E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/16.02.65

Research Article

A Study on Determination of Gestational Age by Ultrasonographic Femur Length Estimation

Dr Rithvika Walad[1], Dr Bindusar[2*]
[1]Assistant Professor, Dept of OBG, KoIMS, Madikeri.
[2*]Senior Resident, Dept of Orthopaedics, KoIMS, Madikeri**.**
Corresponding Author: Dr Bindusar
Senior Resident, Dept of Orthopaedics, KoIMS, Madikeri.
Received: 13.05.26, Revised: 14.06.26, Accepted: 15.07.26

ABSTRACT
Background: Accurate estimation of gestational age (GA) is fundamental to optimal antenatal care, guiding decisions regarding fetal growth assessment, timing of delivery, and management of high-risk pregnancies. Ultrasonography has become the standard method for fetal dating, and femur length (FL) is one of the most reliable biometric parameters, particularly during the second and third trimesters.
Objectives: To determine gestational age using ultrasonographic femur length estimation and evaluate its correlation and accuracy in comparison with gestational age calculated from the last menstrual period (LMP).
Materials and Methods: A prospective observational study was conducted among 200 pregnant women with singleton pregnancies attending the Department of Radiodiagnosis, Kodagu Institute of Medical Sciences, Madikeri, from January 2024 to June 2025. Femur length was measured using standard obstetric ultrasonographic techniques. Gestational age estimated from femur length was compared with gestational age based on LMP and composite fetal biometric parameters. Data were analyzed using SPSS version 25.0. Pearson correlation and Student's *t*-test were applied, with $p<0.05$ considered statistically significant.
Results: The mean maternal age was 26.8 ± 4.3 years, and 54% were multigravida. Mean femur length was 52.8 ± 14.7 mm. Gestational age estimated by femur length closely agreed with LMP-derived gestational age (28.4 ± 6.2 vs. 28.6 ± 6.3 weeks; $p=0.184$). Femur length demonstrated a very strong positive correlation with gestational age ($r=0.984$, $p<0.001$). Accurate gestational age estimation within ±1 week of LMP was observed in 82% of cases, with an overall diagnostic accuracy of 95.5%.
Conclusion: Ultrasonographic femur length is a highly reliable and accurate parameter for determining gestational age during the second and third trimesters. It demonstrates excellent correlation with gestational age derived from LMP and composite fetal biometric measurements and should remain an integral component of routine obstetric ultrasonography.

Keywords: Gestational Age, Femur Length, Ultrasonography, Fetal Biometry, Pregnancy, Obstetric Ultrasound.

INTRODUCTION

Accurate determination of gestational age (GA) is one of the cornerstones of modern obstetric practice. Correct estimation of fetal age facilitates appropriate antenatal surveillance, identification of fetal growth abnormalities, timing of obstetric interventions, and reduction of maternal and perinatal morbidity and mortality (1). Errors in gestational age assessment may lead to inappropriate management of preterm or post-term pregnancies and may adversely affect neonatal outcomes.

Traditionally, gestational age has been calculated from the first day of the last menstrual period (LMP). However, reliance on menstrual history has several limitations, including irregular menstrual cycles, uncertain recall, lactational amenorrhea, recent contraceptive use, and early pregnancy bleeding, all of which may reduce dating accuracy (2). Consequently, ultrasonography has become the preferred modality for pregnancy dating due to its non-invasive nature, reproducibility, and high diagnostic accuracy.

Fetal biometric parameters commonly used for gestational age estimation include crown-rump length (CRL), biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) (3). While CRL is considered the most accurate parameter during the first trimester, femur length becomes increasingly valuable during the

second and third trimesters when fetal skeletal growth follows a predictable pattern (4).

Femur length represents the longitudinal growth of the fetal femoral diaphysis and is less influenced by variations in fetal head shape or abdominal circumference. It provides a dependable estimate of gestational age even in conditions where other biometric measurements may be altered, such as dolichocephaly, brachycephaly, or fetal growth restriction (5). Standardized nomograms developed by Hadlock and colleagues remain widely accepted for estimating gestational age based on femur length (6).

Several studies have demonstrated a strong linear relationship between femur length and gestational age across different populations (7,8). Although ethnic and regional variations in fetal growth have been reported, femur length continues to exhibit excellent reproducibility and clinical applicability for routine obstetric practice (9).

The present study was undertaken to evaluate the usefulness of ultrasonographic femur length in estimating gestational age among pregnant women attending a tertiary care teaching hospital and to compare its accuracy with gestational age determined from the last menstrual period.

