Fetal Gestational Age Determination using Ultrasound Placental Thickness

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Abstract

Background: The purposes of this study are to sonographically measure the placental thickness (PT) in normal fetuses; to correlate it with gestational age (GA), fetal growth parameters, and estimated fetal weight (EFW); and to design a nomogram for the derived PT measurements. Methods: This was a hospital-based cross-sectional study on 400 women with apparently normal pregnancy within the age range of 18–45 years recruited from the Antenatal Clinic of our hospital. The fetal GA was estimated by the last menstrual period (LMP). The fetal growth parameters were determined using standard sonographic methods while the PT was measured at the level of the umbilical cord insertion site. PT was then correlated with GA, fetal growth parameters, and the EFW. Results: The mean PT (mean ± standard deviation) in the 1st, 2nd, 3rd trimesters and the whole duration of pregnancy were 14.5 ± 0.3 mm, 24.6 ± 3.9 mm, 34.8 ± 2.8 mm, and 29.6 ± 7.1 mm, respectively. PT ranged from 13.5 ± 1.9 mm at 11 weeks to 39.1 ± 0.6 mm at 40 weeks. PT (in mm) had a linear relationship and a statistically significant positive correlation with GA (in weeks) in all the trimesters, with most significant correlation recorded in the 2nd trimester (r = 0.79). There was also a statistically significant positive correlation between PT and the fetal growth parameters (biparietal diameter, head circumference, abdominal circumference, femur length and crown-rump length), and EFW. PT nomogram was developed from 11 to 40 weeks of gestation using a scatter plot with 95% confidence interval for our locality. Conclusion: PT has a linear relationship with GA, fetal growth parameters, and EFW and it can be used along with other fetal growth parameters to increase the accuracy for predicting GA in normal pregnancies, especially when the subject is not sure of or does not know her LMP.

Keywords: Fetal parameters, gestational age, last menstrual period, placental thickness, sonography

Introduction

The placenta is a fetal organ that enables it to take oxygen and nutrients from the maternal blood and to excrete carbon dioxide and other waste products of metabolism.[1] The placenta also forms a barrier against the transfer of infection to the fetus and secretes hormones into the maternal circulation.[1] The placenta develops from the chorionic villi at its implantation site at about the 5th week of gestation and by the 9th or 10th week, the diffuse granular echotexture of the placenta is clearly evident at sonography.[2,3] Until recently, the placenta was evaluated mainly to determine its position or its premature separation. However, the size and growth pattern of the placenta also have an impact on pregnancy outcome.[4]

Accurate determination of gestational age (GA) is critical for quality obstetric care. Common sonographic parameters used to date pregnancy include fetal crown-rump length (CRL), biparietal diameter (BPD), femur length (FL), head circumference (HC), and abdominal circumference (AC).[5] The BPD is less accurate and unreliable in the 3rd trimester because it is affected by the shape and size of the fetal head.[6] The fetal head is quite malleable; therefore, in breech presentations, BPD may be underestimated. Measurement of the HC may compensate for these, but again, HC measurement often appears more technically difficult and carries a higher degree of observer bias.[7] Measurement of FL for dating at later stages of pregnancy is also considered unreliable as the femur, in some cases, it appears foreshortened (especially in

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excessive fetal movement) and may not be accurate in cases of dwarfism.\textsuperscript{7,8} Measurement of AC in the later stage of pregnancy has been reported as the single-most important fetal parameter. It is, however, more reflective of fetal size or weight than GA. For instance, AC may not be a reliable estimator of GA in cases of small for date fetuses, omphalocele, and fetal ascites. Considering the shortcomings in the use of the common fetal parameters for estimating GA, the use of placental thickness (PT) was evaluated based on the observation that PT increases with advancing GA.\textsuperscript{9-13} Placental growth results from multiplication and branching of chorionic villi.\textsuperscript{14} The placenta grows throughout pregnancy, with the initial growth being much more rapid than that of the fetus.\textsuperscript{15} Placental and fetal weights are closely correlated in most circumstances,\textsuperscript{16} and it follows nearly a linear pattern except during the past few weeks of gestation. Placental growth can be estimated by measuring the thickness or placental volume.

