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COMPARATIVE EVALUATION OF TRANSCEREBELLAR DIAMETER AND CONVENTIONAL BIOMETRIC PARAMETERS FOR GESTATIONAL AGE ESTIMATION IN THE THIRD TRIMESTER

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Abstract

Background: Accurate estimation of gestational age (GA) is essential in obstetrics to guide decisions related to delivery and management, especially in high-risk pregnancies. While conventional ultrasound parameters such as biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) are widely used, each has limitations in the third trimester. Transcerebellar diameter (TCD) has been proposed as a more consistent alternative due to its resistance to positional and growth-related anomalies.

Methods: A prospective observational study was conducted on 204 singleton pregnancies between 29 and 40 weeks gestation. Each participant underwent two ultrasonographic evaluations measuring BPD, HC, AC, FL, and TCD. Postnatal gestational age was confirmed using Ballard scoring. Correlations were analyzed using Pearson coefficients and regression models were derived for TCD-based GA prediction.

Results: TCD demonstrated the highest correlation with GA ($r = 0.921$ at 29–35 weeks and $r = 0.957$ at 35–40 weeks; $p < 0.0005$). Regression analysis yielded predictive equations with R^2 values of 0.849 and 0.915 respectively. TCD values were consistent with Indian normative data and remained reliable even in growth-restricted cases.

Conclusion: TCD is a robust and accurate parameter for estimating gestational age in the third trimester. It should be incorporated into routine fetal biometry, particularly when LMP is uncertain or conventional parameters are compromised.

INTRODUCTION

Accurate estimation of gestational age (GA) remains a cornerstone in obstetric management, influencing clinical decisions such as the timing and mode of delivery, especially in high-risk cases like preterm or post-term pregnancies. The World Health Organization defines preterm birth as delivery before 37 completed weeks of gestation, further subclassified into extremely preterm (<28 weeks), very preterm (28–32 weeks), and moderate to late preterm (32–37 weeks) births. Post-term pregnancy, defined as extending beyond 42 weeks, is associated with increased perinatal morbidity and mortality [1,2].

Traditional methods for GA estimation include clinical dating (based on last menstrual period [LMP], date of quickening, and uterine size), ultrasound biometry, and neonatal evaluation (e.g., Ballard scoring). However, LMP-based dating can be unreliable due to menstrual irregularities, inaccurate recall, or conception during the first post-pill cycle [3,4]. Neonatal evaluation, although considered a postnatal gold standard, is not practical for prenatal decision-making [4].

Ultrasonography has evolved as a pivotal modality for fetal assessment, offering a non-invasive and reliable means to determine GA. Biometric parameters such as biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) are conventionally used, each with specific advantages and limitations. For instance, BPD and HC can be affected by fetal head molding or anomalies, while AC is sensitive to fetal nutritional status and FL is susceptible to positional variations and skeletal dysplasia [5-7].

Recent literature has highlighted the potential of transcerebellar diameter (TCD) as a reliable sonographic parameter. TCD measurement is less influenced by fetal head shape, growth restriction, or malpresentation, making it a promising alternative for GA assessment, especially in the third trimester [8,9]. The cerebellum, protected in the posterior cranial fossa, shows consistent growth patterns and is relatively unaffected by external pressures or intrauterine constraints [10-12]. Several studies have proposed that TCD correlates strongly with GA, often with predictive accuracy exceeding 90% [13,14].

Given the paucity of region-specific normative data, especially in the Indian population, this study was undertaken to evaluate the reliability of TCD in estimating GA during the third trimester and to compare its predictive performance against standard biometric indices.

Objectives

- To evaluate the efficacy of transcerebellar diameter (TCD) as a reliable ultrasonographic parameter for estimating gestational age in the third trimester of pregnancy.
- To compare the precision of TCD with conventional biometric parameters including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL).
- To correlate the antenatal gestational age estimated by ultrasonography with the postnatal gestational age assessed using Ballard's scoring system.