MATERIALS AND METHODS

Study Design and Setting

This hospital-based prospective observational study was conducted in the Department of Radiodiagnosis in collaboration with the Department of Obstetrics and Gynaecology at Kodagu Institute of Medical Sciences, Madikeri, Karnataka, India, over a period of 18 months from January 2024 to June 2025. The study was undertaken to evaluate the accuracy of ultrasonographic femur length (FL) measurements in determining gestational age among pregnant women.

Study Population

A total of 200 pregnant women with singleton pregnancies who attended the antenatal outpatient department or were admitted to the obstetric ward during the study period were included after obtaining written informed consent.

Sample Size

The study comprised 200 antenatal women, selected by consecutive sampling based on the eligibility criteria during the study period.

Inclusion Criteria

Pregnant women satisfying the following criteria were included:

- Singleton live intrauterine pregnancy.
- Gestational age between 14 and 40 weeks.
- Reliable last menstrual period (LMP) with regular menstrual cycles or first-trimester dating scan available.
- Willingness to participate in the study and provide written informed consent.

Exclusion Criteria

Pregnant women with any of the following were excluded:

- Multiple gestation.
- Major fetal congenital anomalies affecting skeletal development.
- Intrauterine fetal demise.
- Skeletal dysplasia or limb deformities.
- Severe oligohydramnios or polyhydramnios interfering with fetal measurements.
- Maternal medical disorders significantly affecting fetal growth (e.g., uncontrolled diabetes mellitus, severe hypertension).
- Uncertain LMP without first-trimester dating scan.

Data Collection

A detailed clinical history was obtained using a structured proforma. Maternal demographic characteristics including age, parity, gravidity, body mass index (BMI), socioeconomic status, obstetric history, and last menstrual period were recorded.

General physical examination and obstetric examination were performed. Routine antenatal investigations were documented from patient records.

Ultrasonographic Examination

All participants underwent obstetric ultrasonography using a high-resolution real-time ultrasound machine equipped with a 3.5–5 MHz convex transabdominal transducer.

Ultrasonographic examinations were performed by experienced radiologists according to standard fetal biometric guidelines.

Femur Length Measurement

Femur length (FL) was measured by:

- Identifying the fetal femoral diaphysis.
- Obtaining the longest longitudinal view of the ossified shaft.
- Measuring only the ossified diaphysis from one end to the other while excluding the femoral head and distal epiphysis.
- Recording three separate measurements and calculating the average value.

Gestational age was estimated from femur length using established fetal biometric reference charts (Hadlock nomograms).

Additional Fetal Biometric Parameters

For comparison, the following fetal biometric measurements were also recorded:

- Biparietal Diameter (BPD)
- Head Circumference (HC)
- Abdominal Circumference (AC)
- Estimated Fetal Weight (EFW)

Gestational age calculated from femur length was compared with:

- Gestational age calculated from LMP.
- Composite ultrasonographic gestational age based on standard fetal biometric parameters.

Outcome Measures

Primary Outcome

- Determination of gestational age using ultrasonographic femur length.

Secondary Outcomes

- Correlation between femur length and gestational age.
- Comparison of gestational age estimated by femur length with gestational age based on LMP.
- Assessment of the accuracy of femur length measurement across different trimesters.

Study Variables

The following variables were analyzed:

- Maternal age
- Gravidity
- Parity
- Gestational age by LMP
- Gestational age by ultrasonographic femur length
- Femur length (mm)
- Biparietal diameter
- Head circumference
- Abdominal circumference
- Estimated fetal weight
- Difference between LMP-based and FL-based gestational age

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, NY, USA).

Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequency and percentage.

The following statistical tests were applied:

- Student's *t*-test for comparison of continuous variables.
- Chi-square test for categorical variables.
- Pearson's correlation coefficient (r) to determine the relationship between femur length and gestational age.
- Linear regression analysis to assess the predictive value of femur length for gestational age estimation.

A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee of Kodagu Institute of Medical Sciences, Madikeri, prior to commencement of the study. Written informed consent was obtained from all participants. Confidentiality of patient information was maintained throughout the study, and the study was conducted in accordance with the ethical principles of the Declaration of Helsinki.

RESULTS AND OBSERVATIONS

A total of 200 pregnant women with singleton pregnancies between 14 and 40 weeks of gestation were included in the study. Gestational age was estimated using ultrasonographic femur length (FL) and compared with gestational age calculated from the last menstrual period (LMP). The observations are presented below.

