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Ultrasonographic assessment of placental thickness as a predictor of gestational age at Kilimanjaro Christian Medical Centre: A cross-sectional study

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ABSTRACT

Background: Accurate determination of gestational age is essential for prenatal care, guiding pregnancy monitoring and management. Although ultrasonographic fetal biometry is the standard method for estimating gestational age, its accuracy decreases with advancing gestation, variations in fetal position, and fetal anomalies. Adequate placental growth is essential for optimal fetal development. This study aimed to evaluate placental thickness using ultrasound to estimate gestational age.

Methods: This cross-sectional study, conducted between December 2024 and April 2025 at Kilimanjaro Christian Medical Centre, included 206 pregnant women with gestational ages of 14–40 weeks. Placental thickness was measured at the level of the umbilical cord insertion using a 3.5–5-MHz ultrasound transducer. Standard fetal biometric parameters, including head circumference, biparietal diameter, abdominal circumference, and femur length, were recorded. Data were analyzed using SPSS version 25 with Pearson's correlation, regression analysis, and analysis of variance.

Results: The mean maternal age was 31 years, with most participants aged 26–34 years. The majority were multiparous (61.2%), had regular menstrual cycles (77.2%), and over half had a body mass index ≥30 kg/m² Placental locations were anterior (48.1%), posterior (34%), fundal (14.1%), and lateral (3.9%). Placental thickness strongly correlated with gestational age ($r = 0.960$, $p < 0.001$) and all fetal biometric parameters. Regression analysis indicated high coefficients of determination ($R^2 = 0.898–0.913$, $p < 0.001$). Anterior placentas were, on average, 2.9 mm thicker than posterior placentas.

Conclusion: Placental thickness may serve as a reliable parameter for estimating gestational age in the second and third trimesters.

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Introduction

The placenta is a highly vascularized organ that supplies nutrients, oxygen, and hormones to the developing fetus [1]. It forms a functional link between the mother and fetus [2] and reflects maternal and fetal health [3].

Effective placental function is crucial for healthy fetal growth and development. The placenta becomes fully functional after 12 weeks of gestation [2]. As the fetus grows, the placenta enlarges to meet the fetus' needs, serving as an indicator of fetal development [4].

At 12–13 weeks of gestation, the placenta is clearly visible on ultrasonography, exhibiting a uniform echogenic texture along the uterine wall. It is separated from the normal myometrium by a distinct hypoechoic band [5].

Ultrasonography can be used to safely assess placental growth patterns and estimate gestational age (GA) using fetal measurements, such as head circumference (HC), biparietal diameter (BPD),

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abdominal circumference (AC), and femur length (FL) [6]. However, these measurements can be influenced by congenital anomalies, fetal position, movement, and other factors [7].

BPD generally correlates with GA; however, it is inaccurate in breech presentations, hydrocephalus, premature rupture of membranes, and craniosynostosis due to the malleability of the fetal head [8]. Similarly, AC may be unreliable in small-for-GA fetuses, omphaloceles, gastroschisis, or fetal hydrops, while FL measurements are inaccurate in skeletal dysplasia. Given these limitations, additional parameters are needed to facilitate GA estimation with minimal error [9].

The placenta is one such parameter, as it is easy to measure and clinically beneficial. Placental thickness (PT) increases by approximately 1 mm per week and shows a linear relationship with GA, making it a valuable sonographic tool for estimating gestation [1].

According to previous studies, PT increases with fetal age, and sonographic measurement at the level of umbilical cord insertion is a useful parameter for estimating GA in the second and third trimesters [9,10].

While the linear correlation between PT and GA has been established in various international cohorts, significant gaps remain regarding its universal applicability across ethnically and geographically diverse populations. Placental growth dynamics and baseline biometrics are known to be influenced by regional maternal nutrition profiles, endemic infectious diseases (such as malaria and HIV), and genetic variations [11-13]. Consequently, diagnostic reference curves generated in high-income Western or Asian settings may not accurately reflect fetal development in Sub-Saharan African populations. In Tanzania, the diagnostic utility of PT remains entirely underexplored, and it has not yet been integrated into local obstetric imaging protocols or recognized by healthcare providers as a valid biometric adjunct.

