Predicting Gestational Age of Fetus with the Reference of Humerus and Foot Length by Ultrasonography

Rabiya Siddique*
Doctor of Medical Imaging Technology, Department of Allied Health Sciences, Superior College Lahore, University Campus, 17-KM Raiwaind Road, Kot Arain, Lahore, Pakistan

Feeha Hamid
Doctor of Medical Imaging Technology, Department of Allied Health Sciences, Superior College Lahore, University Campus, 17-KM Raiwaind Road, Kot Arain, Lahore, Pakistan

Muhammad Mairaj
Doctor of Medical Imaging Technology, Department of Allied Health Sciences, Superior College Lahore, University Campus, 17-KM Raiwaind Road, Kot Arain, Lahore, Pakistan

Hira Riffat
Masters in Diagnostic Ultrasound, Lecturer, Department of Allied Health Sciences, Superior College Lahore, University Campus, 17-KM Raiwaind Road, Kot Arain, Lahore, Pakistan

Rana Muhammad Athar Azeem Shams
Masters in Medical Imaging Technology, Lecturer, Department of Allied Health Sciences, Superior College Lahore, University Campus, 17-KM Raiwaind Road, Kot Arain, Lahore, Pakistan

Amna Babar
Masters in Diagnostic Ultrasound, Lecturer, Department of Allied Health Sciences, Superior College Lahore, University Campus, 17-KM Raiwaind Road, Kot Arain, Lahore, Pakistan

Rana Muhammad Bakhtawar Khan Sajawal
Masters in Mathematics, Lecturer, Department of Allied Health Sciences, Superior College Lahore, University Campus, 17-KM Raiwaind Road, Kot Arain, Lahore, Pakistan

The research is financed by Asian Development Bank. No. 2006-A171 (Sponsoring information)

Abstract
Objective: The objective of the study is to predict the gestational age of fetus with the reference of humerus and foot length by ultrasonography.
Methodology: A cross sectional analytical study was perform in which 131 pregnant women with a singleton fetus were taken to get the required results. All data of the ultrasonographical reports has been collected from The Department of Radiology, Sheikh Zaid Hospital, Lahore. All pregnant women, from the second trimester to full term, are examined by ultrasound measurement of the full HL and FFL were taken by using a curve array transducer.
Results: 36 women (27.5%) out of 131 had gestational age by LMP was 17-20 weeks and only 2 women (1.5%) having gestational age by foot length of 25-28 weeks. 41 women (31.3%) out of 131 had gestational age by humerus length was 17-20 weeks and 3 women (2.3%) having gestational age by foot length of 37-40 weeks. GA was almost similar from these different parameters i.e. LMP, Foot Length and Humerus Length.
Conclusion: The fetal foot length and humerus length developed with gestational age in a healthily developing fetus. During the late second and third trimesters of pregnancy, the length of a fetus's foot and humerus length could be considered as an exploratory approach to determine the gestation of the fetus. When other parameters failed to reliably estimate gestational age, the length of the fetal foot and humerus length proved effective.
Keywords: Gestational age, Humerus Length, Foot length
DOI: 10.7176/JHMN/91-05
Publication date: July 31st 2021

1. Introduction
In obstetric care, an accurate measurement of gestational age is important. Making effective management decisions necessarily requires correct gestational age information. In addition to assisting obstetricians in correctly counselling women at high risk of preterm birth about possible perinatal outcomes, accurate awareness
of gestational age is also significant in the assessment of growth of fetus and the identification of intrauterine growth retardation. Although clinical data such as menstrual cycle or uterine size are often unreliable, the obstetrician can use ultrasound to assess the accurate parameter for pregnancy timing. Ultrasound is considered reliable and effective tool for determining gestational age in the first and second trimesters of pregnancy, and it can change obstetric performance and improve neonatal care when used as part of routine prenatal care\(^{(1)}\).

