Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
Print ISSN 3007-2379

Accuracy of Ultrasonography for Gestational Age Estimation Compared with Last Menstrual Period: A Cross-Sectional Study

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Keywords: Gestational age, Ultrasonography, Last menstrual period, Crown–rump length, Biparietal diameter, Femur length

Received on 15 Nov 2025
Accepted on 20 Dec 2025
Published on 31 Dec 2025

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Abstract

Objective: To evaluate the accuracy of grayscale ultrasonography for gestational age estimation using fetal biometric parameters compared with clinical assessment based on the last menstrual period (LMP).

Methods: A cross-sectional study was conducted at the Department of Radiology, DHQ Teaching Hospital Swabi, Pakistan, from January to June 2025. A total of 126 pregnant women aged ≤ 35 years with singleton gestations and a documented LMP were enrolled. Gestational age was estimated sonographically using crown–rump length (CRL), biparietal diameter (BPD), and femur length (FL), and compared with clinical gestational age calculated from LMP. Statistical analysis included descriptive statistics, paired t-tests, and Pearson correlation to assess the relationship between clinical and ultrasound-based gestational age estimates. A p-value <0.05 was considered statistically significant.

Results: Gestational age estimated by ultrasonography demonstrated strong positive correlations with clinical assessment. CRL, BPD, and FL showed highly significant correlations with LMP-based gestational age, indicating close agreement between ultrasound and clinical methods. These findings suggest that ultrasound-based estimation provides results comparable to clinical assessment, confirming its reliability and accuracy in obstetric evaluation.
Conclusion: Grayscale ultrasonography using standard fetal biometric parameters is a highly accurate and reliable method for gestational age estimation. Its agreement with LMP-based assessment supports its use as a primary tool for pregnancy dating, especially in cases where LMP is uncertain or unreliable, facilitating informed obstetric management.

Introduction

Accurate estimation of gestational age (GA) is a fundamental component of obstetric care, guiding prenatal screening, the timing of interventions, diagnosis of growth abnormalities, and management of preterm or post-term delivery. Traditionally, GA is estimated based on the first day of the last menstrual period (LMP); however, LMP-based dating is limited by recall bias, irregular menstrual cycles, and ovulation variability, leading to potential misclassification of gestational timing and estimated date of delivery (EDD)(1).

Ultrasonography, particularly early in pregnancy, has become the reference standard for gestational dating due to its objective measurement of fetal biometric parameters such as crown–rump length (CRL), biparietal diameter (BPD), and femur length (FL). First-trimester CRL measurement provides high precision in GA estimation with relatively narrow margins of error compared to LMP dating(2). Ultrasound biometry remains central to clinical practice worldwide, with evidence suggesting improved prediction of delivery date and reduced post-term misclassification when ultrasound dating is used, especially in the first trimester (3). The accuracy of ultrasound dating based on specific biometric parameters varies with gestational age and the measure used. CRL has been shown to have lower systematic and random errors than other biometric parameters such as BPD, head circumference (HC), or abdominal circumference (AC) in predicting delivery dates, especially in early pregnancy(4). In later gestation, combinations of biometric measurements, including FL and BPD, may enhance GA precision but can be influenced by growth variations and anthropometric differences between populations(5).

Several studies have reported strong positive correlations between GA estimated by ultrasound parameters and LMP, supporting the clinical reliability of sonographic dating(6,7). However, discrepancies between LMP-based and ultrasound-based GA remain a subject of clinical importance. For example, differences between methods have been associated with outcomes such as pregnancy loss when ultrasound-based dating significantly lags behind LMP estimates (8).

Despite the established use of ultrasound, uncertainty persists regarding the relative accuracy of individual biometric parameters, particularly in diverse populations and low-resource settings where early ultrasound is often unavailable. Additional studies are needed to evaluate the performance of routine grayscale ultrasonography using CRL, BPD, and FL against LMP-based GA in these contexts.

This study aims to assess the accuracy and reliability of grayscale ultrasonography using standard fetal biometric parameters (CRL, BPD, FL) for gestational age estimation and to compare these ultrasound-based estimates with clinical

gestational age calculated from LMP among pregnant women undergoing routine obstetric evaluation at a tertiary care hospital in Pakistan.