This study addresses this critical geographic and clinical validation gap by examining the specific correlation of PT with GA, standard fetal biometry, and placental location among pregnant women attending the Kilimanjaro Christian Medical Centre (KCMC). By establishing localized data, this work aims to provide healthcare providers in resource-limited settings with a validated, alternative sonographic tool to optimize gestational dating and antenatal surveillance.

Methods

Study design

This cross-sectional study was conducted to assess PT as a predictor of GA at KCMC.

Study setting and population

This study was conducted at KCMC, a zonal referral hospital located in northern Tanzania. As one of the country's four zonal hospitals, KCMC serves a population of over 15 million people, including patients from neighboring countries such as Kenya and Burundi. This study was conducted in the Radiology and Medical Imaging Department, which provides a full spectrum of diagnostic imaging services essential for the detection and management of a wide range of medical conditions. The department is equipped with advanced imaging tools, including digital X-ray systems, multidetector computed tomography scanners, a 1.5-Tesla magnetic resonance imaging machine, tomosynthesis, and ultrasound. These technologies support the production of high-resolution images, enabling radiologists and clinicians to make precise diagnoses, evaluate injuries, and develop appropriate treatment plans.

Study population

This study included all pregnant women referred for routine antenatal scans at KCMC Hospital from December 2024 to April 2025. Most pregnant women who underwent scans were from the outpatient clinic of the obstetrics and gynecology department; they visited weekly, mostly on Mondays, Wednesdays, and Fridays, with at least six pregnant women per day.

Sample size

The sample size for this study was determined based on the primary objective of assessing the correlation between PT and GA. A correlation-based approach using Fisher's Z transformation was employed, which is appropriate for studies examining the association between two continuous variables.

The sample size was calculated using the formula:

Fisher, R. A. (1921) formula for correlation studies,

$$n = \left(\frac{Z_{\alpha/2} + Z_{\beta}}{C} \right)^2 + 3$$

where C

$$C = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right)$$

Where

$Z_{\left\{\frac{a}{2}\right\}}$ = 1.96 for a 95% confidence interval.

Z{β} = 95% 0.95 power. To be used in a sample calculation. Power = 1−β; this is the chance the study will successfully detect a true effect of PT and GA.

$$C = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right)$$

Of which is the expected correlation between PT and GA, r = 0.3, moderate calculation.

An anticipated moderate correlation coefficient of r = 0.3 was assumed based on previous literature. Using these parameters, the minimum required sample size was calculated using G*Power software (version 3.1.9.7). The computed minimum sample size was 111 participants.

To account for potential data loss and incomplete records, as well as to improve the robustness of the analysis, the sample size was increased by ~10%–15%, resulting in a target sample size of 120–130 participants. A further 10% adjustment was applied to enhance statistical reliability, yielding a final minimum sample size of 143 participants. The final size obtained was 206 participants.

A convenience sampling method was employed, whereby all eligible pregnant women who attended the study site during the study period and met the inclusion criteria were recruited until the required sample size was attained. This approach was chosen due to feasibility considerations within the clinical setting.

Inclusion and exclusion criteria

We included women with singleton pregnancies, those with confirmed GA through reliable dating methods (such as last menstrual period and/or early obstetrics ultrasound), and those in their second and third trimester (week 14–40) who provided consent. GA was established using last menstrual period (LMP) and confirmed by first-trimester ultrasound when available. In cases of discrepancy >7 days between LMP and ultrasound dating, the ultrasound estimate was used.

The exclusion criteria were as follows: known fetal abnormalities or congenital anomalies diagnosed before or during the study period; complications affecting PT, such as placenta previa or placental abruption; history of chronic medical illness or pregnancy complications that affects placental development or thickness (e.g., hypertension, diabetes mellitus, and Rhesus incompatibility); and placenta with morphological and cord insertion variation such as battledore, velamentous, succenturiate, and circumvallate placenta.

Variables

The dependent variable was GA measured in weeks and estimated using standard fetal biometry (Hadlock formula).