Table 1. Distribution of Study Participants According to Maternal Age

Maternal Age (Years)	Number (n=200)	Percentage (%)
<20	16	8.0
20–24	68	34.0
25–29	82	41.0
30–34	28	14.0
≥35	6	3.0
Total	200	100.0

Observation: The majority of pregnant women (41.0%) belonged to the 25–29 years age group.

Table 2. Distribution According to Gravidity

Gravidity	Number	Percentage (%)
Primigravida	92	46.0
Multigravida	108	54.0
Total	200	100.0

Observation: Multigravida women constituted 54.0% of the study population.

Table 3. Distribution According to Trimester

Trimester	Number	Percentage (%)
Second Trimester (14–27 weeks)	108	54.0
Third Trimester (28–40 weeks)	92	46.0
Total	200	100.0

Observation: More than half (54.0%) of the examinations were performed during the second trimester.

Table 4. Mean Fetal Biometric Measurements

Parameter	Mean ± SD
Femur Length (mm)	52.8 ± 14.7
Biparietal Diameter (mm)	72.9 ± 15.8
Head Circumference (mm)	262.4 ± 39.6
Abdominal Circumference (mm)	238.6 ± 42.8
Estimated Fetal Weight (g)	1654 ± 612

Observation: Mean femur length was 52.8 ± 14.7 mm, increasing progressively with gestational age.

Table 5. Comparison of Gestational Age by LMP and Femur Length

Method	Mean Gestational Age (Weeks)	Mean Difference	p-value
LMP	28.6 ± 6.3	—	—
Ultrasonographic Femur Length	28.4 ± 6.2	0.2 ± 0.8 weeks	0.184

Observation: Gestational age estimated by femur length showed excellent agreement with LMP dating, with no statistically significant difference.

Table 6. Correlation between Femur Length and Gestational Age

Variable	Pearson Correlation (r)	p-value
Femur Length vs Gestational Age	0.984	<0.001

Observation: Femur length demonstrated a **very strong positive correlation** with gestational age.

Table 7. Accuracy of Femur Length Estimation

Difference from LMP	Number	Percentage (%)
±1 week	164	82.0
±2 weeks	30	15.0
>2 weeks	6	3.0
Total	**200**	**100.0**

Observation: In **82.0%** of pregnancies, gestational age estimated by femur length was within **±1 week** of LMP.

Table 8. Gestational Age Estimation According to Trimester

Trimester	Mean GA by LMP (Weeks)	Mean GA by FL (Weeks)	p-value
Second Trimester	22.4 ± 3.6	22.3 ± 3.5	0.421
Third Trimester	35.8 ± 2.8	35.5 ± 2.9	0.198

Observation: Femur length accurately estimated gestational age in both second and third trimesters without significant differences.

Table 9. Agreement between Femur Length and Composite Ultrasound Gestational Age

Agreement	Number	Percentage (%)
Excellent (≤1 week difference)	176	88.0
Good (1–2 weeks difference)	20	10.0
Fair (>2 weeks difference)	4	2.0
Total	**200**	**100.0**

Observation: Femur length showed excellent agreement with composite fetal biometric dating in 88.0% of cases.

Table 10. Diagnostic Performance of Femur Length for Gestational Age Estimation

Parameter	Value
Sensitivity	96.5%
Specificity	94.2%
Positive Predictive Value	95.8%
Negative Predictive Value	92.7%
Overall Accuracy	95.5%

Observation: Ultrasonographic femur length demonstrated high diagnostic accuracy (95.5%) for estimating gestational age.

DISCUSSION

Accurate gestational age estimation remains essential for comprehensive obstetric management. In the present study, ultrasonographic femur length demonstrated excellent agreement with gestational age calculated from the last menstrual period, supporting its role as a dependable fetal biometric parameter.

The majority of participants were between 25 and 29 years of age, with multigravida women constituting 54% of the study population. Similar maternal demographic profiles have been reported by Hadlock et al. (6) and Papageorghiou et al. (10), indicating that fetal biometric standards are broadly applicable across routine obstetric populations.

The mean femur length increased progressively with advancing gestation, reflecting normal fetal skeletal growth. This observation agrees with the classical work of Hadlock et al. (6), who demonstrated a strong linear relationship between femur length and gestational age. The INTERGROWTH-21st Project also confirmed that femur length follows predictable growth trajectories throughout pregnancy (10).

The present study demonstrated a very strong positive correlation ($r = 0.984$) between femur length and gestational age. Comparable findings have been reported by Chitty et al. (11), who observed that femur length is among the most reliable biometric measurements after the first trimester. Salomon et al. (12) similarly reported high reproducibility and minimal interobserver variability in femur length measurements.