Therefore, the aim of this study is to sonographically measure the PT at the level of umbilical cord insertion site and to correlate it with GA determined by last menstrual period (LMP) and other fetal growth parameters.

**Methods**

This was a hospital-based cross-sectional study conducted in the Department of Radiology of Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun State, Nigeria, from June 2016 to May 2017. The Ethics Committee of the hospital approved the study (Protocol Number: ERC/2016/06/07; Approval Date: June 01, 2016). We enrolled 400 pregnant women with normal pregnancy between 11 and 40 weeks gestation, who had screened negative for hypertension and diabetes mellitus at the antenatal clinic. In addition, women must be sure of their LMP. Their blood pressure was measured in the antenatal clinic by doctors using the mercury sphygmomanometer. Any subject with blood pressure >140/90 mmHg was excluded from the study. The fasting blood sugar (FBS) was also done in the antenatal clinic by doctors using Accu-Check glucometer with glucose strips. Any subject whose FBS was >6.1 mmol/l was excluded from the study.

Other exclusion criteria include being unsure of LMP, multiple gestations, oligohydramnios, polyhydramnios, gestational diabetes mellitus, hypertensive disorders of pregnancy, suspected intrauterine growth restriction (IUGR), placenta previa, abruptio placenta, poor visualization of the placenta and site of cord insertion, placenta showing morphological variations (such as succenturiate placenta, bilobed placenta, and placental membranacea), placenta with variations in the cord insertions (like marginal placenta and velamentous cord insertions), and fetal anomalies.

The participants were recruited consecutively and written informed consent was obtained from all participants. All participants who declined to be part of the study were excluded. The sample size was calculated using 50% to represent the normal population in the Fisher formula.\textsuperscript{17} Participants who met the inclusion criteria had their estimated GA calculated from their LMP. Maternal age was also documented.

**Ultrasound technique**

MINDRAY® DC-7 ultrasound scanner with a 3.8–5.0 MHz transducer and Doppler function (Shenzhen Mindray Bio-medical Electronics, Nanshan, Shenzhen, China) was used for the obstetrics sonography. The procedure was explained to each subject, and they were reassured of the safety of the procedure. Each patient was scanned with a moderately distended urinary bladder in the supine position. There was adequate exposure of the abdominopelvic region and an acoustic gel applied. Scanning in longitudinal, transverse, and oblique planes was done to determine the fetal lie and presentation.

The fetuses were examined for gross fetal anomaly and GA was estimated by CRL from 11 to 12 weeks of pregnancy, whereas GA from 13 to 40 weeks of pregnancy was determined by measurements of other fetal parameters such as BPD, HC, FL, and AC. Ultrasound estimation of GA was obtained using the algorithm of the scanner based on the formula proposed by Hadlock et al.\textsuperscript{18}

The CRL was imaged in a longitudinal plane. The greatest embryonic length was measured by placing the calipers at the head and rump of the fetus. Three adequate CRL measurements were taken and the average used for GA determination.\textsuperscript{19} The HC was measured in a plane that is perpendicular to the parietal bones and traverses the third ventricle and thalamus.\textsuperscript{19} The image also demonstrated smooth and symmetrical calvaria and the presence of a cavum septum pellucidum. The calipers were placed on the outer edges of the calvaria and a computer-generated ellipse adjusted to fit around the fetal head without including the scalp. The BPD was taken in the same plane as the HC by placing the calipers on the outer edge of the near-wall of the calvarium and on the inner edge of the far wall of the calvarium.\textsuperscript{20} To measure the FL, the longest dimension of the femoral shaft was demonstrated. The proximal epiphyseal cartilage (future greater trochanter) and the distal femoral epiphyseal cartilage (future distal femoral condyle) were not included in the measurement but were visualized to assure that the entire osseous femur had been measured without foreshortening or elongation.\textsuperscript{19,21} The AC was measured on a plane slightly superior to the umbilicus at the greatest transverse abdominal diameter, with the liver, gastric bubble, umbilical vein, and junction of the right and left portal veins visualized.