The independent variables were as follows: clinical characteristics of the study participants (age, parity, body mass index [BMI], and menstrual history [regular or irregular]); fetal biometric measurements in weeks (BPD, HC, AC, and FL); placenta locations (anterior, posterior, fundal, and lateral); and PT in millimeters.

We considered confounders in our analysis.

Data resource and measurement

Data collection tool

A structured data collection form using the specific objectives was used to collect data on the participants' social and clinical characteristics (age, parity, BMI, and menstrual history) and clinical variables including GA, fetal biometric measurements, PT, and placental location.

Ultrasound machine and software

A SIEMENS ACUSON NX3 Elite ultrasound system equipped with a 3.5–5-MHz curvilinear transducer was used to obtain all sonographic measurements. Built-in Hadlock reference software was used to estimate GA from fetal biometric parameters.

Picture Archiving and Communication System (PACS)

PACS was used for storage, retrieval, and review of ultrasound images by consultant radiologists to ensure data quality and consistency.

Data collection

The structured data collection tool was pilot-tested and validated in a preliminary study involving 22 participants. A consultant radiologist independently reviewed the ultrasound images and measurements to ensure technical accuracy and consistency, while the data collection instrument and variable structure were evaluated by a statistician for methodological rigor and analytical suitability prior to commencement of the main study.

Each participant underwent routine standardized transabdominal ultrasonography while lying in the supine position, with a moderately full bladder.

Two operators independently performed ultrasound examinations: the principal investigator and an assigned radiologist at the ultrasound unit. Interobserver variability was assessed in a subset of 30 participants. Intraclass correlation coefficients (ICC) for PT measurements were calculated, demonstrating excellent reproducibility (ICC = 0.92). The principal investigator initially scanned each participant to determine placental location (anterior, posterior, fundal, or lateral). The umbilical cord insertion site was identified using Doppler imaging, and PT was measured perpendicularly to the cord insertion, with the transducer positioned at a right angle to visualize the chorionic and basal plates. Since the placenta varies from being highest at the center and least at the periphery, many observers have documented that measurement of placental thickness is to be taken perpendicularly at the level of the umbilical cord [14,15]. The placental thickness was measured once at the level of umbilical cord insertion in the longitudinal direction from the lateral chorionic plate to the cord insertion, excluding the retroplacental area. PT was expressed in millimeters (Fig. 1). All images were saved for review.

Subsequently, the assigned radiologist at the unit performed a standardized routine obstetric ultrasound to estimate GA using fetal biometric parameters, in which BPD was measured as the distance between the outer and inner tables of the skull at the level of the thalamus and third ventricle. HC was measured along the perimeter of the inner and outer table of the skull. AC was measured at the point where the portal vein and stomach were visible, by tracing the circumference along the outer skin. FL was measured with the bone shaft oriented as close to 90º to the scan plane. The amniotic fluid index was also assessed to ensure the absence of polyhydramnios or oligohydramnios. The ultrasound machine used built-in software to estimate the GA based on Hadlock tables.

A consultant radiologist independently reviewed all the stored PT measurements and obstetric scan