Materials and methods

This comparative cross-sectional study was conducted at the Department of Radiology, District Headquarter Teaching Hospital, Swabi, Pakistan, from January to June 2025, and included 126 pregnant women presenting for routine obstetric ultrasonography. Pregnant women aged ≤35 years with singleton gestations and a documented last menstrual period (LMP) were enrolled in the study, irrespective of parity or body mass index. Participants with known fetal anomalies or in whom a comprehensive and reliable ultrasonographic assessment could not be performed were excluded.

The sample size was calculated using the formula $n=Z^2\times P(1-P)/d^2$, where Z = 1.96 at 95% confidence level, P = 0.80 (estimated proportion), and d = 0.07 (margin of error). The calculation yielded a minimum required sample size of 126 participants. Participants were recruited using a convenience sampling technique.

Ultrasonographic examinations were performed using a Toshiba Nemio ultrasound machine equipped with a 3.5–5.0 MHz convex transducer. All scans were carried out using a transabdominal grayscale approach with participants in the supine position. Gestational age was estimated sonographically using standard fetal biometric parameters, including crown–rump length (CRL), biparietal diameter (BPD), and femur length (FL), measured in accordance with established obstetric ultrasound guidelines. Clinical gestational age was calculated from the first day of the last menstrual period.

Ethical approval for the study was obtained from the Department of Diagnostic Medical Sonography, Women University Swabi, and DHQ Teaching Hospital, Swabi. Written informed consent was obtained from all participants prior to enrollment, and strict confidentiality of participant information was maintained throughout the study.

Data were collected using a structured, pre-designed questionnaire that recorded demographic characteristics, menstrual history, and sonographic findings. Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 24. Quantitative variables were summarized as mean ± standard deviation, while qualitative variables were presented as frequencies and percentages. Gestational age estimates obtained by ultrasonography were compared with those calculated using LMP using paired t-tests and Pearson correlation analysis. A p-value of less than 0.05 was considered statistically significant.

Results

A total of 126 pregnant women were included in this study. Gestational age (GA) was estimated using grayscale ultrasonography with crown-rump length (CRL), biparietal diameter (BPD), and femur length (FL), and was compared with clinical GA calculated from the last menstrual period (LMP).

The demographic and menstrual characteristics of participants are summarized in Table 1. The majority of women were aged 21–25 years (n = 54, 43.3%). Early pregnancy bleeding or spotting was reported in 39 participants (30.7%). Regarding menstrual cycles, 67 women (52.8%) reported regular cycles, and 60 (47.2%) had irregular cycles. The average menstrual cycle length ranged from 27 to 35 days, with the highest frequencies observed at 29 and 30 days (n = 29 each, 22.8%).

Table 1: Baseline Characteristics of the Participants (n = 126)

Characteristic	Category	Frequency	Percentage (%)
Age (years)	16–20	26	20.5
	21–25	54	43.3
	26–30	38	29.9
	31–35	8	6.3
Spotting/Bleeding	Yes	39	30.7
	No	88	69.3
Menstrual Cycle Regularity	Regular	67	52.8
	Irregular	60	47.2
Average Menstrual Cycle Length (days)	27	6	4.7
	28	23	18.1
	29	29	22.8
	30	29	22.8
	32	28	22.0
	35	12	9.4

Pearson correlation analysis demonstrated a strong and statistically significant relation between gestational age estimated by clinical assessment using the last menstrual period and ultrasonographic measurements. Gestational age calculated by crown–rump length showed a very strong positive correlation with clinical estimation by last menstrual period ($r = 0.967$, $p < 0.001$). Similarly, biparietal diameter exhibited the highest correlation with gestational age by last menstrual period ($r = 0.983$, $p < 0.001$), while femur length also demonstrated a robust and significant association ($r = 0.968$, $p < 0.001$). These findings indicate that clinical and ultrasound-based assessments provide nearly equivalent estimations of gestational age, confirming the reliability and accuracy of both methods in obstetric evaluation (Table 2).