The estimated fetal weight (EFW) was calculated automatically by the ultrasound machine using the Hadlock et al.\textsuperscript{22} formula:

\[
\text{Log}_{10} \text{BW} = 1.4 + x (\text{AC}) + x (\text{FL}) - x (\text{AC} \times \text{FL}) \quad \text{or} \quad \text{Log}_{10} \text{BW} = 1.5 + x (\text{BPD})^2 + x (\text{AC}) + x (\text{FL}) - x (\text{AC} \times \text{FL}).
\]

**Placental thickness measurement**

The placenta was located and its thickness measured at the level of the umbilical cord insertion site. The transducer was
orientated to scan perpendicular to both the chorionic and basal plates as tangential scan will distort the measurement of the thickness of the placenta.\[^{[4]}\] The cord insertion site is usually central, but a slightly eccentric position may be normal. The cord insertion was seen as either V-shaped hypoechoic area closest to the chorionic plate in the thickest portion of the placenta as or linear echoes emanating at right angles from the placental surface [Figure 1].

All placental measurements were taken during the relaxed phase of the uterus as contractions could spuriously increase the PT. PT was then taken from the echogenic chorionic plate to placental myometrial interface [Figure 2]. The myometrial and retroplacental veins were not included in the measurement. Three measurements were taken, and the average taken for each participant to reduce intra-observer variability. All measurements were obtained by a fourth-year radiology resident doctor under the supervision of a consultant radiologist.

The study data were analyzed and interpreted using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) windows version 20. Categorical variables were presented in percentage, whereas continuous variables were expressed as a mean ± standard deviation. Analysis of variance was used to compare mean PT in the anterior, fundal, and posterior locations, whereas Scheffe post hoc analysis was used to evaluate variations between the groups when appropriate. The relationship between continuous variables was assessed using Pearson’s correlation. A value of \( p \leq 0.05 \) was considered to be statistically significant.

**RESULTS**

A total of 400 apparently healthy pregnant participants were studied. The age range of the study participants was 18–45 years with a mean age of 30.44 ± 4.44 years. The age distribution of the study participants is shown in Table 1.

In the 1\(^{st}\) trimester (11–13 weeks), 2\(^{nd}\) trimester (14–26 weeks), and 3\(^{rd}\) trimester (27–40 weeks), there was an incremental PT with advancing GA. The PT increased by almost 2 mm in a week in the 1\(^{st}\) trimester (from 11 to 12 weeks), with a mean PT of 14.5 ± 0.3 mm [Table 2]. From the 14\(^{th}\) to 26\(^{th}\) weeks (2\(^{nd}\) trimester), the PT increased by more than 10 mm without any decrescendo, with a mean PT of 24.6 ± 3.9 mm [Table 2] increased by more than 6 mm from the 27\(^{th}\) week to the 38\(^{th}\) week in the 3\(^{rd}\) trimester without any significant decrescendo, with a mean PT of 34.8 ± 2.9 mm. It decreased between the 38\(^{th}\) week and 39\(^{th}\) week by 0.66 mm, thereafter increased again at 40 weeks [Table 2]. The mean PT in the combined trimesters was 29.6 ± 7.1 mm. The maximum PT of 40.9 mm was recorded at 38 weeks gestation, whereas the minimum PT of 11.5 mm was recorded at 11 weeks.

