Original Article

Fetal Gestational Age Determination using Ultrasound Placental Thickness

Angus Sunday Azagidi[1], Bolanle Olubunmi Ibitoye[1], Olufemiwa Niyi Makinde[2], Bukunmi Michael Idowu[1]*, Adeniyi Sunday Aderibigbe[1]

[1]Department of Radiology, Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun, Nigeria, [2]Department Obstetrics and Gynecology, Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun, Nigeria

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

Received: 22-12-2018 **Revised:** 31-05-2019 **Accepted:** 01-07-2019 **Available Online:** 09-10-2019

Access this article online

Quick Response Code:	
	Website: www.jmuonline.org
	DOI: 10.4103/JMU.JMU_127_18

Address for correspondence: Dr. Bukunmi Michael Idowu, Department of Radiology, Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, Osun, Nigeria.
E-mail: ibmcontacts@gmail.com

How to cite this article: Azagidi AS, Ibitoye BO, Makinde ON, Idowu BM, Aderibigbe AS. Fetal gestational age determination using ultrasound placental thickness. J Med Ultrasound 2020;28:17-23.

excessive fetal movement) and may not be accurate in cases of dwarfism.[7] 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, omphalocoele, and fetal ascites.[7,8] 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.[9-13]

Placental growth results from multiplication and branching of chorionic villi.[14] The placenta grows throughout pregnancy, with the initial growth being much more rapid than that of the fetus.[15] Placental and fetal weights are closely correlated in most circumstances,[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 placentae, 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.[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*.[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.[19] The HC was measured in a plane that is perpendicular to the parietal bones and traverses the third ventricle and thalami.[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.[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.[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*.[22] formula: $\text{Log}_{10}\ \text{BW} = 1.4 + x\ (\text{AC}) + x\ (\text{FL}) - x\ (\text{AC} \times \text{FL})$ or $\text{Log}_{10}\ \text{BW} = 1.5 + x\ (\text{BPD})^2 + x\ (\text{AC}) + x\ (\text{FL}) - x\ (\text{AC} \times \text{FL})$.

Placental thickness measurement

The placenta was located and its thickness measured at the level of the umbilical cord insertion site. The transducer was oriented 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 or as 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.

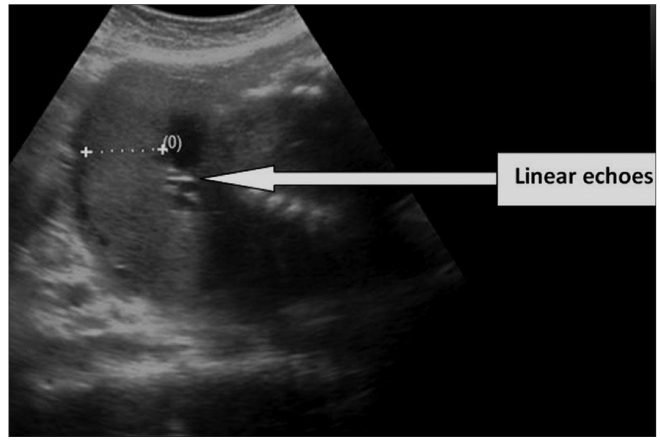

Figure 1: Grey scale obstetrics sonogram showing the measurement of fundally located placental thickness (in between calipers) measured from the chorionic plate to the basal plate at the level of umbilical cord insertion site (linear echoes emanating at right angles from the placental surface)

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)

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 1st trimester (11–13 weeks), 2nd trimester (14–26 weeks), and 3rd trimester (27–40 weeks), there was an incremental PT with advancing GA. The PT increased by almost 2 mm in a week in the 1st trimester (from 11 to 12 weeks), with a mean PT of 14.5 ± 0.3 mm [Table 2]. From the 14th to 26th weeks (2nd 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 27th week to the 38th week in the 3rd trimester without any significant decrescendo, with a mean PT of 34.8 ± 2.9 mm. It decreased between the 38th week and 39th 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 2nd trimester; $r = 0.841$, $P < 0.0001$, 3rd trimester; $r = 0.791$, $P < 0.0001$, and combined trimester; $r = 0.913$, $P < 0.0001$. No statistically significant correlation was observed in the 1st trimester; $r = 0.487$, $P = 0.153$. The relationship between PT and EFW is represented by the regression equation as follows:

$Y = 0.1143\ (PT) + (-1.1429)$; 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: $Y = 0.29\ (PT) + 7.86$ (1st trimester); $Y = 0.48\ (PT) + 6.8$ (2nd trimester); $Y = 0.70\ (PT) + 8.5$ (3rd 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 1st trimester [Table 4]. There was no statistically significant difference in the PT across the three locations in the 1st and 2nd trimesters. However, in the 3rd trimester, the placentas located in the uterine fundus were slightly thicker than those in other locations with