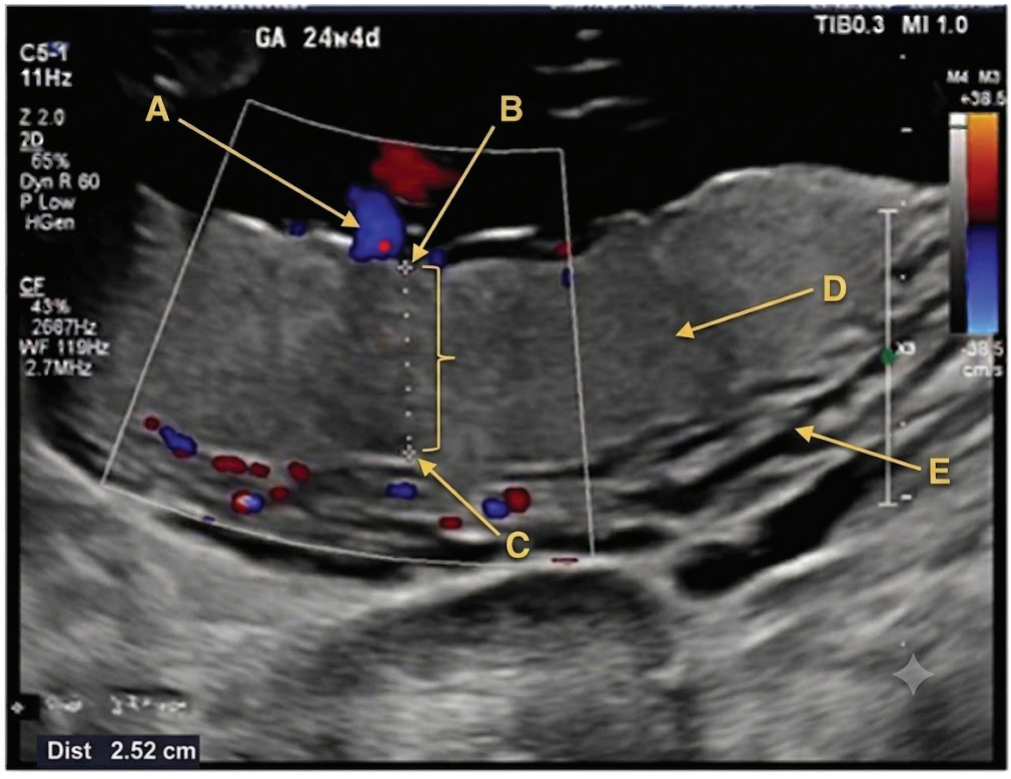


Figure 1. Placental assessment and umbilical cord insertion. An ultrasound image, sagittal view of the uterus at 24w4d GA, with color Doppler showing blood flow. A: Umbilical cord insertion point. B: Chorion (fetal surface) landmark for measurement. C: Basal plate (maternal surface) landmark for measurement. D: Placental parenchyma (P). E: Uterine wall (UW). The perpendicular distance (bracket and points B–C) measures placental thickness (25.2 mm), taken between the inner surface of the chorion and the inner surface of the basal plate.

images for accuracy and consistency prior to data entry into the structured collection tool. The use of two independent operators was intended to minimize measurement and observer bias, particularly the risk of influencing GA estimation based on PT measurements.

Data analysis

Data collected using the structured data collection tool were entered, cleaned, and analyzed using the Statistical Package for Social Sciences version 25. Data were collected in a consistent and carefully supervised manner to ensure accuracy and reliability. Data cleaning was performed by checking for completeness, consistency, and accuracy. The data were reviewed to identify missing values, outliers, and entry errors. Discrepancies were verified against source documents or from the PACS and corrected where appropriate, while variables with substantial missing or inconsistent data were excluded from the analysis.

Placental location was treated as a categorical variable. Descriptive statistics were performed. Continuous variables are summarized using means and standard deviations, while categorical variables are presented as frequencies and percentages. Analytical statistics were conducted to assess the relationship between PT and GA using the Pearson correlation coefficient. Linear regression analysis was performed to evaluate the association between PT and fetal biometric parameters.

One-way analysis of variance (ANOVA) was used to compare mean PT across different placental locations. Where appropriate, multivariate regression analysis was conducted to control for potential confounders, including maternal age, parity, and BMI. p-value <0.05 was considered significant.

Ethical consideration

Ethical approval for the study was obtained from the Kilimanjaro Christian Medical University College Ethical Review Committee, and permission to conduct the research was granted by the director of KCMC and the heads of the Radiology and Obstetrics/Gynecology Departments.

Informed consent was obtained from all participants after giving them a detailed explanation of the procedure, with assurances of confidentiality.

Patient privacy and confidentiality were maintained using registration numbers. The electronic patient files were neither edited, photographed, downloaded, nor shared with any third party.