The nomogram for PT throughout gestation from 11 weeks to 40 weeks with a mean and 95% confidence interval (CI) is shown in Figure 3. Table 3 shows Pearson’s correlational analysis of GA with PT and EFW in all the trimesters. There was a statistically significant strong positive correlation between PT and EFW in the 2\(^{nd}\) trimester; \( r = 0.841, P < 0.0001 \), 3\(^{rd}\) trimester; \( r = 0.791, P < 0.0001 \), and combined trimester; \( r = 0.913, P < 0.0001 \). No statistically significant correlation was observed in the 1\(^{st}\) trimester; \( r = 0.487, P = 0.153 \). The relationship between PT and EFW is represented by the regression equation as follows:

\[
Y = 0.1143 \times PT - 1.1429; \text{ where } Y = EFW.
\]

Regression analysis yielded the following linear equations for the relationship between GA (Y) in weeks and PT in mm for the three trimesters: Y = 0.29 (PT) + 7.86 (1\(^{st}\) trimester); Y = 0.48 (PT) + 6.8 (2\(^{nd}\) trimester); Y = 0.70 (PT) + 8.5 (3\(^{rd}\) trimester); and Y = 0.75 (PT) + 2.5 (combined entire duration of pregnancy).

Amongst the 400 participants studied, anterior placenta (AP) was noted in 191 participants (47.75%), posterior placenta (PP) in 152 participants (38.00%) and fundal placenta (FP) in 57 participants (14.25%). There was no placenta located in the fundal region among those patients who were scanned in the 1\(^{st}\) trimester [Table 4]. There was no statistically significant difference in the PT across the three locations in the 1\(^{st}\) and 2\(^{nd}\) trimesters. However, in the 3\(^{rd}\) trimester, the placentas located in the uterine fundus were slightly thicker than those in other locations with

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**Table 1: Age distribution of all study subjects**

| Age (years) | Outcome |
|-------------|---------|
| Range       | 18-45   |
| Age groups, n (%) | |
| 18-22       | 11 (2.8) |
| 23-27       | 81 (20.2) |
| 28-32       | 195 (48.8) |
| 33-37       | 88 (22.0) |
| ≥38         | 25 (6.2) |
| Total       | 400 (100.0) |

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**Figure 1:** Grey scale obstetrics sonogram showing the measurement of fundally located placental thickness (in between calipers) measured from the chorionic plate to the basal plate at the level of umbilical cord insertion site (linear echoes emanating at right angles from the placental surface)
The PT was still directly related to GA for all the placental locations. The relationship between PT and GA by LMP in the different placental showed a statistically significant and very strong positive correlation in all the placental locations ($r = 0.937$ for AP vs. PT, $r = 0.937$ for AP vs. EFW; $r = 0.951$ for PP vs. PT, $r = 0.937$ for PP vs. EFW; $r = 0.905$ for FP vs. PT, $r = 0.922$ for FP vs. EFW); $P < 0.0001$ for all the pairs.

In this study, the mean GA by LMP was $26.87 \pm 7.79$ weeks, mean BPD was $28.04 \pm 7.05$ weeks, mean HC was $28.17 \pm 7.05$ weeks, mean AC was $28.35 \pm 7.09$ weeks, mean FL was $28.55 \pm 7.07$ weeks, mean CRL was $11.59 \pm 0.62$ weeks, mean PT was $29.64 \pm 7.12$ mm, and the mean EFW was $1.61 \pm 1.08$ kg. There was a very strong positive correlation between PT (mm) and BPD, HC, AC, FL and CRL, which were statistically significant at a 95% CI [Table 5]. Table 5 also shows a statistically significant very strong positive correlation between EFW and GA, BPD, HC, AC, and FL.

**Discussion**

Accurate assessment of GA is imperative for delivery optimal obstetric care. Currently, the most effective way to date pregnancy is by assessing fetal growth parameters such as CRL, BPD, HC, AC, and FL using ultrasonography (USG). Nomograms are also handy tools frequently developed for various obstetrics USG parameters.