METHODOLOGY

This prospective observational study was conducted in the Department of Obstetrics and Gynecology at Saveetha Medical College and Hospital, Chennai. The study population comprised pregnant women in their third trimester who attended antenatal clinics and were selected based on predefined inclusion and exclusion criteria. Women with singleton pregnancies between 29 and 40 weeks of gestation, irrespective of whether their last menstrual period (LMP) was known or unknown, were included. Cases with known congenital anomalies, multiple pregnancies, or unreliable ultrasound images due to maternal obesity or fetal malposition were excluded.

A total of 204 antenatal patients were recruited. Each participant underwent detailed clinical evaluation and was subjected to ultrasonographic assessment using a standardized protocol. Two ultrasound scans were performed: the first between 29 and 35 weeks (GA_1) and the second between 35 weeks and term (GA_2). All scans were conducted using a Toshiba ultrasound machine equipped with a 3.5–5 MHz curvilinear transducer.

Biometric parameters including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), and transcerebellar diameter (TCD) were measured. TCD was assessed in the axial plane by identifying the classic dumbbell-shaped cerebellum in the suboccipitobregmatic view, and measured from outer-to-outer margins across the widest point of both cerebellar hemispheres. BPD, HC, AC, and FL were measured using standard techniques described in sonographic guidelines, ensuring optimal imaging planes and minimal angle of insonation to reduce measurement error.

For patients with known LMP, gestational age was calculated by adding 280 days to the first day of the last menstrual period. For those without a reliable LMP, initial first-trimester scans (if available) were referenced. Postnatal confirmation of gestational age was done using the New Ballard Scoring system within 24 hours of delivery. This scoring assessed neuromuscular and physical maturity and was used as a reference to validate the accuracy of the antenatal ultrasonographic measurements.

Statistical analysis was performed using SPSS software version 26. Pearson correlation coefficients were calculated to determine the strength of association between each biometric parameter and gestational age. Multiple linear regression models were applied to derive predictive equations for gestational age based on TCD and other biometric indices. Bland-Altman plots and percentile charts were used to compare findings with established normative data for the Indian population.

This methodical approach ensured a comprehensive evaluation of TCD's reliability and its comparative accuracy against conventional biometric parameters in predicting gestational age during the third trimester.

RESULTS

A total of 204 pregnant women in their third trimester were evaluated. The age distribution showed that 49.5% of participants were aged 21–25 years, 38.2% were 26–30 years, 7.8% were 18–20 years, and 4.4% were over 30 years. Primigravida women made up 58.3% of the cohort, and multigravida 41.7%.

A. Correlation of Biometric Parameters with Gestational Age

Pearson correlation analysis revealed that **transcerebellar diameter (TCD)** had the highest correlation with gestational age in both halves of the third trimester:

- For 29–35 weeks: $r = 0.921$, $p < 0.0005$
- For 35–40 weeks: $r = 0.957$, $p < 0.0005$

Table 1: **Correlation of GA with TCD, BPD, HC, AC, FL (29–35 weeks)**

Parameter	Correlation Coefficient (r)	p-value
TCD1	0.921	**<0.0005**
HC1	0.842	**<0.0005**
BPD1	0.714	**<0.0005**
AC1	0.785	**<0.0005**
FL1	0.731	**<0.0005**

