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# A STUDY EXHIBITING CORRELATION BETWEEN GESTATIONAL AGE AND FETAL FOOT LENGTH AND FEMUR/FOOT LENGTH RATIO.

Radiology

**Dr. Bhoomika Katbamna** III year resident , Dept. of Radiodiagnosis, GMCH, Udaipur. Pramukhvandan , vaishalinagar street 7 , Raiya road , Rajkot

**Dr. N.C.Sharma*** Professor & Head , Dept. of Radiodiagnosis, GMCH , Udaipur.209,Priyadarshini nagar, Bedla road, Udaipur *Corresponding Author

**Dr. Akanksha Maheshwari** MD Radiology.74, Gokul nagar, Near bohra ganesh temple , Udaipur

## ABSTRACT

**Background:** Multiple parameters are used to measure gestational age by ultrasound , but when routine parameters are not applicable fetal foot length by literature is a good alternative. Also femur/foot length ratio can be used to access skeletal dysplasia.

**Material and method:** 62 singleton women with 15-40 weeks gestation were included and fetal foot length along with routine parameters were measured. Femur/foot length ratio was also calculated.

**Results:** Simple linear regression showed a linear relationship between foot length and gestational age with correlation factor of 0.9785 and P=0.000 and between foot length and femur length with significant correlation with r2=0.9797 and P=0.000. The fetal femur length/foot length ratio was found to be more than or equal to 0.92 and constant throughout gestation.

**Conclusions:** Foetal foot length is a reliable parameter for assessment of gestational age and femur length/foot length ratio is approximately 1

## KEYWORDS

fetal foot length , gestational age , ratio

## INTRODUCTION

Ultrasound assessment of gestational age is feasible in a majority of pregnancies and may be used to establish gestational age with greater accuracy than physical examination. In the first trimester, gestational sac mean diameter and CRL measurements have become the primary means of evaluating gestational age, while in the second and third trimesters, biparietal diameter, head circumference, abdominal circumference, and femur length.[1] However, gestational age assessment may be difficult in fetus with anencephaly, hydrocephalus, and short limb dysplasia. Difficulty can also arise even in normal term pregnancy when head is engaged and HC/ BPD cannot be correctly measured. Keeping the above mentioned limitations in mind, study for a new easily measurable and reproducible parameter is looked for. Study of literature suggests that fetal foot has a characteristic pattern of normal growth and the fetal foot could be used to estimate gestational age.[1]Boehm[2] had described the development of the foot in 4 stages.

## MATERIALS AND METHODS

A prospective study was conducted in 62 normal singleton pregnant women of 15-40 weeks gestation with normal sonographic findings , in the Department of Radio-Diagnosis, GMCH, UDAIPUR. Cases with sonographic abnormalities such as IUGR, structural anomalies, oligohydramnios, polyhydramnios, multiple pregnancies. Sonographic measurements were done of four major parameters viz ; Bi-parietal diameter (BPD), head circumference(HC), abdominal circumference (AC), and femur length(FL) and obtaining the final average of GA by measurement.

The fetal foot was measured from skin edge overlying heel to the distal end of the longest toe, either 1st or 2nd toe, on either the plantar or sagittal views by electronic calipers.(Figure 1,2). The Femur diaphyseal length was measured by measuring only the ossified portions of diaphysis and metaphysis, an internationally accepted method and the femur length/ foot length ratios was calculated for each.

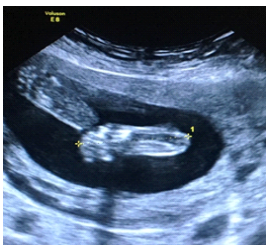


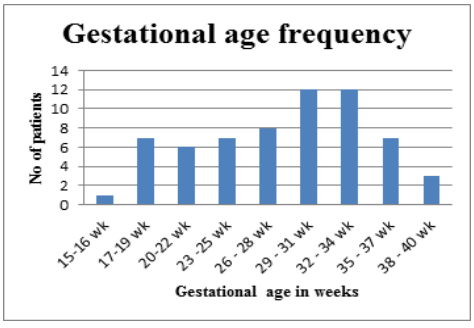
**Figure – 1 Fetal foot length measurement in plantar view.**