Although PT is easy to measure, there are relatively few studies on normal PT during gestation in our locality. Sonographic measurement of PT at the level of the umbilical cord insertion site has been suggested to be a useful adjunct in the assessment of fetal GA.

This study confirmed that PT is related to GA. Its measurement is, therefore, relevant for determining the age of the fetus. PT had a linear relationship with the GA from 11 weeks to 40 weeks of gestation and increased with advancing GA. This pattern is in concord with previous studies.

### Table 2: Nomogram for determining gestational age from placental thickness

| GA (weeks) | n  | PT (mm), mean±SD | 95% CI          |
|-----------|----|-----------------|-----------------|
| 11        | 11 | 13.53±1.88      | 12.26-14.79     |
| 12        | 6  | 15.20±1.79      | 13.32-17.08     |
| 13        | 10 | 15.18±0.99      | 14.47-15.89     |
| 16        | 11 | 20.91±2.69      | 19.09-22.72     |
| 17        | 2  | 21.60±1.41      | 8.89-34.30      |
| 18        | 11 | 22.65±2.37      | 21.06-24.24     |
| 19        | 7  | 24.14±2.68      | 21.67-26.62     |
| 20        | 15 | 24.55±2.95      | 22.92-26.19     |
| 21        | 16 | 24.65±2.09      | 23.53-25.77     |
| 22        | 9  | 25.59±1.09      | 24.75-26.43     |
| 23        | 14 | 26.69±2.26      | 25.39-27.99     |
| 24        | 16 | 26.89±2.20      | 25.71-28.06     |
| 25        | 18 | 28.33±3.39      | 26.69-29.96     |
| 26        | 10 | 28.52±2.09      | 27.03-30.01     |
| 27        | 16 | 31.98±2.20      | 30.81-33.15     |
| 28        | 12 | 31.94±2.71      | 30.22-33.66     |
| 29        | 16 | 32.22±1.83      | 31.24-33.19     |
| 30        | 22 | 33.59±2.24      | 32.60-34.59     |
| 31        | 18 | 33.43±3.23      | 31.82-35.03     |
| 32        | 21 | 34.19±2.31      | 33.14-35.24     |
| 33        | 21 | 34.97±2.14      | 33.99-35.95     |
| 34        | 22 | 35.73±2.41      | 34.66-36.80     |
| 35        | 20 | 36.14±1.91      | 35.24-37.03     |
| 36        | 19 | 36.34±1.35      | 35.69-36.99     |
| 37        | 19 | 37.35±1.51      | 36.62-38.07     |
| 38        | 10 | 38.44±1.03      | 37.70-39.17     |
| 39        | 9  | 37.78±2.00      | 35.30-40.26     |
| 40        | 3  | 39.07±0.60      | 37.57-40.56     |

$n$: Numbers of subjects, PT: Placental thickness, GA: Gestational age, CI: Confidence interval, SD: Standard deviation

$P < 0.05$. No significant difference was seen in the mean thickness of placentas in the anterior and posterior uterine wall [Table 4].
We observed that PT increased by almost 2 mm from the 11th to 12th week; increased by 10 mm in the 2nd trimester; by more than 6 mm in the 3rd trimester up to 38 weeks before it decreased in the 39th week by 0.66 mm; thereafter, it increased again at 40 weeks of gestation. This is similar to findings by Karthikeyan et al.\textsuperscript{[9]} who reported that PT increased by more than 2 mm in a week in the 1st trimester, increased more than 9 mm in the 2nd trimester from 15th to the 25th week, decreased by 3.5 mm from 28th to 29th week and thereafter increased without much decrement.