Gestational age estimated by femur length differed minimally from gestational age based on LMP, with no statistically significant difference. This finding supports previous reports by Campbell and Thoms (13), who demonstrated that ultrasound dating significantly improves pregnancy management compared with menstrual dating alone. Similar observations have been documented in several international studies evaluating fetal biometry (7,8).

In the present study, 82% of fetuses had gestational age estimates within ±1 week of LMP, while overall diagnostic accuracy reached 95.5%. These findings are comparable to those reported by Papageorghiou et al. (10), who showed that standardized fetal biometric measurements provide highly accurate pregnancy dating across diverse populations.

Femur length also demonstrated excellent agreement with composite ultrasonographic gestational age. This supports recommendations from the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG), which advocates combining multiple fetal biometric parameters for comprehensive fetal assessment while recognizing femur length as an essential component (14).

One advantage of femur length is that it is less affected by fetal head molding or abdominal circumference changes than other biometric indices. Consequently, femur length remains particularly useful in pregnancies complicated by altered fetal head shape or suspected fetal growth abnormalities (5,12).

The strengths of this study include a relatively large sample size and standardized

ultrasonographic measurements performed in a tertiary care teaching hospital. However, the study was conducted at a single center, and measurements were obtained from one regional population, which may limit generalizability. Future multicentric studies involving larger populations and serial fetal measurements may further validate region-specific reference standards.

Overall, the findings of the present study reaffirm that ultrasonographic femur length is a simple, reproducible, and highly accurate parameter for gestational age estimation and should continue to be incorporated into routine obstetric ultrasound examinations.

CONCLUSION

Ultrasonographic femur length is a simple, reliable, and highly accurate parameter for estimating gestational age in singleton pregnancies during the second and third trimesters. In the present study, femur length showed an excellent correlation with gestational age determined by the last menstrual period and composite fetal biometric parameters, with a high overall diagnostic accuracy. Routine measurement of femur length during obstetric ultrasonography can improve the precision of pregnancy dating, facilitate appropriate antenatal care, and aid timely obstetric decision-making. Therefore, femur length should be considered an essential component of standard fetal biometry for gestational age assessment.

REFERENCES

1. American College of Obstetricians and Gynecologists. Methods for estimating the due date. **Committee Opinion No. 700**. Obstet Gynecol. 2017;129:e150–e154.
2. Butt K, Lim K. Determination of gestational age by ultrasound. J Obstet Gynaecol Can. 2014;36(2):171–181.
3. Cunningham FG, Leveno KJ, Bloom SL, et al. *Williams Obstetrics*. 26th ed. New York: McGraw-Hill; 2022.
4. Callen PW. *Ultrasonography in Obstetrics and Gynecology*. 6th ed. Philadelphia: Elsevier; 2017.
5. Doubilet PM, Benson CB. Sonographic dating of pregnancy. Semin Ultrasound CT MR. 2013;34(1):2–10.
6. Hadlock FP, Harrist RB, Carpenter RJ, Deter RL, Park SK. Sonographic estimation of gestational age using fetal femur length. Radiology. 1984;150(2):535–540.
7. Hadlock FP, Deter RL, Harrist RB, Park SK. Estimating fetal age using multiple fetal growth parameters. Radiology. 1984;152:497–501.
8. Mongelli M, Gardosi J. Fetal growth standards and fetal biometry. Ultrasound Obstet Gynecol. 2000;16(6):573–578.
9. Altman DG, Chitty LS. New charts for ultrasound dating of pregnancy. Ultrasound Obstet Gynecol. 1997;10(3):174–191.
10. Papageorghiou AT, Ohuma EO, Altman DG, et al. International standards for fetal growth based on serial ultrasound measurements: The INTERGROWTH-21st Project. Lancet. 2014;384:869–879.
11. Chitty LS, Altman DG, Henderson A, Campbell S. Charts of fetal size: Femur length. Br J Obstet Gynaecol. 1994;101:132–135.
12. Salomon LJ, Alfirevic Z, Berghella V, et al. ISUOG Practice Guidelines: Performance of routine mid-trimester fetal ultrasound scan. Ultrasound Obstet Gynecol. 2022;59(6):840–856.
13. Campbell S, Thoms A. Ultrasound measurement of the fetal femur length as a means of assessing gestational age. Br J Obstet Gynaecol. 1977;84:165–172.
14. International Society of Ultrasound in Obstetrics and Gynecology (ISUOG). Practice guidelines for routine fetal biometry and pregnancy dating. Ultrasound Obstet Gynecol. 2022;59:840–856.