**Figure – 2 Fetal foot length measurement in sagittal view**

## RESULTS

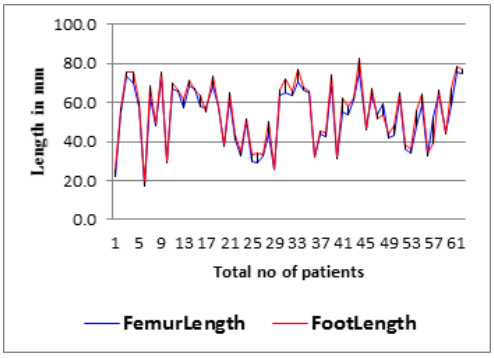
Among the 62 cases collected matching the inclusion and exclusion criteria the frequency distribution of data as per gestational age is shown in following graph.

**Graph No - 1: Gestational age frequency distribution**

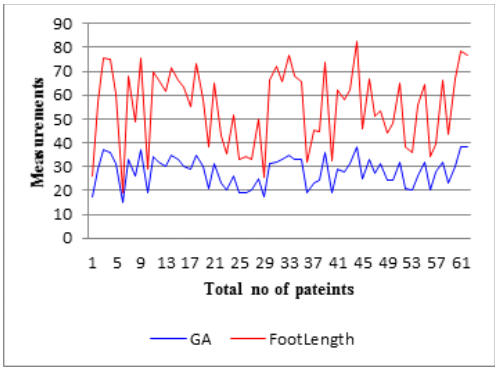



Simple linear regression(Y = a + bX) showed a linear relationship between foot length and gestational age with correlation factor of 0.9785 and P=0.000 and between foot length and femur length with significant correlation with r2=0.9797 and P=0.000.(Graph 2,3)

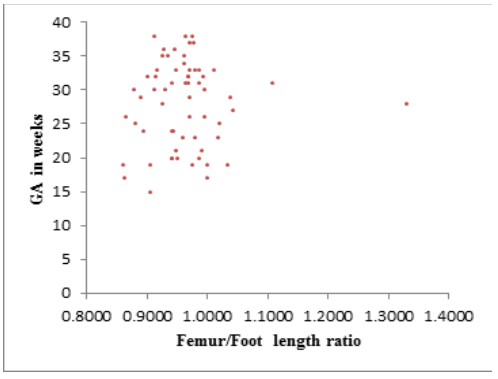
The femur to foot length ratio was observed to be constant throughout gestation with mean 0.961(graph 4). The ratio between 0.9 – 1.0 was found in 45 cases out of 62(72.6%) ,within the range of 0.95-0.99 was maximum and found in 25 cases(40.3%). 1 or above 1 was seen in 10 cases (16.1%) .In the range of 0.85 – 0.89 which was seen in only 7 cases (11.3%).




**Graph No -2: Relationship between femur length and predicted foot length.**




**Graph No -3: Relationship of GA and foot length.**




**Graph No-4: Relationship of femur/foot length ratio with GA**

## DISCUSSION

Antenatal ultrasonography has become the prime modality for assessment of fetal gestational age. Almost all fetal measurements change with gestational age. In the first trimester, the Crown rump length (CRL) measurement is used to estimate gestational age, whereas in the second and third trimesters fetal head parameters like BPD and HC, AC, and in extremity, FL measurements are used to assess GA. Use of the multiple parameters for assessing gestational age is valid when the gestational age estimates of the various ultrasound parameters are similar. If the gestational age estimates of one or several parameters is greater than 2 weeks different than the estimates of the other parameters, either the abnormal ultrasound parameters should be excluded or a different method should be used to estimate gestational age. When the various ultrasound parameters predict different gestational ages ,the fetus should be further evaluated to explain these differences. For example, an abnormally small FL measurement may suggest short-limb defects & chromosomal abnormalities like down's syndrome, a large BPD may be secondary to hydrocephalus and an abnormally small or large AC measurement may suggest asymmetric intrauterine growth retardation or macrosomia, respectively. Difficulty can arise even in normal term pregnancy when head is engaged and HC/ BPD cannot be correctly measured. Keeping the above mentioned limitations in mind, study for a new easily measurable and reproducible parameter is looked for. One such parameter is fetal foot length.Streeter[3], in 1920, showed that the fetal foot has a characteristic normal growth pattern. He proposed that the fetal foot could be used to estimate the gestational age. Shalevet al[4] tested the reliability of sonographic measurement of the fetal foot and found a good agreement in repeated measurements for and between the two planes.

