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Original Researcher Article

Role of Fetal Head Biometry in Ultrasonographic Estimation of Gestational Age

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Abstracts: ***Background*:** Accurate estimation of gestational age (GA) is fundamental to obstetric care, influencing antenatal monitoring, assessment of foetal growth, and timing of delivery. Ultrasonographic foetal biometry remains the most reliable method for gestational age estimation. Among biometric parameters, head circumference (HC) is considered a robust indicator of foetal age, particularly in the second and third trimesters, as it reflects overall cranial growth and is less affected by head shape variations. ***Aim*:** To evaluate the utility of foetal head circumference measured by ultrasonography for estimation of gestational age. ***Materials and Methods:*** This cross-sectional observational study included pregnant women with singleton pregnancies between 14 and 39 weeks of gestation who underwent routine obstetric ultrasonography. Foetal head circumference was measured using standardized ultrasonographic techniques. Gestational age was determined by ultrasonographic dating. Statistical analysis included descriptive statistics, Pearson's correlation analysis, and linear regression to assess the relationship between head circumference and gestational age. ***Results*:** Foetal head circumference showed a strong positive correlation with gestational age across the studied gestational period. Mean head circumference increased progressively with advancing gestation, and regression analysis demonstrated head circumference to be a reliable predictor of gestational age. ***Conclusion*:** Foetal head circumference measured by ultrasonography is a reliable and useful parameter for estimation of gestational age. Its strong correlation with gestational age supports its use as an effective biometric indicator, particularly in the second and third trimesters.

Keywords: Head circumference; Gestational age; Ultrasonography; Foetal biometry; Pregnancy

INTRODUCTION

Accurate determination of gestational age is a critical component of prenatal care, as it guides obstetric decision-making, assessment of foetal growth, and identification of preterm or post-term pregnancies [1]. Errors in gestational age estimation may result in inappropriate clinical interventions and adverse perinatal outcomes [2]. While the last menstrual period has traditionally been used for dating pregnancy, its reliability is often limited by recall bias and irregular menstrual cycles, making ultrasonography the preferred method for gestational age estimation [3].

Ultrasonographic foetal biometry plays a central role in estimating gestational age, particularly in

the second and third trimesters [4]. Commonly used parameters include biparietal diameter, head circumference, abdominal circumference, and femur length [5]. Among these, head circumference is considered a comprehensive measure of foetal cranial growth, as it accounts for both biparietal and occipitofrontal dimensions and is less influenced by variations in head shape compared to biparietal diameter alone [6].

Head circumference has been shown to correlate closely with gestational age and foetal brain development, making it a valuable parameter for pregnancy dating [7]. Unlike biparietal diameter, which may be affected by dolichocephaly or brachycephaly, head circumference provides a more stable and reproducible assessment of cranial size [8]. This advantage becomes particularly important in late gestation and in conditions where head shape abnormalities are suspected [9].

Several studies have demonstrated a strong linear relationship between foetal head circumference and gestational age, supporting its role as a reliable predictor of foetal age across different populations [10–12]. Population-specific reference data are essential, as foetal growth patterns may vary with ethnicity, nutritional status, and environmental factors [13]. Indian data on the utility of head circumference for gestational age estimation remain relatively limited, highlighting the need for region-specific studies.

The present study was undertaken to evaluate the relationship between foetal head circumference measured by ultrasonography and gestational age, and to assess its utility as a reliable parameter for gestational age estimation in a tertiary care setting.

MATERIALS AND METHODS

This cross-sectional observational study was conducted in the Department of Radiodiagnosis of a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee. Pregnant women attending the antenatal clinic and referred for routine obstetric ultrasonography were consecutively enrolled after obtaining informed consent. A total of **456 pregnant women** with singleton pregnancies between **14 and 39 weeks of gestation** were included in the study. Gestational age was determined based on ultrasonographic dating, and cases with uncertain last menstrual period but reliable ultrasonographic assessment were also included.