Estimating GA can be done in a variety of ways. The first day of the last menstrual cycle (LMP) and ultrasonography are used to measure GA during the antenatal period. If the menstrual cycle is normal, LMP is a common way to measure GA. In the case of an irregular cycle, however, LMP may not be a reliable method of estimating the GA. Ultrasound (US) analysis is believed to be important for determining the age of fetus \(^{(2)}\). Gestational age can be determined at any point during pregnancy, and there are many methods for doing so, each involving different equipment or abilities and varying degrees of accuracy\(^{(3, 4)}\). If a fetal size is appropriate for gestational age, accurate GA measurement is essential. LMP is a clinical test for GA that can be confusing or unreliable. The CRL is the most reliable parameter for assessing gestational age earlier in pregnancy during an ultrasound test in the first trimester. In the second trimester, BPD has the most precise association with gestational age, but FL can be used to assess GA if the head is abnormally shaped or if BPD cannot be imaged correctly, but its accuracy decreases as GA increases\(^{(5)}\). The difference between the first day of the last menstrual period (LMP) and the delivery date is used to calculate GA. Early pregnancy ultrasound is also believed to be important for determining GA \(^{(6, 7)}\). Many methods have been identified in the last 30 years concerning the relation between different biometric parameters such as crown rump length, diameter of gestational sac, biparietal diameter (BPD), femur bone length (FL) and abdominal circumference (AC) and gestation. Early prenatal sonography has been shown to be a reliable and objective method of determining gestational age \(^{(1)}\).

The ability to determine gestational age (GA) early in pregnancy is helpful in identifying growth abnormalities later in the pregnancy. GA may be determined by keeping a detailed record of your last menstrual period (LMP) or using ultrasonographical measurements\(^{(8)}\). In the management of obstetric patients, accurate prediction of gestational age (GA) is very useful for preparing a timely outcome. To determine gestational age in early pregnancy, sonographers may use mean sac diameter (MSD) at 0-7 weeks and crown-rump length (CRL) at 9-13 weeks. Sonographers use parameters such as biparietal diameter at 13-40 weeks, femur length at 24-40 w/g, head circumference, and abdominal circumference in the second and third trimesters. However, these biometric parameters have limitations. For example, conditions that affect the shape of the skull, such as cranial malformations, will affect biparietal diameter (BPD) and head circumference (HC). In these cases, we must rely on other parameters to provide a more accurate estimate of gestational age \(^{(9, 10)}\). BPD measurements will overestimate or underestimate gestational age if a head is disproportionately rounded (brachycephalic) or unusually elongated (dolichocephalic). Similarly, variations in AC measurements were found in macrosomic and growth-retarded fetus due to differences in liver size and subcutaneous tissue width\(^{(11)}\). It is possible to estimate the fetal length with a great accuracy because it is simple to locate and measure. To estimate the accurate GA, many antenatal assessment factors have been studied. While biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) are all considered reliable predictors and are used as typical parameters, using foot length along with humerus length to determine gestational age is more accurate. These parameters are useful in determining the fundal height of patients whose last menstrual period does not correspond to their fundal height on abdominal examination (LMP). The humerus length (HL) is determined using the same principles as the femur. After the forearm and shoulder regions have been identified, the beam of ultrasound is direct perpendicularly and the diaphysis alone is measured. From the tip of the longest toe (usually the second toe) to the tip of the heel, the fetal foot is measured \(^{(12)}\). Several studies have shown that using the CRL and foot length, i.e. heel-toe length, and other extremity parameters in second and third-trimester fetuses improves age determination \(^{(13)}\). As a result, length of the fetus feet was positively correlated with gestational age\(^{(14)}\).

The aim of this research is to discover other parameters that can be used to assess gestational age more accurately or in situations where the previous parameters are inaccurate, such as foot length, which can also be used as a replacement in the diagnosis of many karyotypic defects and syndromes. We use the fetal foot length along with the humerus length to find the gestational age of the fetus. Our study is based on the fetal foot length as an accurate estimate of the gestational age in early pregnancy. This study clarify the role of HL and foot length in determining the gestational age. In some cases when other parameters are not reliable then HL or foot length is of great interest in obstetric practice.

1.1 Materials and Methods

This is cross sectional analytical study, included normal pregnant women with a singleton fetus in the second and third trimesters, with the aim of determining the accuracy of HL and FFL in determining gestational age. This was an institutional base study conducted between January 2021 and March 2021 in department of radiology, Sheikh Zaid Hospital, Lahore. The study duration is 4 months. These pregnant women, from the
second trimester to full term, are examined by ultrasound while lying comfortably on their backs (supine); apply
gel to the lower abdomen and measure full HL and FFL using a 3.5 MHz transducer. The inclusion criteria is
Pregnant women with singleton fetus GA verified clinically in 2nd and 3rd trimester Pregnant women with
accurate LMP. The exclusion criteria is Pregnant women before 2nd trimester. Patients with unknown date of last
menstrual period. Women having gestational diabetes, skeletal dysplasia, Oligo-hydramnios, Poly-hydramnios,
Pre-eclampsia. Women with more than single gestations. Ultrasound machine convex array transducer with
frequency range of 2-7 MHz

2. Results
In our study total number of 131(100%) women and the maximum number of cases were reported in age of 30
years. The total number of cases in age of 30 years were 15 (11.5%). 36 women (27.5%), 37 women (28.2%) and
41 women (31.3%) out of 131(100%) women had gestational age by LMP, foot and humerus length were
between the 17-20 weeks respectively.