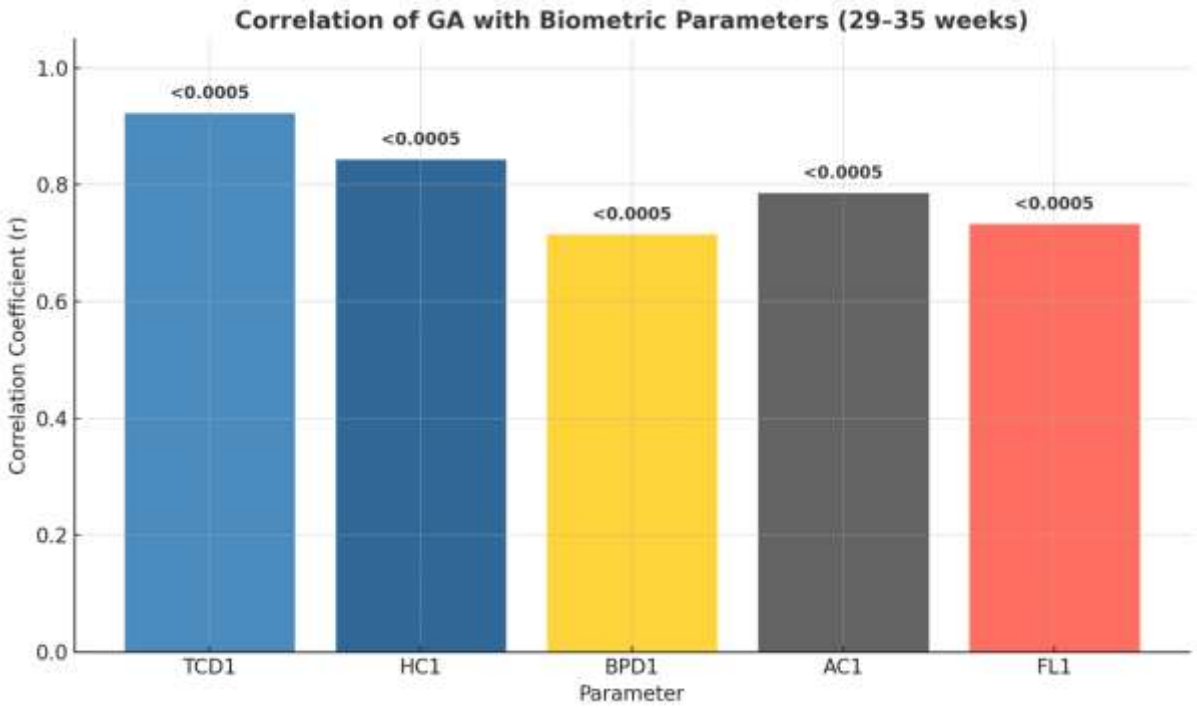
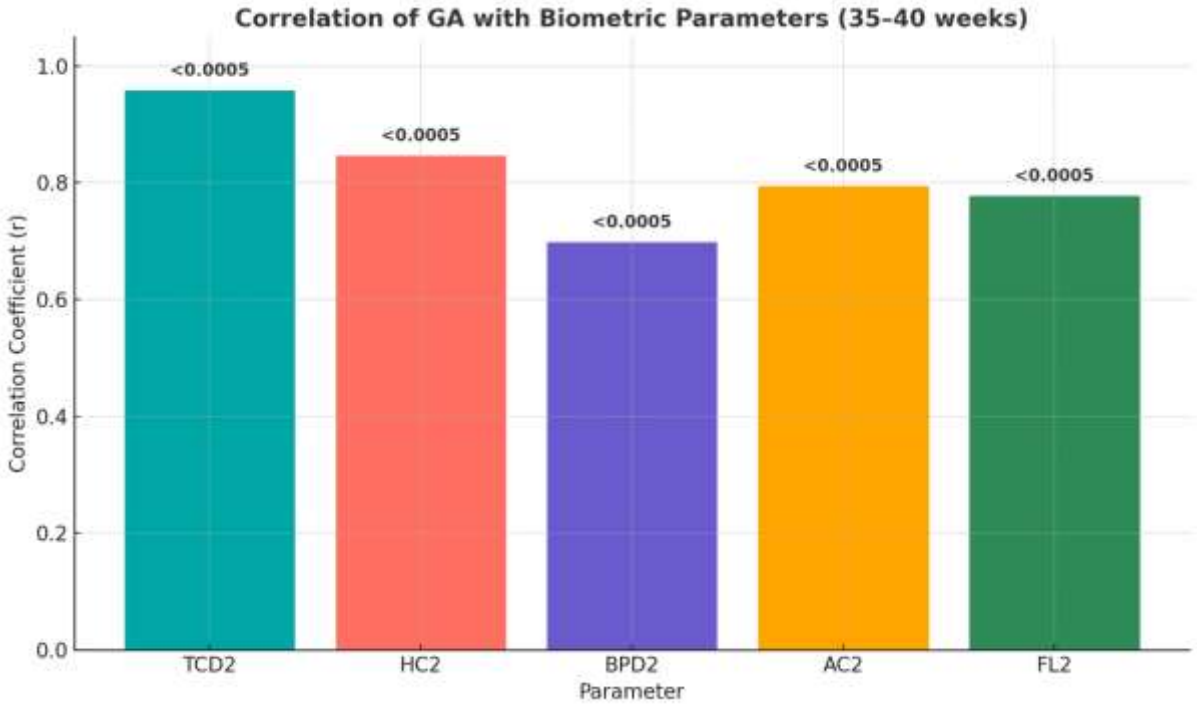