This study is in comparison with previous studies as discussed below, which conclude that the ultrasonographic measurement of foot length is a reliable indicator of gestational age. A study by Mandarim-de-Lacerdaet al[5] 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 paediatrics. One such past study is on 103 pregnant women ranging from GA of 16-37 weeks with the majority of patients (38.8%) between 22 weeks -24 weeks gestation done by Mukta Mittal et al[6] in 2014 , in which linear relationship between foot length and gestational age was present with a $R^2$ value of 0.90 ($p <$ than 0.001). Further more K S Joshi et al[7] in 2011 showed in their study of 799 singleton pregnant women a linear relationship between foot length and gestational age with significant correlation (r=0.970 and p=0.000) and also found linear relationship between fetal foot length and femur length with significant correlation (r=0.980 and P=0.000). A study of fetal foot length in 105 pregnant women of GA 13 to 42 weeks by R. Mhaskar et al[8] showed linear relationship between foot length and gestational age was present with a $R^2$ value of 0.90 ($p <$ than 0.001). In comparison to our study, the results are alike with a slightly higher R2 value in ours, meaning a stronger linear relationship between the two parameters i.e. GA and Foot length. Platt et al[9] , Molly S. Chatterjee et al[10] , Eun Kyung Jiet al[11] also showed a significant correlation between gestational age and foot length.

Our study also had the ratio of between 0.9 – 1 was most frequent in 72.6%, among which between 0.95-0.99 was found in maximum(40.3%). 1 or above 1 was seen in 16.1% and between 0.85 – 0.89 was seen in 11.3%. Also the FL/Foot length ratio was found to be relatively constant through of the gestation with mean of 0.961. Campbell J et al[12]in 1988 measured femur/foot length ration in 182 fetuses between 14-40 weeks' gestation, and ratio was approximately 1 throughout these gestation age. They used femur/foot length ratio chart to differentiate fetuses with skeletal dysplasias from those with pseudo-limb reduction due to constitutional factors or intrauterine growth retardation (IUGR) in 16 suspected with femur measurements below the fifth percentile. R.Mhaskar et al[8] also showed the fetal femur length/foot length ratio was found to be more than or equal to 0.92. They concluded that femur length/foot length ratio is approximately 1 and a ratio of < 0.92 shall be useful in the detection of most skeletal dysplasia. K S Joshi et al[7] as mentioned previously observed femur/foot length ratio. 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% (40cases, n=779), the ratio was less than 0.9. In remaining 3.9% (31 cases, n=779), the ratio was 1.1. Accordingly, the mean Femur/ Foot length ratio was 0.9 (SD 0.08). However in our study, the cases in which the ratio values were more or less than 0.9, no major sonological defect or abnormality was detected unlike study by Campbell J et al. These observations perhaps are attributable to intra observer error or lack of high end investigations to detect genetic/chromosomal abnormalities. Moreover Grandjeanet al[13] 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.

## CONCLUSION

Our study results show a significant linear relationship and good correlation between foot length and gestational age and foot length and Femur length. Foot length is one of the secondary parameters whose measurement is simple, less time consuming, reproducible on daily routine obstretic ultrasonographic examination. Fetal foot length can thus be used as an alternative fetal parameter to assess gestational age when other routine parameters cannot predict true gestational age like in fetal hydrocephalus or anencephaly, macrosomia or short limb dysplasia. Femur/ foot length ratio remains nearly constant during the gestation period in our study with a mean of 0.96 and value of ≥0.9 to be considered normal. If ratio is found to be more or less than 0.9, careful lookout should be done for any skeletal anomalies.

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