Results

Clinical characteristics of the study population

A total of 206 pregnant women were enrolled. The mean age was 31 years, with the majority aged 26–34 years (59.7%). Most participants were multiparous (61.2%) and reported regular menstrual cycles (77.2%). Over half of the patients (50.5%) had a BMI ≥30 kg/m2. The placenta was most located anteriorly, as observed in 99 cases (48.1%), followed by posterior (34%), fundal (14.1%), and lateral (3.9%) locations (Table 1).

Correlation between PT and GA

The overall correlation between PT and GA was strong and significant (r = 0.960, p < 0.001). When analyzed by GA, moderate positive correlations were observed across all groups (Fig. 2).

Table 1. Clinical characteristics of the study participants (n = 206).

Age category	N (%)
19–25	36 (17.5)
26–35	123 (59.7)
>35	47 (22.8)
Median (IQR)	31 (27–35)
Parity	
Nullipara	80 (38.8)
Para 1–5	126 (61.2)
Menstrual History	
Regular	159 (77.2)
Irregular	47 (22.8)
BMI (Kg/m^2)	
18.5–24.9(Normal)	35 (17)
25–29.9(Overweight)	67 (32.5)
≥30 (Obese)	104 (50.5)
GA in weeks	
14–19	36 (17.5)
20–25	42 (20.4)
26–30	32 (15.5)
31–35	44 (21.4)
36–40	52 (25.2)
Placental Location	
Anterior	99 (48.1)
Posterior	70 (34)
Fundal	29 (14.1)
Lateral	8 (3.9)

BMI = body mass index; IQR = interquartile range.

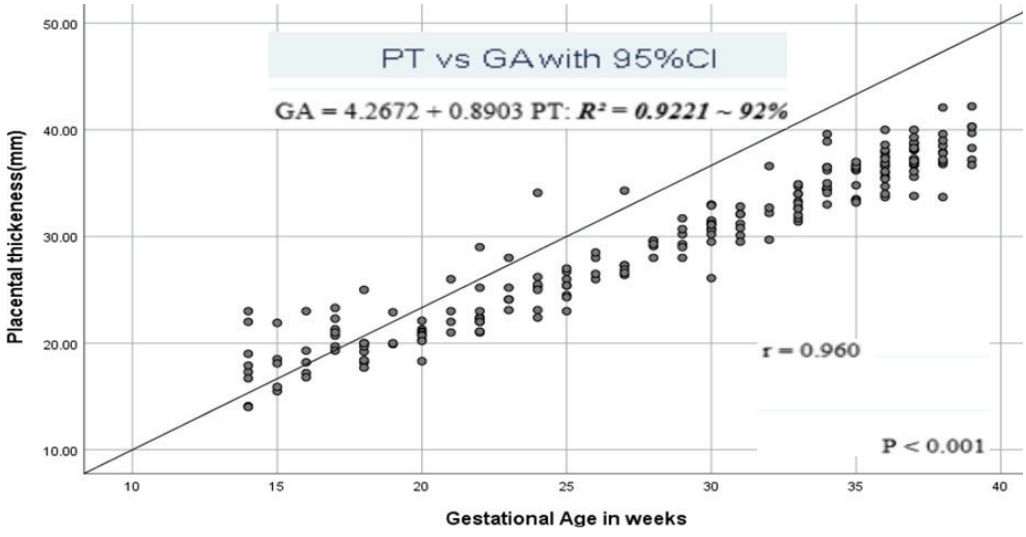


Figure 2. Correlation between placental thickness and gestation age.

Table 2. Correlation of placental thickness with fetal biometry (n = 206).

Predictor	R^2	RMSE (√MSE)	β coefficient	SE of Estimate	F-statistic	p-value
HC	0.909	2.16	0.872	2.159	2044.23	<0.001**
BPD	0.911	2.14	0.871	2.136	2093.14	<0.001**
AC	0.898	2.29	0.879	2.288	1798.59	<0.001**
FL	0.913	2.11	0.869	2.109	2152.78	<0.001**

**. Correlation is significant at the 0.01 level (2-tailed). 0.000=<0.001
MSE, mean squared error; RMSE, root mean squared error

Correlation between PT and fetal biometric measurements (BPD, HC, AC, and FL)

The regression equation derived was GA (weeks) = 4.2672 + 0.8903 PT (mm) with R^2 = 0.9221. This equation suggests that each 1-mm increase in PT corresponds to approximately 0.9 weeks increase in GA. Regression analysis revealed that all fetal biometric parameters (HC, BPD, AC, and FL) were significantly correlated with PT (p < 0.001). FL demonstrated the strongest correlation (R^2 = 0.913), followed by BPD and HC (R^2=0.911 and 0.909, respectively) (Table 2).