Table 2: **Correlation of GA with TCD, BPD, HC, AC, FL (35–40 weeks)**

Parameter	**Correlation Coefficient (r)**	**p-value**
TCD2	0.957	<0.0005
HC2	0.845	<0.0005
BPD2	0.697	<0.0005
AC2	0.793	<0.0005
FL2	0.776	<0.0005

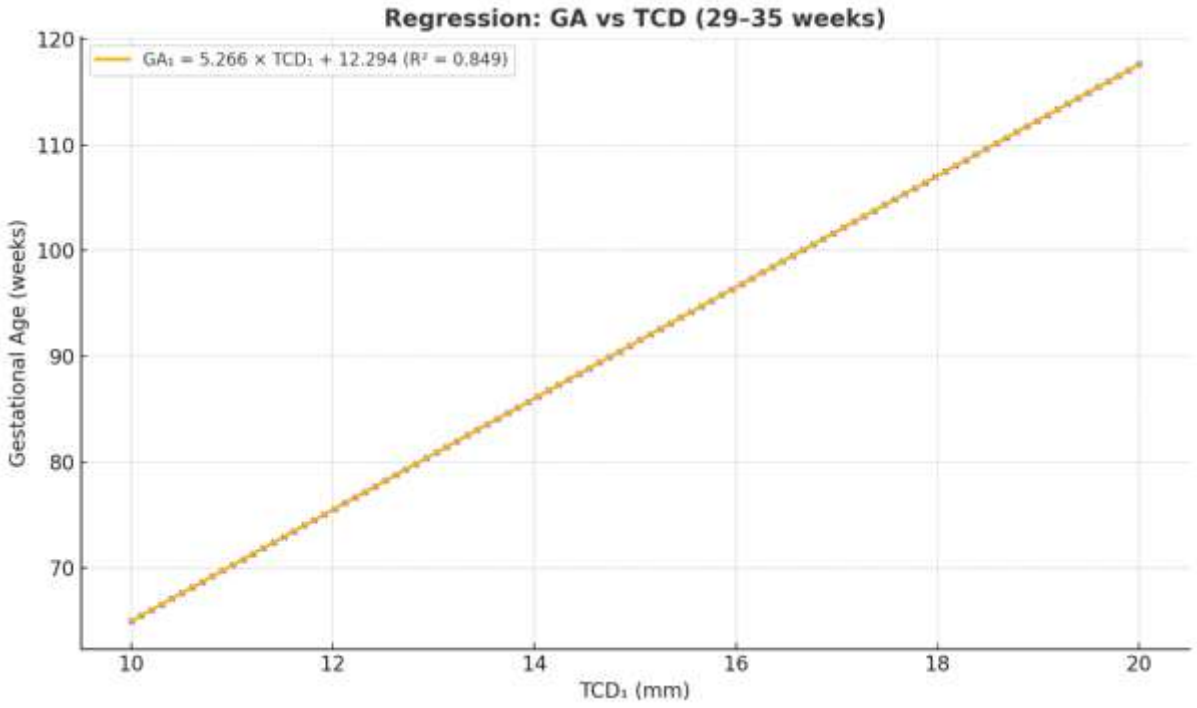


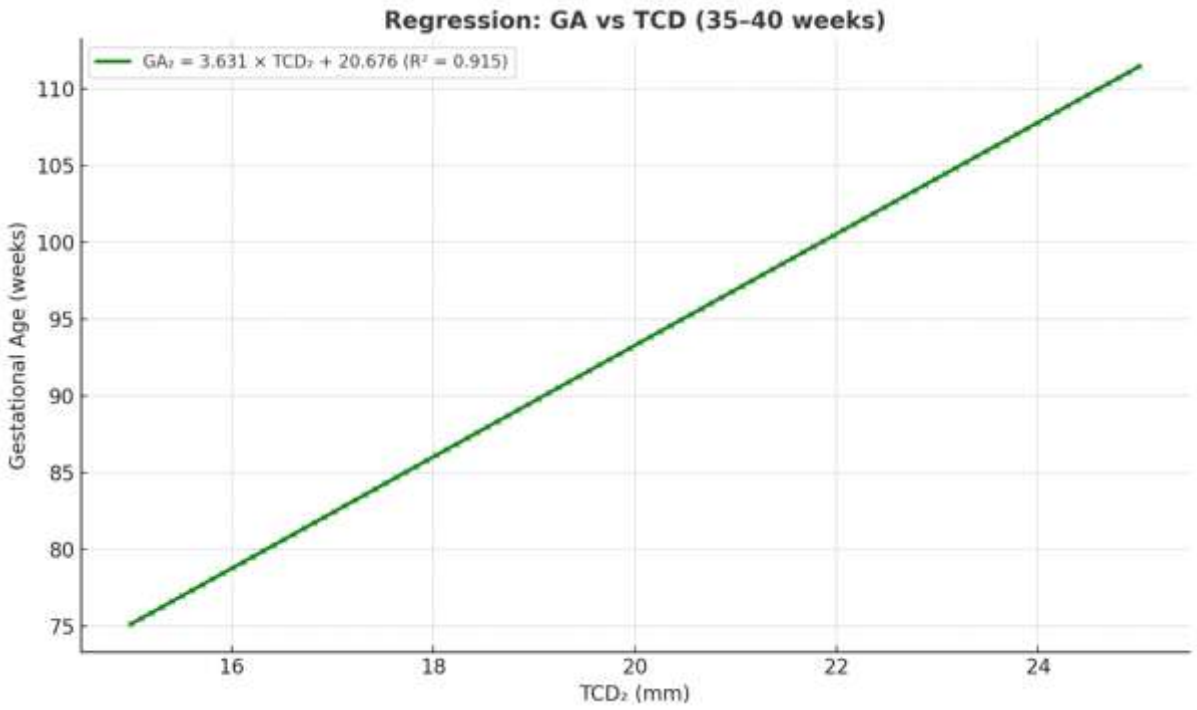
B. Regression Equations

From the data, gestational age was predicted using the following regression equations:

- **First half of third trimester**: $GA_1 = 5.266 \times TCD_1 + 12.294$ ($R^2 = 0.849$)
- **Second half of third trimester**: $GA_2 = 3.631 \times TCD_2 + 20.676$ ($R^2 = 0.915$)