The mean PT in this study was higher than the GA by 1–5 mm up to 30 weeks, almost matching the GA from 31 weeks to 35 weeks and perfectly matching it from 36 weeks to 38 weeks and was lower than GA from 39 weeks to 40 weeks of gestation by <2 mm. This is similar to the study conducted in India by Jain et al.\textsuperscript{[11]} who observed that from 10 weeks to 25 weeks, the PT was higher than GA by 1–5 mm and matched almost equally between 27 and 33 weeks. Mital et al.\textsuperscript{[12]} in India, also reported that from 10 to 21 weeks of gestation, PT was slightly higher than GA by 1–4 mm, almost matched the GA from 22 to 35 weeks, and was lower than GA by 1–2 mm thereafter up to term. Nagwani et al.\textsuperscript{[13]} found their average PT to be roughly equivalent to GA in weeks. They reported a mean PT of 3.90 ± 1.1 cm, which increased till 38 weeks of gestation and decreased thereafter. Baghel et al.\textsuperscript{[14]} reported that PT (mm) almost matched the GA in weeks at 24 weeks (24.5 mm), 32 weeks (31.8 mm) and 36 weeks (35.5 mm). Adeyekun\textsuperscript{[26]} in Nigeria documented a linear increase in PT till 30 weeks GA, followed by slight decrease till 33 weeks when another increase was noted which continued to maximum value of 39.2 mm at 39–40 weeks of gestation.

Ohagwu et al.\textsuperscript{[27]} observed that PT in mm equaled GA only at 10 and 11 weeks of gestation and observed no trend thereafter. The maximum mean PT in their study was 39.07 mm recorded at 40 weeks. This is similar to 39.26 mm at 40 weeks, reported by Adeyekun\textsuperscript{[28]} in Nigeria but is at variance with the study by Abu et al.\textsuperscript{[29]} also in Nigeria, who reported 43.0 mm at 40 weeks. The measurements of Abu et al. were about 5–7 mm higher than all the studies in the literature. They could not explain these higher values, but attributed them to racial differences and asserted that the placenta is thicker in indigenous Africans. This declaration might not be correct as a study done in Nigeria by Adeyekun\textsuperscript{[26]} agreed with studies done in India by La Torre et al.\textsuperscript{[37]} and in the USA by Hoddick et al.\textsuperscript{[10]} stating that at no stage of pregnancy was the mean PT >40 mm. This was also confirmed in the present study. It could be that Abu et al.\textsuperscript{[29]} consistently overestimated the PT measurements.

There was a strong positive correlation between PT and GA estimated by LMP. This is similar to the observation of many authors of previous studies.\textsuperscript{[4,9,26,31,35,38]} Pearson’s correlation coefficient (\(r\)) was the highest for the 2nd trimester; \(r = 0.794\), implying that the most significant correlation between PT and GA occurs in the 2nd trimester. This may be due to the rapid growth of placenta in the 2nd trimester in relation to the GA. We observed that PT increased by more than 10 mm in the 2nd trimester compared to the 3rd trimester where it increased by 6 mm and 1st trimester where it increased by 2 mm. This is similar to the observation by Kapoor and Dudhat\textsuperscript{[38]} who also reported the most significant correlation in the 2nd trimester; though, no reason was advanced for their observation.

The moderately positive correlation in the 1st trimester compared to other trimesters in this study could be due to inadequate sample size as subjects in our environment do not come for antenatal booking until 2nd trimester while majority come to the hospital in the 3rd trimester. This trend was also observed by Adeyekun.\textsuperscript{[26]} This may explain the largest number of participants being in the 3rd trimester in the index study.