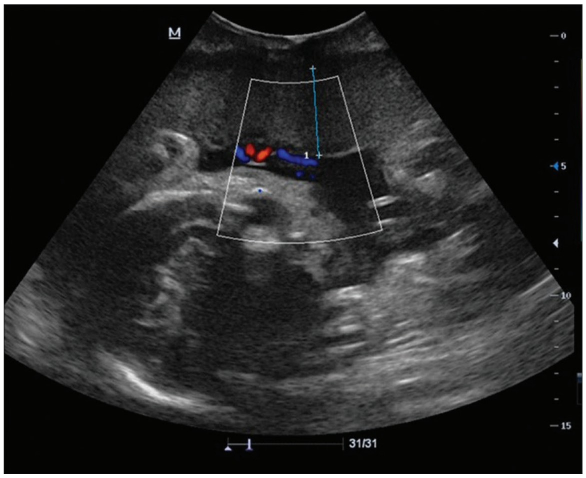

Figure 2: Duplex obstetric sonogram showing the measurement of placental thickness (in between calipers) measured from the chorionic plate to the basal plate at the level of umbilical cord insertion site (color-filled tubular structures at right angles to the chorionic plate)

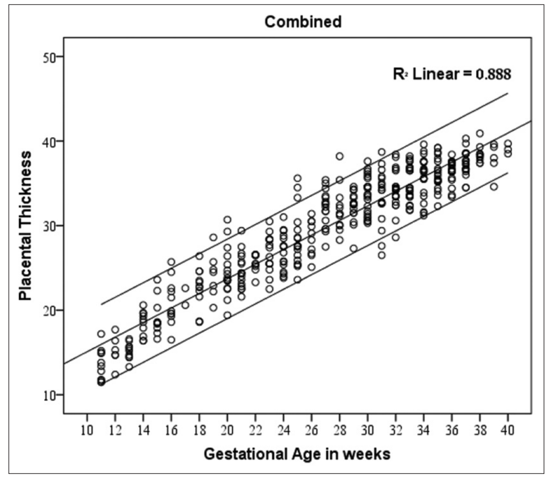

Figure 3: Scatterplot depicting relationship between the placental thickness (mean and 95% confidence interval) and gestation age in weeks

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	5	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].

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 ± 7.79 weeks, mean BPD was 28.04 ± 7.05 weeks, mean HC was 28.17 ± 7.05 weeks, mean AC was 28.35 ± 7.09 weeks, mean FL was 28.55 ± 7.07 weeks, mean CRL was 11.59 ± 0.62 weeks, mean PT was 29.64 ± 7.12 mm, and the mean EFW was 1.61 ± 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).[22] Nomograms are also handy tools frequently developed for various obstetrics USG parameters.[23-25]

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.[4,9,11,26-34]

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.[4,9-12,26,27]

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*.[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 decrescendo.

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*.[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*.,[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*.[35] 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*.[36] 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[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.

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

Ohagwu *et al*.[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[26] in Nigeria but is at variance with the study by Abu *et al*.,[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 indigeneous Africans. This declaration might not be correct as a study done in Nigeria by Adeyekun[26] agreed with studies done in India by La Torre *et al*.[37] and in the USA by Hoddick *et al*.,[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*.[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.[4,9,26,33-35,38] 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[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.[26] This may explain the largest number of participants being in the 3rd trimester in the index study.

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

Variables	Placental location			*F*	df	*p*
	Anterior	Posterior	Fundal			
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

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

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 Dudhat[38] also reported no variation in mean PT with different locations of the placentae. 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 Karthikeyan *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*.[29] 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 Karthikeyan *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 fetuses 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 Karthikeyan *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%.