3. Discussion
Molly S. Chatterjee et al, demonstrated a significant linear association between fetal foot length and gestational
age (R2= 0.89, p<0.0001) in a study that was published in 2010. They used sonography to measure the length of the
foot from 15 to 36 weeks of pregnancy. According to their findings, the foot length of the fetus could be
detected by ultrasonography at 15 weeks of pregnancy, with a mean of foot length (17.5±2.9), and at 36 weeks of
gestation, with a mean sonographic length of foot of 64.4±3.28. (15).

Moawia Gameraddin et al, conducted a study in Dream Specialized Hospital in Khartoum State from
August to October 2015, which was a descriptive cross-sectional study. The researchers came to the conclusion
that HL was a reliable method of estimating the GA. In their study, there was a significant positive connection
between HL and GA. The HL is a fundamental fetal bone biometry test used in the assessment of gestational age,
and it can be used in conjunction with the FL to discover anomalies in the fetal bone. (16)

Our research was carried out on 131(100%) women who had normal singleton pregnancies, regular
menstrual cycles, and known LMP in order to measure the accuracy of ultrasound in determining the weeks of
gestation by humeral length and foot length, respectively. The length of the femur is already a well-established
ultrasonography measure for estimating the gestational age of a fetus. Despite the fact that the fetal humerus and
foot length are not currently used to determine gestational age, we noticed that the humerus and foot length were
associated with gestational age in a similar manner to the gestational age associated with the other parameters. In
our study we measure the gestational age by LMP and 36 women out of 131 having gestational age between the
17-20 weeks having percentage and standard deviation 27.5% and 1.805 respectively. We also measure the fetal
humerus length in 131 pregnant women to estimate the gestational age. 41 out of 131 women having gestational
age between the 17 to 20 weeks having percentage 31.0 % and standard deviation 1.799. We also measure the fetal
foot length in 131 pregnant women to estimate the gestational age. 37 out of 131 women having gestational
age between the 17 to 20 weeks having percentage 31.3 % and standard deviation 1.935. The lengths of the fetal
foot and humerus were measured using ultrasound, and the weeks of gestation was determined by using
abdominal sonography that measured the femur length, biparietal diameter and abdominal circumference.
Biparietal diameter, head and abdominal circumference and femur length are reliable predictors of gestational
age. Due to the fact that the humerus length and foot length are not usually taken as biometric parameters for
calculating GA, the study was conducted in order to assess fetal gestational age by measuring humerus length
and foot length in 2nd and 3rd trimester.

Few studies are present in which the determination of GA by foot length and HL were predict. We predicted
gestational age by foot length and humerus length which were very close to that gestational ages which were
predict by LMP. Our results were much similar to their result in which it was found that foot length and humerus
length were considered useful parameters for determining the GA.

Conclusion
The fetal foot length and humerus length are used to calculate the correct gestational age. The fetal foot length
develops with gestational age in a healthily developing fetus. Fetal foot length is an excellent predictor of
gestational age, particularly in situations with femur achondroplasia, dolichocephaly, or brachycephaly. During
the late second and third trimesters of pregnancy, the length of a fetus's foot can be used as exploratory tool to
determine the weeks of gestation of the developing fetus. When other parameters failed to reliably estimate
gestational age, the length of the fetal foot proved to be particularly effective. The HL was the most precise
variable, especially in the third trimester of pregnancy. HL would contribute to the highest level of accuracy
across all parameters.
Conflict of Interest
There is no conflict of interest in this research.