### Table 3: Pearson’s correlation of gestational age with placental thickness and estimated fetal weight in all the trimesters

| Trimesters | n  | PT  | EFW |
|------------|----|-----|-----|
|            |    | \(r\) | \(P\) | \(r\) | \(P\) |
| First      | 27 | 0.432 | 0.024 | NA | NA |
| Second     | 149 | 0.794 | <0.001 | 0.806 | <0.001 |
| Third      | 224 | 0.676 | <0.001 | 0.843 | <0.001 |
| Combined   | 400 | 0.943 | <0.001 | 0.938 | <0.001 |

\(n\): Number of subjects, \(r\): Pearson correlation co-efficient, PT: Placental thickness, EFW: Estimated fetal weight, NA: Not applicable

### Table 4: Placental thickness in the three trimesters according to placental location

| Variables | Placental location | Fundal | \(F\) | df | \(p\) |
|-----------|-------------------|--------|------|----|-----|
| n (%)     |                   |        |      |    |     |
| First     | 12 (6.3)          | 15 (9.9) | 0 (0.0) | -  | -  |
| Second    | 72 (37.7)         | 65 (42.8) | 12 (21.1) | -  | -  |
| Third     | 107 (56.0)        | 72 (47.4) | 45 (78.9) | -  | -  |
| Total     | 191 (100.0)       | 152 (100.0) | 57 (100.0) | -  | -  |

(Mean=SD)

| First     | 15.12±1.45 | 14.03±1.84 | -  | 2.812 | 1  | 0.106 |
| Second    | 25.11±3.58 | 23.79±3.94 | 25.42±4.92 | 2.316 | 2  | 0.102 |
| Third     | 34.73±3.05 | 34.27±2.65 | 35.99±2.65 | 5.304 | 2  | 0.006* |

\(*p\) values from Scheffe post hoc tests are: Anterior versus Posterior=0.552, Anterior versus Fundal=0.045, Posterior versus Fundal=0.006. \(F\): One-way analysis of variance, df: Degree of freedom, SD: Standard deviation.
Participants with FP had the highest mean PT (33.77 mm) when all trimester measurements were combined, followed by AP (29.87 mm) and then PP (28.03 mm). This trend was, however, not observed when data were analyzed separately for each trimester. This is in agreement with Ravi[39] who stated that PT did not vary relative to the placental location. Kapoor and Duddhat[38] also reported no variation in mean PT with different locations of the placenta. Consistent measurements were obtained irrespective of placental location. Contrarily, Durnwald and Mercer[40] stated that PP was thicker than the AP in the 2nd trimester by 4.8 mm, while the PP and FP were thicker than the anteriorly located placenta. Lee et al.[41] also disclosed that PP are 6–7 mm thicker than the AP and opined that the difference cannot be accounted for by ultrasound physics because the axial resolution is determined by spatial pulse length, which does not vary with depth.

There was no placenta located in the fundal region in the 1st trimester in the index study. This was also observed by Durnwald and Mercer[40] Currently, the reason (s) for this is not clear. Our data showed that PT was directly related to GA for all the placental locations. The correlation between PT and GA in the different locations was similar and statistically significant, as also observed by Ravi.[39]

There was a statistically significant positive correlation between PT and fetal growth parameters (CRL, BPD, HC, AC, and FL). A similar finding was reported by Karrthikeyan et al.[9] in India who reported that PT correlated well with GA and other fetal growth parameters. Similarly, Ohagwu et al.[27] reported a statistically significant positive correlation between PT and BPD and AC, while Adhikari et al.[42] disclosed a statistically significant positive correlation between PT, FL, BPD, and AC.

There was a progressive increase in the mean value of PT and EFW with GA throughout gestation with a slight decrease at 17 weeks, 21 weeks, 26 weeks, and 39 weeks of gestation. There was a strong positive correlation between PT and EFW in the 2nd, 3rd and combined trimesters. There was no statistically significant correlation between PT and EFW in the 1st trimester. This might have been due to the few number of subjects (10 only) in the 13th week of gestation and again, no EFW was recorded from 11 to 12 weeks as the GA was measured using CRL. This relationship between PT and EFW was also observed by Abu et al.[39] and Adeyekun and Ikubor[43] Their studies were done on pregnant women in the 2nd and 3rd trimesters only, with no data in the 1st trimester for comparison. They concluded that PT can be used as a fairly accurate indicator of normality of fetal weight and to predict deviations from norms of birth weight in late pregnancy, respectively. This relationship was also observed in the study carried out in India by Karrthikeyan et al.[9]

Habib[44] in a study of Saudi women, reported that the probability of a normal birth weight increases with increase in PT and also reported that PT was 22 mm at 36 weeks in the fetuses which weighed <2500 g and 34.8 mm at 36 weeks in the fetus which weighed >2500 g. They concluded that PT was a predictor of low birth weight infants.