These findings indicate that PT can serve as an additional marker for fetal biometry, particularly FL, which showed the strongest correlation. Clinically, PT may be valuable when fetal position or anomalies limit standard measurements.

Association between PT and placental locations

To evaluate potential confounding in the relationship between GA and PT, linear regression models were constructed sequentially by introducing maternal age, BMI, and parity step by step. After adding maternal age, the PT coefficient changed minimally (+0.1%), and age was not significant (p = 0.451). The inclusion of BMI caused a 0.3% decrease in the PT coefficient, and BMI was also non-significant (p = 0.210). Finally, adding parity to the model had no material impact on the association (PT β = 0.888, change = −0.2%, p for parity = 0.599).

ANOVA revealed a significant difference in PT across different placental locations (p = 0.024). Post hoc analysis using Tukey's honest significant difference test showed that anterior placentas were significantly thicker than posterior placentas, with a mean difference of 2.97 mm (p = 0.037). No significant differences were observed between other placental location groups (Table 3).

Discussion

Our findings demonstrated a strong positive correlation between PT and GA across the second and third trimesters, consistent with previous studies like Fredrick et al. [16], who documented a correlation coefficient of r = 0.96 (p = 0.0001), concluding that PT could serve as a reliable parameter for estimating GA, particularly when the last normal menstrual period is unknown or uncertain.

Similarly, InaPREVENT [17] reported a strong correlation between PT and GA (r = 0.985, p =

Table 3. Tukey's honest significant difference post-hoc test showing placenta thickness by location (n = 206).

Group comparison	Mean difference (mm)	SE	Sig. (p-value)	95% CI (lower–upper)	p-value
Anterior vs. posterior	2.970	1.099	0.037	0.123 to 5.817	0.037*
Anterior vs. fundal	−0.848	1.486	0.941	−4.698 to 3.001	0.941
Anterior vs. lateral	0.005	2.587	1.000	−6.696 to 6.707	1.000
Posterior vs. fundal	−3.819	1.554	0.070	−7.845 to 0.208	0.070
Posterior vs. lateral	−2.965	2.627	0.672	−9.769 to 3.840	0.672
Fundal vs. lateral	0.854	2.811	0.990	−8.135 to 6.427	0.990

ANOVA and post hoc (Tukey HSD): between groups = F(3.198), sig = 0.024, CI = confidence interval.

0.001), reinforcing the linear association between them. These findings support the clinical utility of PT measurements.

Olaleye et al. [18] reported a significant linear relationship, with a correlation coefficient of r = 0.99 (p = 0.0001), suggesting a near-perfect positive correlation. Similarly, Menon and Vinodha [19] found a correlation of r = 0.98 (p < 0.0001), further demonstrating the linear relationship between GA and PT. These findings indicate that PT can be reliably used to estimate GA.

This linear relationship has been attributed to biological and methodological factors in which continuous placental growth and increasing vascular development are required to meet the demands of the growing fetus. The strong correlation identified in the present study supports the use of PT as a reliable adjunct parameter for estimating GA.

Pearson's correlation was used to assess the relationship between PT (in mm) and GA (in weeks) for each fetal parameter (HC, BPD, AC, and FL). The analysis demonstrated a significant positive correlation between PT and all assessed fetal measurements. The strength of this relationship was supported by high coefficients of determination (R^2 = 0.909 for HC, 0.911 for BPD, 0.898 for AC, and 0.913 for FL), with all associations attaining significance (p < 0.001). The observed correlation between PT and fetal biometric parameters further reinforces the role of the placenta as a reflection of fetal growth and development. In this study, FL demonstrated the strongest correlation with PT, followed by BPD, HC, and AC. These findings are consistent with those of Fredrick et al. [16], who reported a significant positive correlation between PT and fetal growth parameters. In their study, the strongest correlations were observed with AC (r = 0.956) and FL (r = 0.956), whereas BPD showed the lowest correlation (r = 0.949), all of which were significant (p < 0.001).