References
1. Pandey VD, Singh V, Nigam G, Usmani Y, Yadav Y. Fetal foot length for assessment of gestational age: A comprehensive study in North India. Sch J Appl Med Sci. 2015;3(1C):139-44.
2. Tikmani SS, Roujani S, Azam SI, Yasmin H, Bano K, Jessani S, et al. Relationship Between Foot Length and Gestational Age in Pakistan. Global Pediatric Health. 2020;7:2333794X20974206.
3. Naidu K, Fredlund KL. Gestational Age Assessment. StatPearls [Internet]: StatPearls Publishing; 2018.
4. Lee AC, Mullany LC, Ladhani K, Uddin J, Mitra D, Ahmed P, et al. Validity of newborn clinical assessment to determine gestational age in Bangladesh. Pediatrics. 2016;138(1).
5. Waseem N, Afsar R, Batool N, Aleem W. THE ULTRASOUND EVALUATION OF FETAL BIOMETRY IN INTRAUTERINE GROWTH RESTRICTION: A NARRATIVE REVIEW. Annals  of Allied Health Sciences. 2020;6(2).
6. Tiruneh C. Estimation of Gestational Age Using Neonatal Anatomical Anthropometric Parameters in Dessie Referral Hospital, Northeast Ethiopia. Risk Management and Healthcare Policy. 2020;13:3021.
7. Moller A-B, Petzold M, Chou D, Say L. Early antenatal care visit: a systematic analysis of regional and global levels and trends of coverage from 1990 to 2013. The Lancet Global Health. 2017;5(10):e977-e83.
8. Rahman ML, Sultana A, Das K. Determination of Gestational Age: A Perspective With the Bangladeshi Ethnicity.
9. Joshi K, Marahatta S, Karki S, Tamrakar S, Shrestha N. Fetal foot length and femur/foot length ratio: Significance in Nepalese context. Nepalese Journal of Radiology. 2011;1(1):15-22.
10. Hebarb S, Kopal S, Adiga P, Rai L. Fetal foot length throughout gestation: a nomogram. Sri Lanka Journal of Obstetrics and Gynaecology. 2013;35(2).
11. Kumar S, Pandey VD, Yadav Y. Fetal humerus Length for Prediction of Gestational Age: An Ultrasonographic Study.
12. Youisf NAM. The Determination of Gestational age by Humerus and Femur Length measurements by using ultrasound: The National Ribat University; 2017.
13. Malik BA, Ibrahim M, Ali Q, Yousef M, Alshammari QT, Jastaniah S. Use of foot measurements as sonographic parameter for estimation of fetal age. Open Journal of Medical Imaging. 2017;7(4):248-62.
14. Dagnew N, Tazebew A, Ayinalem A, MucHe A. Measuring newborn foot length to estimate gestational age in a high risk Northwest Ethiopian population. PloS one. 2020;15(8):e0238169.
15. Chatterjee MS, Izquierdo LA, Nevils B, Gilson G, Barada C. Fetal foot: evaluation of gestational age. Proceeding of the WFUMB, Sydney, Australia. 2010:206.
16. Gameraddin M, Abdelmaboud S, Alshoabi S. The role of fetal humeral length in determination of gestational age compared with femoral length using ultrasonography. IOSR-JDMS. 2015;14(5):65-8
Table No: 1 table showing the frequency of patient age

| Frequency | Age(Years) | Percent | Valid Percent | Cumulative Percent |
|-----------|------------|---------|---------------|--------------------|
| Valid     | 19         | 1.8     | .8            | .8                 |
|           | 20         | 1.5     | 1.5           | 2.3                |
|           | 21         | 1.5     | 1.5           | 3.8                |
|           | 22         | 6.1     | 6.1           | 9.9                |
|           | 23         | 6.9     | 6.9           | 16.8               |
|           | 24         | 3.8     | 3.8           | 20.6               |
|           | 25         | 10.7    | 10.7          | 31.3               |
|           | 26         | 4.6     | 4.6           | 35.9               |
|           | 27         | 8.4     | 8.4           | 44.3               |
|           | 28         | 7.6     | 7.6           | 51.9               |
|           | 29         | 7.6     | 7.6           | 59.5               |
|           | 30         | 11.5    | 11.5          | 71.0               |
|           | 31         | 4.6     | 4.6           | 75.6               |
|           | 32         | 3.1     | 3.1           | 78.6               |
|           | 33         | 5.3     | 5.3           | 84.0               |
|           | 34         | 4.6     | 4.6           | 88.5               |
|           | 35         | 6.1     | 6.1           | 94.7               |
|           | 36         | 1.5     | 1.5           | 96.2               |
|           | 38         | .8      | .8            | 96.9               |
|           | 39         | .8      | .8            | 97.7               |
|           | 40         | .8      | .8            | 98.5               |
|           | 42         | 1.5     | 1.5           | 100.0              |
| Total     | 131        | 100.0   | 100.0         |                    |

Table No 2: Total of 131 patients having the average age of 28.4 the table below showing mean of gestational age by LMP (3.40), mean of gestational age by foot length (3.52) and mean of gestational age by humerus length (3.37).
Table No: 3 the table below showing mean of gestational age by LMP, mean of gestational age by foot length and mean of gestational age by humerus length.