Table 2: Correlation between Gestational Age Estimated by Last Menstrual Period and Ultrasonographic Parameters

Comparison	Gestational Age by Last Menstrual Period (Mean ± SD, weeks)	Gestational Age by Ultrasonography (Mean ± SD, weeks)	Correlation Coefficient (r)	p-value
Last menstrual period vs crown–rump length	8.80 ± 1.78	8.73 ± 1.79	0.967	<0.001
Last menstrual period vs biparietal diameter	27.77 ± 7.34	27.82 ± 7.52	0.983	<0.001
Last menstrual period vs femur length	28.76 ± 6.45	28.38 ± 6.52	0.968	<0.001

Discussion

In this cross-sectional study evaluating the accuracy of grayscale ultrasonography for gestational age (GA) estimation using crown–rump length (CRL), biparietal diameter (BPD), and femur length (FL), we observed very strong, statistically significant correlations between ultrasound-derived and last menstrual period (LMP)-based gestational age estimates. Specifically, BPD showed the highest correlation ($r = 0.983$), with CRL ($r = 0.967$) and FL ($r = 0.968$) also demonstrating excellent agreement with LMP (all $p < 0.001$). These results confirm that routine fetal biometric measurements perform well in estimating GA when compared with LMP, supporting their continued use in obstetric practice.

Our findings are consistent with multiple recent studies demonstrating strong correlations between ultrasound biometric parameters and LMP-based GA**.** For example, a large cross-sectional study in Sudan reported a significant positive correlation between GA by LMP and ultrasound ($r = 0.921$, $p < 0.001$), with very small mean differences between methods, indicating close agreement in real-world settings similar to ours(9). First-trimester CRL measurement has long been established as the most accurate method for dating a pregnancy, with performance superior to LMP due to less susceptibility to recall bias and menstrual irregularity(10). Studies comparing CRL and BPD indicate that both parameters are comparably precise for first-trimester dating, though CRL may sometimes offer marginally lower systematic error (11). Our results support these observations with strong positive correlations between ultrasound metrics and LMP-based GA across the studied gestational window.

The high correlations observed in our study between sonographic parameters and LMP are consistent with other contemporary research in diverse populations. For instance, population-based cohorts have demonstrated strong positive correlations between CRL and GA across different ethnic groups, reinforcing the robust applicability of ultrasound biometry even in settings with variable menstrual cycle characteristics(12).

In contrast, some studies have documented discrepancies between methods, particularly when ultrasound is performed later in gestation. Correlations may weaken in the second and third trimesters due to increased biological variability in fetal growth and measurement error i.e., a prospective study examining late-gestation ultrasound found that while ultrasound remained superior to fundal height in accuracy, the precision relative to LMP decreased as gestation advanced, emphasizing challenges of late dating (13).

This study was cross-sectional and thus lacked follow-up to assess how gestational age estimations predict actual delivery dates. Future longitudinal research should evaluate the predictive accuracy of ultrasound versus LMP dating across diverse populations and gestational ages and consider advanced approaches such as automated biometry or machine learning enhanced predictions for more accurate GA estimation in broader clinical settings.

Conclusion

Grayscale ultrasonography using fetal biometric parameters including crown–rump length, biparietal diameter, and femur length demonstrates excellent accuracy and strong agreement with gestational age estimated from the last menstrual period. The findings indicate that ultrasound-based assessment provides gestational age estimates comparable to clinical evaluation. Ultrasonography is therefore a reliable and effective method for pregnancy dating, particularly in cases where the last menstrual period is uncertain or unreliable, and can be confidently applied to guide obstetric management.

Acknowledgements
The authors would like to thank the Department of Radiology, DHQ Teaching Hospital Swabi, and the Department of Diagnostic Medical Sonography, Women University Swabi, for their support and facilitation of this study. We are also grateful to all participants for their cooperation and contribution to this research.

Author contributions
Rabia Khan, Qurat ul Ain, and Saman Batool contributed to conceptualization, methodology, investigation, validation, and writing of the original draft. Hudabia Arshad Iqbal, Qudsia Hussain, Khadija Bibi Afsar, and Sara Bibi contributed to methodology, data curation, ultrasonographic assessment, validation, and review & editing of the manuscript. All authors have read and approved the final version of the manuscript.

Funding
None

Data Availability
The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations Conflict of Interest
The authors declare that they have no competing interests.

Ethical Approval and Informed Consent
The study was conducted following approval from the Institutional Review Board of the Department of Diagnostic Medical Sonography, Women University Swabi, and the DHQ Teaching Hospital, Swabi. Written informed consent was obtained from all participants prior to enrollment, and all procedures were carried out in accordance with the ethical standards of the Helsinki Declaration.

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