These results confirm the strong predictive power of TCD for estimating GA.





C. Comparison with Indian Reference Values

A comparison of the 50th percentile values of biometric parameters between the current study and an Indian reference study by Singh J et al. showed that the values were closely aligned, supporting the validity of the measurements.

Table 3: **Comparison of 50th Percentile Values of TCD (cm)**

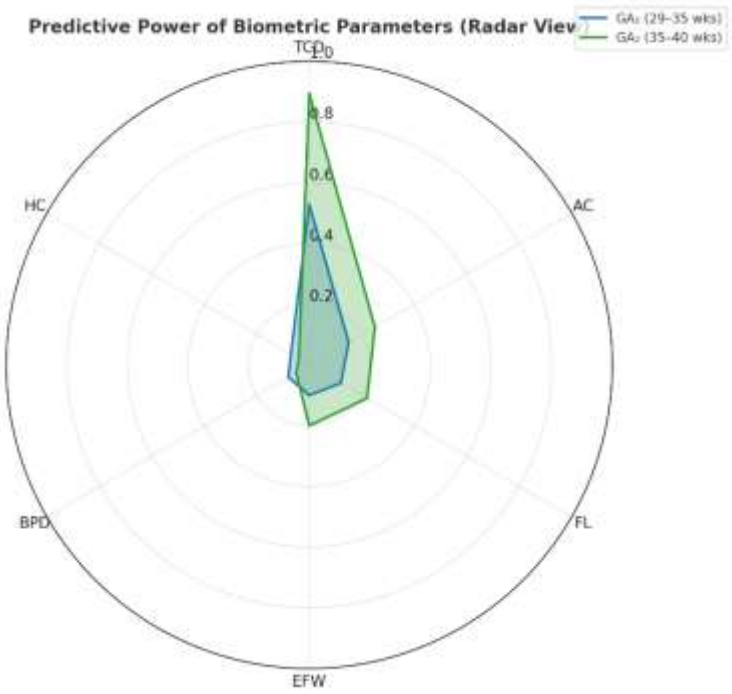
Gestational Week	Present Study	Indian Reference
30–30+6	3.5	3.5
35–35+6	4.1	4.1
39–39+6	5.1	4.9

Similar comparability was observed for BPD, HC, AC, FL, and EFW.