Pregnancies with multiple gestations, foetal congenital anomalies, skeletal dysplasias, intrauterine growth restriction, or maternal systemic illnesses known to affect foetal growth were excluded from the study to ensure inclusion of uncomplicated pregnancies with normal foetal development.

All ultrasonographic examinations were performed using a real-time ultrasound machine equipped with a curvilinear transducer, following standard obstetric scanning protocols. Examinations were conducted with the pregnant woman in the supine position during routine antenatal ultrasound evaluation. Foetal head measurements were obtained in the standard axial transthalamic plane, ensuring visualization of the cavum septi pellucidi, thalami, and falx cerebri. Biparietal diameter was measured from the outer margin of the proximal parietal bone to the inner margin of the distal parietal bone. Head circumference was measured by placing an electronic ellipse along the outer margin of the foetal skull in the same axial plane.

Care was taken to ensure that measurements were obtained when the foetal head was symmetrical and free from obliquity. At least two consistent measurements were obtained for both biparietal diameter and head circumference, and the average value was recorded. All measurements were performed by experienced radiologists using standardized techniques, as described in previous studies, to minimize inter-observer variability [6,11].

Statistical analysis

The collected data were entered into a Microsoft Excel spreadsheet and analyzed using standard statistical software. Continuous variables were expressed as mean ± standard deviation, median, interquartile range, and range. The relationship between gestational age and foetal head circumference and biparietal diameter was assessed using Pearson's correlation coefficient. Linear regression analysis was performed to derive predictive equations for gestational age based on head circumference and biparietal diameter. A p value of less than 0.05 was considered statistically significant.

RESULTS

A total of **456 pregnant women** fulfilling the inclusion criteria were evaluated in the present

study. The **mean maternal age** was **25.3 ± 3.93 years**, with the majority of participants belonging to the **21–30 years age group**, reflecting the predominant reproductive age in the study population. Most women were **housewives**, and a substantial proportion were **primigravida**, indicating a relatively low-risk antenatal cohort. The majority of pregnancies were registered early, and most women had received at least one antenatal visit before undergoing ultrasonography.

The **mean gestational age at the time of ultrasound examination** was **26.36 weeks**, with a wide range extending from **14 to 39.3 weeks**, ensuring adequate representation of second and third trimester fetuses. This broad gestational distribution allowed reliable assessment of foetal head growth patterns across advancing gestation.

Table 1. Baseline demographic and obstetric characteristics of study subjects (n = 456)

Variable	Value
Maternal age (years), mean ± SD	25.3 ± 3.93
Hindu: Muslim	391 (85.7%):65 (14.3%)
House Wife	427 (93.6%)
Mean gestational age at scan (weeks)	26.36
Gestational age range (weeks)	14 – 39.3
Gravidity (primigravida)	192 (42.1%)
History of abortion	380 (83.3%)
Pregnancy Registered within 12 weeks	350 (76.8%)

Correlation of Head Circumference & Biparietal diameter with Gestational Age

Head circumference demonstrated a **very strong positive correlation** with gestational age. Statistical analysis showed a **correlation coefficient (r) of 0.95**, which was **highly significant (p < 0.001)**, indicating that foetal head circumference increases consistently and predictably with advancing gestation. This strong linear association confirms head circumference as a **robust and reliable parameter** for estimation of gestational age on ultrasonography.

The progressive increase in head circumference was observed across all gestational weeks. Growth was relatively uniform during mid-gestation, while a slightly wider variability was noted in late gestation, likely reflecting physiological differences in foetal growth patterns and smaller sample sizes at certain gestational weeks.

Biparietal diameter also showed an **excellent positive correlation** with gestational age, with a **correlation coefficient (r) of 0.96** and a **highly significant p value (<0.001)**. The mean BPD increased progressively from early gestation to term, confirming its continued relevance as a standard biometric parameter for gestational age estimation.

The close similarity in correlation strength between **BPD and HC** suggests that both parameters are highly reliable; however, head circumference offers an advantage by being **less affected by variations in skull shape**, particularly in cases of dolichocephaly or brachycephaly.