Similarly, Olaleye et al. [18] found strong positive correlations between PT and fetal biometric indices, with correlation coefficients of r = 0.9157 for BPD, r = 0.9758 for HC, r = 0.8754 for AC, and r = 0.9651 for FL, reinforcing the predictive value of PT in assessing fetal growth.

Earlier research by Karthikeyan et al. [9] supports these findings, demonstrating significant positive correlations between PT and BPD (r = 0.926), FL (r = 0.935), HC (r = 0.946), and AC (r = 0.914), and concluding that PT can serve as a parameter for estimating fetal age and development.

The consistency with previous research may be attributed to biological consistencies, as the placenta grows in parallel with fetal skeletal and somatic development and methodological alignment across studies.

Our findings showed a significant association between PT and placental location. Specifically, anterior placentas were observed to be thicker than posterior placentas. This finding partially aligns with but also contrasts with previous studies. For instance, Lee et al. [20] reported that anterior placentas were thinner than posterior or fundal placentas ~6.6–7 mm in the second trimester, suggesting that placental position may influence thickness measurements depending on GA and maternal body habitus. Similarly, Sharami et al. [21] reported that posterior placentas had a greater average thickness than anterior ones (29.49 *vs*. 26.94 mm), and the difference was significant (p = 0.009). Conversely, Menon and Vinodha [19] found no significant differences in PT across different placental locations during any trimester.

Our findings diverge from those of earlier studies, which may be attributable to differences in study populations, genetic diversity, and the GA at

which PT was measured across studies. Some prior studies, such as that by Lee et al. [20], focused primarily on the second trimester, whereas our study included second and third trimesters of gestation, where placental morphology may vary by location and measurement techniques. These discrepancies may also suggest physiological or compensatory mechanisms unique to the study population, where anterior placentation supports greater volumetric development to meet fetal demands.

Placental thickness measurement is simple, quick, and requires no additional equipment beyond routine obstetric ultrasound. It can be integrated as an adjunct parameter, particularly in resource-limited settings where fetal biometry may be challenging.

Study limitations

This was conducted in a single tertiary healthcare facility; therefore, results may not be entirely representative of the general population across different healthcare settings and the absence of formal interobserver variability analysis across all participants. Additionally, the cross-sectional design limits the ability to evaluate longitudinal changes in PT within the same pregnancy. Only uncomplicated pregnancies were included in the analysis, which restricts the applicability of the findings to pregnancies affected by maternal or fetal complications such as hypertensive disorders, gestational diabetes, fetal growth restriction, placental abnormalities, or rhesus isoimmunization. Future multicenter studies are needed to confirm generalizability.

Conclusion

Our findings provide further evidence that PT is a valuable and practical parameter in prenatal ultrasonography.

PT increased progressively from 14 to 39 weeks of gestation and demonstrated a strong correlation with GA and fetal biometric parameters, supporting its use as a reliable indicator for estimating GA.

Placental location was also found to influence PT measurements.

Overall, PT has the potential to enhance obstetric assessment, particularly in situations where conventional fetal biometric parameters are limited. PT may contribute to improved maternal and fetal care.

What is already known on this topic?

PT increases linearly (~1 mm per week) with advancement in GA and is strongly correlated with standard fetal biometric measures.

Standard fetal biometric parameters (BPD, HC, AC, and FL) remain the primary tools for estimating GA and assessing fetal growth.

What this study adds?

To the best of our knowledge, there are limited published data from Tanzania, particularly from Northern Zonal Referral Hospitals, on the use of placental thickness for GA estimation; this study helps address that gap.

This study adds valuable regional evidence to the growing global body of literature supporting PT as an adjunctive parameter for estimating gestational age.

Conflict of interest

The authors declare no competing interests.

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