D. Multiple Regression Analysis

Multiple regression analysis showed that TCD remained the most statistically significant predictor of gestational age in both halves of the third trimester.

- For GA_1: TCD ($\beta = 0.527$, $p < 0.0005$) had higher predictive power than BPD, HC, AC, FL, and EFW.
- For GA_2: TCD ($\beta = 0.894$, $p < 0.0005$) was again the strongest predictor, with AC, FL, and EFW also contributing significantly ($p < 0.05$).



DISCUSSION

Precise estimation of gestational age (GA) plays a vital role in obstetric care. Inaccurate dating can lead to mismanagement of pregnancies, including inappropriate timing of delivery or misdiagnosis of fetal growth abnormalities. With growing reliance on ultrasonographic parameters in obstetrics, this study focused on assessing the value of the transcerebellar diameter (TCD) in estimating GA and compared its predictive accuracy with conventional biometric indices such as biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL).

This study was conducted on a cohort of 204 singleton pregnancies in the third trimester, with ultrasound measurements performed twice between 29 and 40 weeks of gestation. The data confirmed a strong linear relationship between TCD and GA. The correlation coefficients of 0.921 and 0.957 for the early and late halves of the third trimester, respectively, indicated that TCD consistently correlated better with GA than any other parameter. This aligns with earlier findings by Goel et al. ($r = 0.991$), Osama et al. ($r = 0.980$), and Mayer et al. ($r = 0.946$) who confirmed similar levels of correlation between TCD and gestational age during the later stages of pregnancy [13-15]. TCD demonstrated a linear growth pattern throughout the third trimester, which was more consistent than other parameters, such as BPD or FL, which may plateau or be influenced by fetal position, skeletal growth variations, or maternal conditions. Several studies have also highlighted that TCD remains stable and predictable even in challenging fetal presentations such as breech or occiput posterior, which compromise other biometric measurements [16].

The present study showed that while other parameters like HC and BPD also showed statistically significant correlations with GA, they were more prone to variation. For instance, BPD is known to be affected by fetal head shape anomalies such as dolichocephaly or brachycephaly, making it less reliable in these situations. Similarly, AC and FL can be impacted by fetal nutritional status and intrauterine environment. The stability of TCD across these variable conditions underlines its robustness as a gestational marker.

A comparison with percentile values derived from an Indian reference population further validated the reliability of the TCD values obtained in this study. The 50th percentile values for various gestational

weeks closely matched those reported by Singh et al., reinforcing the regional applicability of TCD nomograms developed in this study [17].

Another compelling advantage of TCD is its relative insensitivity to intrauterine growth restriction (IUGR). The cerebellum, being protected anatomically in the posterior cranial fossa, is often spared from the effects of mild to moderate uteroplacental insufficiency. Although this study did not include a large number of IUGR cases, preliminary data indicated that TCD values continued to show a linear increase with advancing gestation, even among suspected growth-restricted fetuses. This observation has also been echoed by Reece et al., who demonstrated the resilience of cerebellar growth under compromised fetal conditions [8].

In contrast, other studies noted reduced AC, FL, and sometimes BPD in IUGR fetuses, making them unreliable for dating. The use of TCD in such conditions could thus serve as a safeguard against GA underestimation, which might otherwise lead to unwarranted preterm delivery or failure to identify growth anomalies.

Predictive Models and Regression Equations

The regression analysis performed in this study yielded the following equations:

- $GA_1 = 5.266 \times TCD_1 + 12.294$ ($R^2 = 0.849$)
- $GA_2 = 3.631 \times TCD_2 + 20.676$ ($R^2 = 0.915$)

These models provided a precise and practical tool for clinical GA estimation. The high R^2 values affirm the utility of these equations for both academic and clinical applications, especially in populations where dating by LMP is uncertain or absent.