In this study, the mean PT and mean EFW at 36 weeks were 36.34 mm and 2.961 kg, respectively which fell within the normal range for GA. This finding is similar to that of Karrthikeyan et al.[9] who reported that the mean PT at 36 weeks was 37.6 mm. Baghel et al.[36] recorded 35.5 mm as mean PT at 36 weeks and stated that a PT below the 10th percentile at 36 weeks could detect IUGR with a sensitivity of 53.5%, specificity of 92%, and positive predictive value of 80%.

Tongson and Boonyanurak[13] stated that PT was increased in pregnant women with Hb Barts disease (mean = 34.5 ± 6.7 mm) than in their normals (mean = 24.6 ± 5.2 mm) between 18 and 21 weeks. From this, they inferred that a decreased PT for GA is associated with IUGR.

A subnormal PT may be the earliest indicator of IUGR, and an enlarged placenta is suspected if the PT is >40 mm at term. Placentalomegaly may be associated with diabetes mellitus, intrauterine infections, hydrops fetois, and α-thalassemia Type 1.[45]

**Conclusion**

PT has a linear relationship with GA, fetal growth parameters, and EFW and can be used along with other fetal growth parameters to increase the accuracy for predicting GA in normal pregnancies, especially when the patient is not sure or does not know her LMP. An abnormal PT for the corresponding GA should raise the suspicion of underlying fetal or maternal disease condition. The nomogram developed can be used to calculate the GA with minimal error. It is suggested that measurement of PT be carried out routinely during obstetric ultrasound scans.

This was a cross-sectional study design made up of observations on different individuals. It was not a true placental growth curve as these can only be obtained from serial measurements taken on the same patient throughout gestation. It may, therefore, not provide a clear understanding of individual growth patterns. However, it is a reasonable approximation of a true placental growth curve.

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**Table 5: Pearson’s correlation of placental thickness with fetal growth parameters** (Biparietal diameter, head circumference, abdominal circumference, femur length and crown rump length)

|        | GA (r) | PT (r) | EFW (r) | BPD (r) | HC (r) | AC (r) | FL (r) | CRL (r) |
|--------|--------|--------|---------|---------|--------|--------|--------|---------|
| GA     | 1      | 0.943  | 0.938   | 0.966   | 0.967  | 0.968  | 0.967  | 0.507   |
| PT     | 0.943  | 1      | 0.913   | 0.953   | 0.956  | 0.958  | 0.957  | 0.728   |
| EFW    | 0.938  | 0.913  | 1       | 0.959   | 0.956  | 0.966  | 0.955  | -       |
| BPD    | 0.966  | 0.953  | 0.959   | 1       | 0.992  | 0.991  | 0.988  | -       |
| HC     | 0.967  | 0.956  | 0.956   | 0.992   | 1      | 0.989  | 0.988  | -       |
| AC     | 0.968  | 0.958  | 0.966   | 0.991   | 0.990  | 1      | 0.992  | -       |
| FL     | 0.967  | 0.957  | 0.955   | 0.988   | 0.988  | 0.992  | 1      | -       |
| CRL    | 0.507  | 0.728  | -       | -       | -      | -      | -      | -       |

r: Pearson’s correlation coefficient, BPD: Biparietal diameter, HC: Head circumference, AC: Abdominal circumference, FL: Femur length, CRL: Crown rump length, GA: Gestational age, PT: Placental thickness, EFW: Estimated fetal weight.
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Conflicts of interest
There are no conflicts of interest.

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