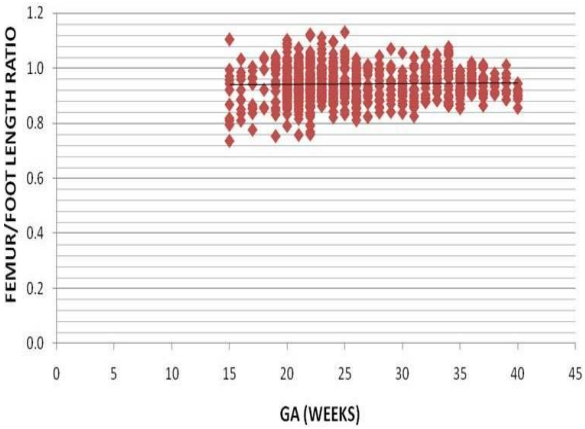

Figure 6: Relationship between fetal femur/foot length ratio and gestational age (weeks)

the duration of gestational age. In normal situations, these parameters are adequate to come to the conclusion. However in cases of macrocephaly/ hydrocephalus/ anencephaly, we obviously cannot use BPD and HC to assess GA. Similarly in short limb dwarfism, FL gives erroneous reading and so does AC in IUGR. Difficulty can arise even in normal term pregnancy when head is engaged and HC/ BPD cannot be correctly measured. Though rare events, aforementioned conditions can impose problems in calculating correct gestational age. Hence we have to look for other alternatives. One handy and useful alternative is measuring fetal foot length. In our experience, fetal foot length measurement is relatively simple technique and can be easily performed in normal day to day practice with good reliability. Shalev et al[14] tested the reliability of sonographic measurement of the fetal foot and found a good agreement in repeated measurements for and between the two planes.

Our study shows a clear linear relationship between fetal foot length and gestational age with significant correlation between these parameters. This is in comparison with previous studies[10,11,12] which conclude that the ultrasonographic measurement of foot length is a reliable indicator of gestational age. A study by Mandarim-de-Lacerda et al[15]

presents statistically significant curves of the foot length growth in relation to fetal parameters and concluded that these curves are useful in anatomy, forensic medicine, feto-pathology, medical imaging, obstetrics and pediatrics. We have developed a nomogram which is almost comparable to that of Western population. This shows that our fetal foot growth is not significantly different from those of Western population. We therefore recommend fetal foot length be considered for evaluation of gestational age; but only when other routine parameters as described above are not conclusive.

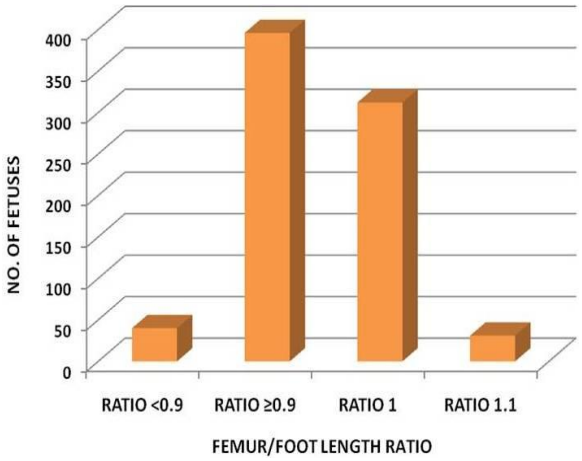

Figure 7: Frequency distribution of fetuses as per femur/foot length ratio.

Meirowitz et al[16] however, opined that there are limitations to the use of fetal foot length for gestational age assessment, particularly in fetuses with growth abnormalities. But we feel the measurement of foot length is still helpful in these situations to find out femur/foot length ratio which can be a useful additional tool for further evaluation of these fetuses. Campbell et al[17] found the femur/foot length ratio to be approximately 1 throughout the gestation ages between 14-40 weeks. They have also concluded that femur/foot length ratio nomogram is a useful parameter to help differentiate fetuses that have dysplastic limb reduction from those whose limbs are short because of constitutional factors or IUGR. If the fetus is constitutionally small or there is symmetrical intrauterine growth retardation, the ratio is greater than or equal to 0.9 and in most skeletal dysplasias characterized by limb shortening, the ratio is generally less than 0.9 because of the relative sparing of the hands and feet.[18] Johnson et al[19] found femur/foot length ratio an additional ultrasonographic marker for identification of fetuses at increased risk for trisomy 21.