Figure 1: Correlation between Biparietal Diameter and Gestational Age

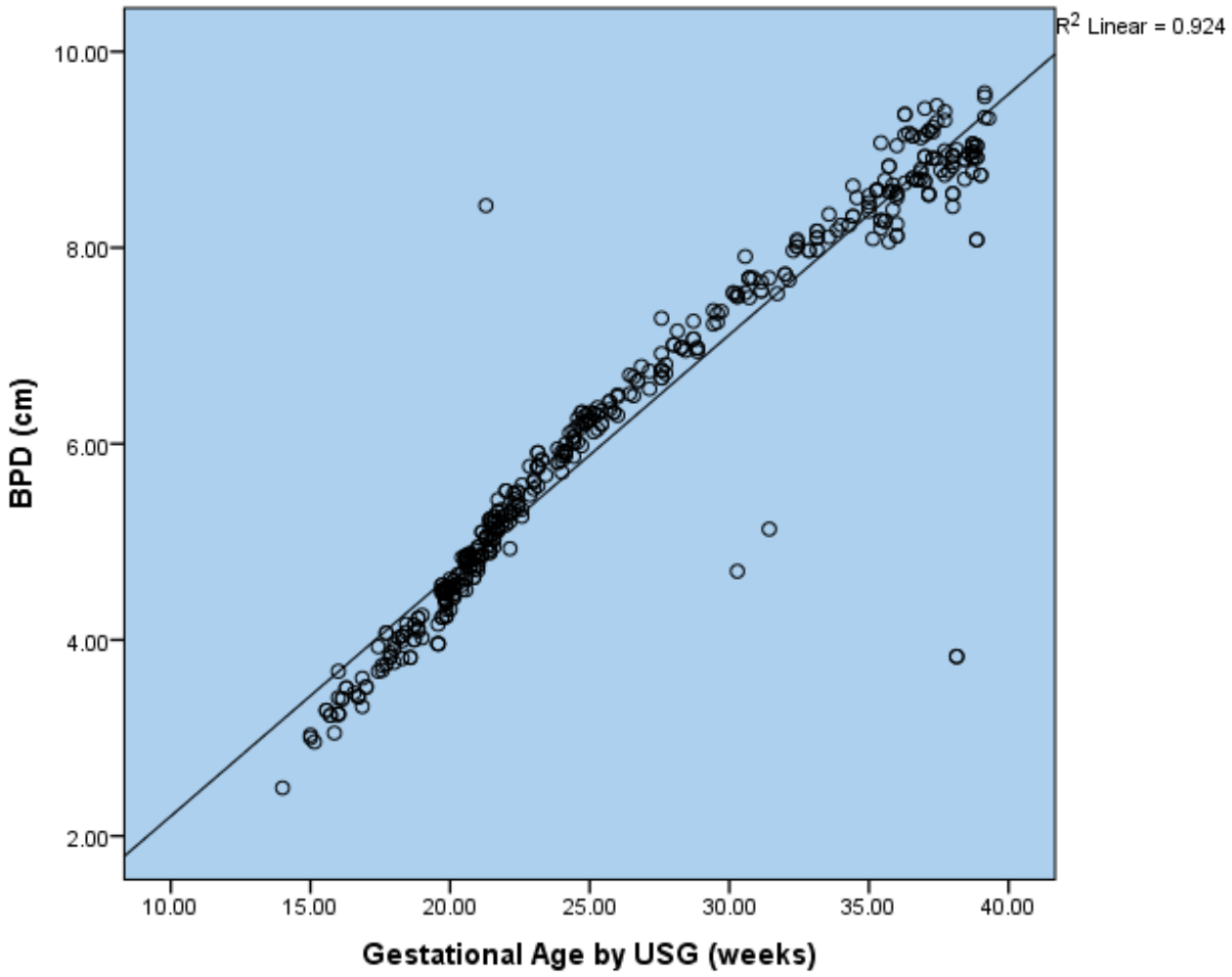
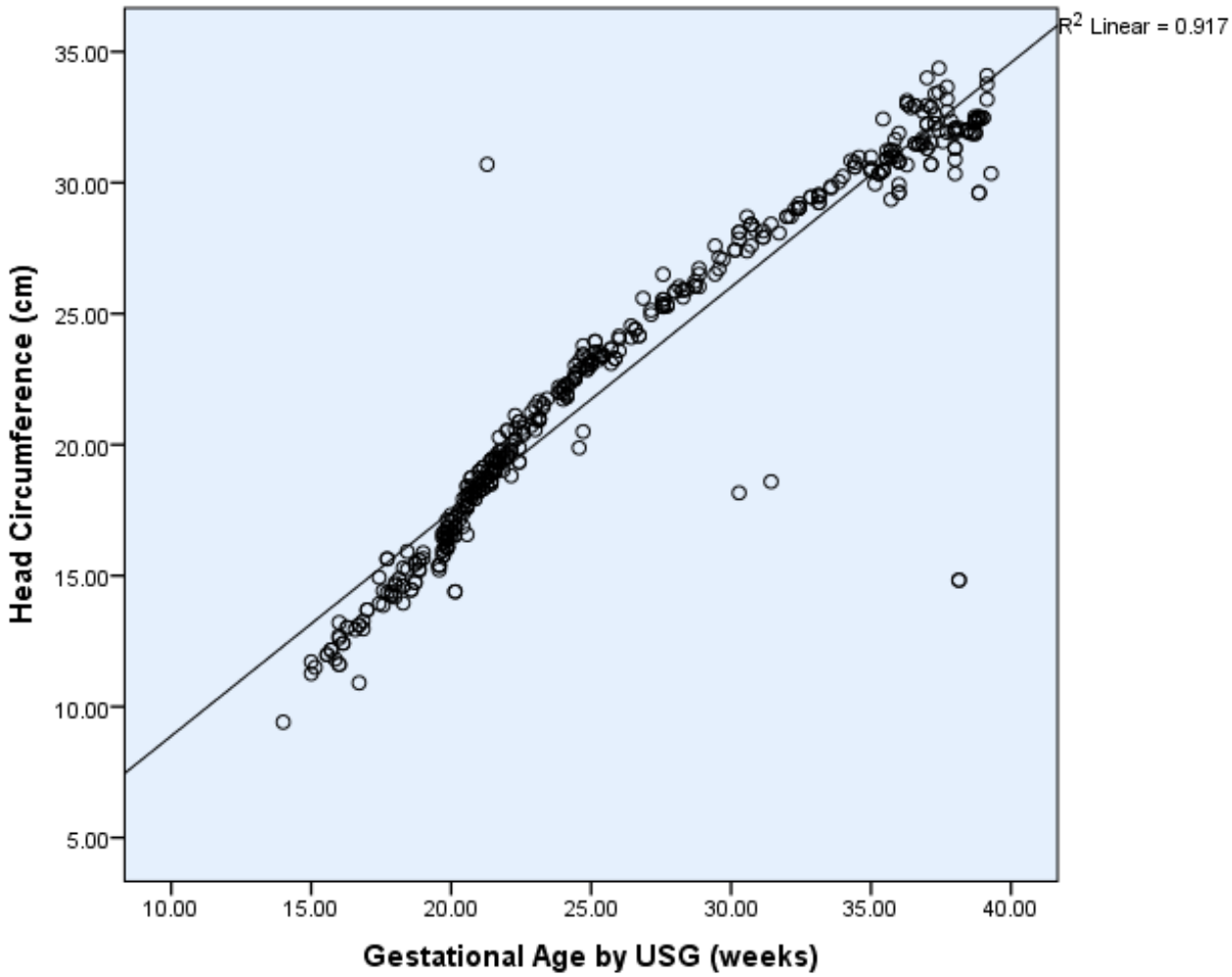