| Age(Years) | Gestational Age by LMP(weeks) | Gestational Age by foot length(weeks) | Gestational Age humerus length(weeks) |
|------------|-------------------------------|--------------------------------------|-------------------------------------|
| N          | 131                           | 131                                  | 131                                 |
| Missing    | 0                             | 0                                    | 0                                   |
| Mean       | 28.47                         | 3.40                                 | 3.52                                |
| Minimum    | 19                            | 1                                    | 1                                   |
| Maximum    | 42                            | 7                                    | 7                                   |

Table No 4: 36 (27.5%) women out of 131(100%) had gestational age by LMP is 17-20 weeks and only 2 (1.5%) women having gestational age by LMP of 37-40 weeks. Table shows the frequency of total women having different gestational ages.

| Gestational Age by LMP(weeks) | Frequency | Percent | Valid Percent | Cumulative Percent |
|-------------------------------|-----------|---------|---------------|--------------------|
| Valid                         |           |         |               |                    |
| 13-16                         | 18        | 13.7    | 13.7          | 13.7               |
| 17-20                         | 36        | 27.5    | 27.5          | 41.2               |
| 21-24                         | 26        | 19.8    | 19.8          | 61.1               |
| 25-28                         | 7         | 5.3     | 5.3           | 66.4               |
| 29-32                         | 16        | 12.2    | 12.2          | 78.6               |
| 33-36                         | 26        | 19.8    | 19.8          | 98.5               |
| 37-40                         | 2         | 1.5     | 1.5           | 100.0              |
| Total                         | 131       | 100.0   | 100.0         |                    |

Table No: 5 frequency and the percent of women having different gestational ages from LMP.
Table No 6: 37 (28.2%) women out of 131(100%) had gestational age by foot length was 17-20 weeks 8 (6.1%) women having gestational age by foot length of 25-28 weeks. Table shows the frequency of total women of different gestational ages predicting from foot length.

| Gestational Age by foot length(weeks) | Frequency | Percent | Valid Percent | Cumulative Percent |
|--------------------------------------|-----------|---------|---------------|--------------------|
| Valid                                |           |         |               |                    |
| 13-16                                | 17        | 13.0    | 13.0          | 13.0               |
| 17-20                                | 37        | 28.2    | 28.2          | 41.2               |
| 21-24                                | 25        | 19.1    | 19.1          | 60.3               |
| 25-28                                | 8         | 6.1     | 6.1           | 66.4               |
| 29-32                                | 10        | 7.6     | 7.6           | 74.0               |
| 33-36                                | 25        | 19.1    | 19.1          | 93.1               |
| 37-40                                | 9         | 6.9     | 6.9           | 100.0              |
| Total                                | 131       | 100.0   | 100.0         |                    |

Table No: 7 frequency and the percent of women having different gestational ages predicting from foot length.

Table No 8: 41 (31.3%) women out of 131 (100%) had gestational age by humerus length was 17-20 weeks and 3 (2.3%) women having gestational age by foot length of 37-40 weeks. Table shows the frequency of total women of different gestational ages predicting from humerus length.

| Gestational Age humerus length(weeks) | Frequency | Percent | Valid Percent | Cumulative Percent |
|---------------------------------------|-----------|---------|---------------|--------------------|
| Valid                                 |           |         |               |                    |
| 13-16                                 | 16        | 12.2    | 12.2          | 12.2               |
| 17-20                                 | 41        | 31.3    | 31.3          | 43.5               |
| 21-24                                 | 24        | 18.3    | 18.3          | 61.8               |
| 25-28                                 | 9         | 6.9     | 6.9           | 68.7               |
| 29-32                                 | 13        | 9.9     | 9.9           | 78.6               |
| 33-36                                 | 25        | 19.1    | 19.1          | 97.7               |
| 37-40                                 | 3         | 2.3     | 2.3           | 100.0              |
| Total                                 | 131       | 100.0   | 100.0         |                    |
Table No: 9 frequency and the percent of women having different gestational ages predicting from humerus length.

Table No: 10 showing the mean and standard deviation of the gestational ages from LMP, foot length and humerus length

| One-Sample Statistics |       |       |       |       |
|-----------------------|-------|-------|-------|-------|
|                       | N     | Mean  | Std. Deviation | Std. Error Mean |
| Gestational Age by LMP(weeks) | 131   | 3.40  | 1.805  | .158  |
| Gestational Age by foot length(weeks) | 131   | 3.52  | 1.935  | .169  |
| Gestational Age humerus length(weeks) | 131   | 3.37  | 1.799  | .157  |