Our observation shows femur/ foot length ratio of ≥0.9 in approx. 50% of cases and 1 in approx. 40% of cases (mean 0.9 and SD 0.08). IUGR was ruled out on ultrasound/ MCA Doppler and on physical examination at birth whenever indicated. Congenital anomalies were also ruled out at sonograms and at birth. So the fact that majority of fetuses with femur/ foot length ratio of ≥0.9 at present study perhaps is attributed to constitutionally small fetuses compared to Western population. In 40 cases, the ratio was less than 0.9. However, no major abnormality was detected at birth. In further 31 cases, the ratio was 1.1 with no major sonological or birth defects. These observations perhaps are attributable to intraobserver error or lack of high end investigations to detect genetic/chromosomal abnormalities. Moreover Grandjean et al[20] concluded that determination of the femur/foot ratio improves ultrasonographic detection of trisomy 21 in the second trimester, although for systematic use it would lead to an unacceptable number of unnecessary amniocenteses. Further large scale study with possible addition of karyotyping perhaps may resolve the issue of these abnormal femur/ foot length ratios in our context.

Conclusion

The results of this study provide nomogram for fetal foot length at various gestational ages in our population. The study also shows

linear relationship and good correlation between foot length and gestational age and foot length and FL. Fetal foot length can thus be used as an alternative fetal parameter to assess gestational age when other routine parameters are not conclusive. Femur/ foot length ratio of ≥0.9 still can be considered normal in view of constitutionally small fetuses in our country provided mild IUGR is ruled out.

Acknowledgements

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Table 1. Nomogram of fetal foot length (in millimeters) according to percentile distribution

GA (week)	No. of fetuses	5	10	25	50	75	90	95
15	11	17.30	17.60	17.95	19.00	20.50	21.40	21.70
16	10	17.56	17.92	18.53	19.20	19.95	20.86	21.13
17	10	21.04	21.58	25.78	26.30	27.23	28.92	29.46
18	6	25.05	25.20	25.50	25.90	27.80	29.55	30.18
19	22	27.21	27.44	29.00	30.00	32.20	33.27	36.06
20	71	29.50	30.00	31.25	33.70	36.30	37.40	38.90
21	87	32.46	33.00	34.35	36.70	38.95	40.42	41.07
22	100	34.67	35.47	36.98	40.00	41.50	44.00	45.96
23	60	35.90	37.19	40.00	41.20	43.85	45.11	46.01
24	51	39.00	39.80	42.70	44.90	46.85	49.40	49.95
25	35	42.41	43.96	46.35	48.30	49.20	51.30	53.20
26	39	45.84	46.86	48.90	51.10	54.50	57.02	57.78
27	19	48.78	49.80	50.90	56.40	58.75	60.10	60.96
28	18	50.23	51.65	55.33	56.50	59.13	60.51	61.78
29	16	54.28	55.35	56.45	59.25	60.78	62.25	62.75
30	23	56.43	56.80	58.60	62.00	63.45	67.00	67.59
31	20	56.86	58.61	60.85	62.90	65.15	69.23	69.59
32	27	58.60	60.24	61.00	64.40	66.45	67.96	68.85
33	23	60.30	60.34	61.55	66.00	70.00	73.66	74.18
34	29	62.44	63.70	66.30	70.00	72.90	74.62	75.80
35	28	68.14	68.68	70.15	72.35	73.85	75.15	77.39
36	25	69.20	70.08	71.10	73.00	75.00	78.26	79.78
37	19	71.35	71.64	72.60	75.60	77.85	79.84	80.00
38	9	74.84	75.88	76.80	78.40	79.00	80.24	80.72
39	10	75.63	76.26	77.25	78.75	79.78	81.23	81.37
40	11	77.80	78.90	80.05	81.00	82.60	84.00	84.55

Table 2. Summary of relationship of fetal foot length and GA and Femur length

y-axis	x-axis	Regression Formula	Correlation Coefficient	P value
Foot length	GA	y = 2.494xGA(weeks)-15.46	0.970	< 0.001
	Femur length	y =1.049xFL(mm)+0.648	0.980	< 0.001

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