Figure 2: Scatterplot showing correlation between head circumference and gestational age in study subjects



Linear regression analysis was performed to derive an equation for estimation of gestational age using biparietal diameter. The regression model demonstrated a strong linear relationship between BPD and gestational age, with a high correlation coefficient and statistical significance.

The **regression equation derived in the present study** is:

This equation closely aligns with regression models reported in earlier studies, confirming the reliability and validity of BPD as a predictor of gestational age. The high correlation coefficient (**r = 0.96, p < 0.001**) indicates excellent predictive accuracy.

DISCUSSION

Accurate estimation of gestational age is fundamental to optimal antenatal care, as it directly influences clinical decision-making related to foetal growth assessment, timing of delivery, and perinatal outcomes. Ultrasonography remains the most reliable modality for gestational age estimation, particularly when the date of the last menstrual period is uncertain or unreliable. Among various biometric parameters, foetal head measurements have long been considered dependable indicators of gestational age, owing to their relatively predictable growth patterns [1–3].

In the present study, **head circumference demonstrated a very strong positive correlation with gestational age (r = 0.95, p < 0.001)**, indicating a near-linear increase throughout the second and third trimesters. This finding is consistent with earlier observations by Campbell [1] and Hadlock et al. [2,3], who reported that head circumference closely reflects foetal age and exhibits less variability compared to some other biometric indices. The strong association observed in our study reinforces the

reliability of head circumference as a robust parameter for gestational age estimation in routine obstetric practice.

The utility of head circumference is particularly notable because it incorporates the entire foetal cranial perimeter, thereby minimizing the influence of variations in skull shape. Benson and Doubilet [4] highlighted that biparietal diameter alone may be affected in conditions such as dolichocephaly and brachycephaly, potentially leading to errors in gestational age estimation. Head circumference, by contrast, provides a more comprehensive representation of cranial growth and is therefore considered less susceptible to such distortions. The findings of the present study support this concept, as head circumference maintained a strong correlation with gestational age across a wide gestational range.

Biparietal diameter also showed an excellent correlation with gestational age in this study (**$r = 0.96$, $p < 0.001$**), and the derived regression equation further confirms its predictive accuracy. These results are in agreement with those reported by Hadlock et al. [2,3] and Schmidt and Kubli [5], who demonstrated that BPD remains a reliable parameter for gestational dating, particularly in the mid-trimester. However, several authors have emphasized that reliance on BPD alone may be less accurate in late gestation due to foetal head molding and positional factors [4,6]. In this context, the complementary use of head circumference alongside BPD enhances the accuracy of gestational age estimation.

The strong correlation between head circumference and gestational age observed in the present study is also consistent with large population-based and international standards. The INTERGROWTH-21st Project [9] and the population-based cohort study by Verburg et al. [10] both reported that head circumference follows a consistent growth trajectory across gestation, making it suitable for both dating and growth assessment. Similarly, ISUOG practice guidelines recommend the inclusion of head circumference as a standard biometric parameter during ultrasound evaluation [11].

In the Indian context, accurate gestational age assessment is particularly important due to variations in maternal nutrition, socioeconomic status, and late antenatal registration. Although several Indian studies have focused on long bone measurements for gestational age estimation [13,15], fewer have emphasized the standalone and comparative utility of head circumference. The present study contributes valuable data by demonstrating that head circumference performs comparably to biparietal diameter in gestational age estimation within the studied population.

Overall, the findings of this study suggest that **head circumference is a reliable, simple, and reproducible biometric parameter for gestational age estimation**, with accuracy comparable to that of biparietal diameter. Its use is especially advantageous in cases where cranial shape abnormalities or technical limitations affect BPD measurement. Incorporating head circumference routinely into obstetric ultrasound protocols may therefore improve the precision of gestational dating and enhance foetal growth assessment.

CONCLUSION

The present study demonstrates that **foetal head circumference is a highly reliable and accurate parameter for estimation of gestational age**, showing a strong and statistically significant correlation across the second and third trimesters. Its near-linear growth pattern and reduced susceptibility to variations in foetal head shape make head circumference a dependable alternative and complementary measure to biparietal diameter. When used alongside standard biometric parameters, head circumference enhances the precision of ultrasonographic gestational age assessment, particularly in cases with uncertain menstrual dating or altered cranial morphology. Routine incorporation of head circumference into obstetric ultrasound protocols may therefore contribute to improved antenatal evaluation and better perinatal care outcomes.

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