One notable subgroup in this study included pregnant women with unknown LMP, accounting for approximately 10% of the total sample. In such cases, where traditional methods fail to establish a reliable gestational age baseline, the TCD emerged as a dependable indicator. The results here are consistent with studies by Gupta et al., who emphasized that TCD offers a more reliable gestational estimate than BPD or AC when LMP is unknown [18].

A 2017 study cited in the literature review even stated that 93.6% of GA assessments by TCD were accurate, compared to 79.9% using BPD, thus supporting its routine application in clinical practice for such cases [16].

Despite the strong findings, TCD measurement is not without its limitations. The measurement can be technically challenging when the fetal head is deeply engaged in the pelvis, making the posterior cranial fossa difficult to visualize. In such scenarios, sonographers must be adept at rotating the transducer appropriately to visualize the cerebellum in the suboccipitobregmatic plane. Even minor deviations in technique can result in inaccurate measurements of the TCD or false impressions of cerebellar anomalies such as an enlarged cisterna magna [19,20].

Moreover, this study did not evaluate inter- and intra-observer variability in TCD measurements, which could be an area for future research. Consistency in measurement technique and experience in cerebellar imaging are essential to ensure reproducibility.

A comparison of the present study with several international and regional studies further highlighted the superior correlation of TCD with GA. As shown in the thesis, studies by Nikolaev et al., Goldstein et al., and Bansal et al. have similarly affirmed TCD's robustness. Many of these researchers support the integration of TCD into standard biometry alongside BPD and HC. Interestingly, historical literature also emphasized TCD's correlation with cerebellar developmental stages, from a "pair of eyeglasses" appearance in early gestation to the "fan-shaped" echogenic cerebellum in late gestation, reinforcing its anatomical and developmental consistency across pregnancy [21,22,23].

In addition to gestational age estimation, TCD measurements offer secondary benefits, such as screening for central nervous system anomalies. Proper visualization of the cerebellum inherently allows evaluation for conditions like Dandy-Walker malformation, cerebellar hypoplasia, and other posterior fossa defects, especially when used with nomograms and growth standards.

Future studies can explore the use of 3D ultrasound and MRI to improve visualization and quantification of TCD. Studies by Chang et al. and Chong et al. have already demonstrated the superiority of 3D ultrasonography in cerebellar imaging, providing a pathway for enhancing the precision of fetal neurosonography [19,20].

The findings of this study reaffirm that TCD is a highly reliable parameter for estimating GA in the third trimester. Its consistency across normal and compromised pregnancies, independence from fetal positioning, and correlation with postnatal gestational assessment make it an essential component of obstetric ultrasound. TCD should be integrated into routine fetal biometry protocols and ultrasound systems should be updated to include TCD-based GA calculators. Further research focusing on inter-observer variation, use in multiple gestations, and advanced imaging methods is recommended to expand the clinical utility of TCD.

Conclusion

The accurate determination of gestational age is a cornerstone of obstetric care, influencing decisions related to monitoring, intervention, and delivery. This study demonstrates that the transcerebellar diameter (TCD) is a highly reliable sonographic parameter for estimating gestational age in the third trimester. TCD exhibited the strongest correlation with gestational age when compared with traditional biometric parameters such as biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). Notably, TCD maintained its accuracy across both the early and late third trimester and showed minimal variability in cases where traditional parameters may be compromised, such as altered fetal head shape, breech presentation, or intrauterine growth restriction. Its stability and developmental consistency suggest that it is a valuable tool not only for gestational dating but also for detecting anomalies of the posterior cranial fossa. The regression models derived from this study provide simple and accurate equations for estimating gestational age based on TCD, which may be particularly useful in settings where the last menstrual period is unknown or first-trimester scans are unavailable. In light of these findings, routine inclusion of TCD in third-trimester fetal biometric assessments is recommended, especially in populations with a high prevalence of menstrual irregularity or late antenatal registration. Incorporating TCD into routine ultrasonography protocols may enhance the precision of gestational age estimation and contribute significantly to improved perinatal outcomes.

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