Tongsong 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. Placentomegaly may be associated with diabetes mellitus, intrauterine infections, hydrops fetalis, 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.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Sadler TW. Longman's Medical Embryology. 9th ed.. Baltimore, MD: Lippincott Williams and Wilkins; 2004. p. 117-48.
2. Spirt BA, Gordon LP. Sonography of the placenta. In: Fleischer AC, Manning FA, Jeanty P, Romero R, editors. Sonography in Obstetrics and Gynecology: Principles and Practice. New York: Appleton and Lange; 1996. p. 173-202.
3. Callen PW, editor. Ultrasonography in Obstetrics and Gynecology. 4th ed.. Philadelphia, PA: W.B. Saunders; 2000. p. 105-45.
4. Kaushal L, Patil A, Kocherla K. Evaluation of placental thickness as a sonological indicator for estimation of gestational age of foetus in normal singleton pregnancy. Int J Res Med Sci 2015;3:1213-8.
5. Schwärzler P, Bland JM, Holden D, Campbell S, Ville Y. Sex-specific antenatal reference growth charts for uncomplicated singleton pregnancies at 15-40 weeks of gestation. Ultrasound Obstet Gynecol 2004;23:23-9.
6. Lee W, Lee VL, Kirk JS, Sloan CT, Smith RS, Comstock CH, *et al.* Vasa previa: Prenatal diagnosis, natural evolution, and clinical outcome. Obstet Gynecol 2000;95:572-6.
7. Malhotra N, Kumar P. Measurement of fetal parameters. In: Ultrasound in Obstetrics and Gynecology. 3rd ed.. Mumbai: Jaypee Brothers Publishers Ltd.; 1999. p. 92-8.
8. Verma AK, Malhotra V, Yadav R, Chavhan R. Placental thickness estimation by ultrasonography and its correlation with gestational age in normal pregnancies in late 2nd and 3rd trimester. Asian Pac J Health Sci 2017;4:130-2.
9. Karthikeyan T, Subramaniam RK, Johnson W, Prabhu K. Placental thickness and its correlation to gestational age and foetal growth parameters – A cross sectional ultrasonographic study. J Clin Diagn Res 2012;6:1732-5.
10. Hoddick WK, Mahony BS, Callen PW, Filly RA. Placental thickness. J Ultrasound Med 1985;4:479-82.
11. Jain A, Kumar G, Agarwal U, Kharakwal S. Placental thickness: A sonographic indicator of gestational age. J Obstet Gynaecol India 2001;51:48-9.
12. Mital P, Hooja N, Mehndiratta K. Placental thickness: A sonographic parameter for estimating gestational age of the fetus. Indian J Radiol Imaging 2002;12:553-4.
13. Tongsong T, Boonyanurak P. Placental thickness in the first half of pregnancy. J Clin Ultrasound 2004;32:231-4.
14. Shirish ND, Sudip C. Holland and Brews: Manual of Obstetrics. 16th ed.. New Delhi: B.I Churchill Livingstone Pvt., Ltd.; 1998. p. 23-32.
15. Hendricks CH. Patterns of fetal and placental growth: the second half of normal pregnancy. Obstet Gynecol 1964;24:357-65.
16. Robinson JS. Fetal growth and development. In: Chamberlain G, editor. Turnbell's Obstetrics. 2nd ed.. Hong Kong: Churchill Livingstone; 1995. p. 97-114.
17. Whitley E, Ball J. Statistics review 4: Sample size calculations. Crit Care 2002;6:335-41.
18. Hadlock FP, Deter RL, Harrist RB, Park SK. Estimating fetal age: Computer-assisted analysis of multiple fetal growth parameters. Radiology 1984;152:497-501.
19. Filly RA, Hadlock FP. Sonographic determination of menstrual age. In: Callen PW, editor. Ultrasonography in Obstetrics and Gynecology. Philadelphia: W.B. Saunders; 2000. p. 146-70.
20. Manning FA. General principles and applications of ultrasonography. In: Creasy RK, Resnik R, editors. Maternal-Fetal Medicine. Philadelphia: W.B. Saunders Company; 1999. p. 169-206.
21. Goldstein RB, Filly RA, Simpson G. Pitfalls in femur length measurements. J Ultrasound Med 1987;6:203-7.
22. Hadlock FP, Harrist RB, Sharman RS, Deter RL, Park SK. Estimation of fetal weight with the use of head, body, and femur measurements – A prospective study. Am J Obstet Gynecol 1985;151:333-7.
23. Zador IE, Bottoms SF, Tse GM, Brindley BA, Sokol RJ. Nomograms for ultrasound visualization of fetal organs. J Ultrasound Med 1988;7:197-201.
24. Ayoola OO, Bulus PU, Idowu BM, Loto OM. Normogram of Doppler indices of the umbilical artery in singleton pregnancies of a South-Western Nigerian population. J Obstet Gynaecol Res 2016;42:1694-8.
25. Ishola A, Asaleye CM, Ayoola OO, Loto OM, Idowu BM. Reference ranges of fetal cerebral lateral ventricle parameters by ultrasonography. Rev Bras Ginecol Obstet 2016;38:428-35.
26. Adeyekun A. Ultrasound assessment of placental thickness and its correlation with gestational age in normal pregnancy: A preliminary report. Sahel Med J 2012;15:10-5.
27. Ohagwu CC, Abu PO, Ezeokeke UO, Ugwu AC. Relationship between placental thickness and growth parameters in normal Nigerian fetuses. Afr J Biotechnol 2009;8:133-8.
28. Ohagwu CC, Abu PC, Udoh BE. Placental thickness: A sonographic indicator of gestational age in normal singleton pregnancies in Nigerian women. Int J Med Update 2009;4:9-14.
29. Abu PO, Ohagwu CC, Eze JC, Ochie K. Correlation between placental thickness and estimated fetal weight in Nigerian women. Ibnosina J Med Biomed Sci 2009;1:80-5.
30. Agwuna KK, Eze CU, Ukoha PO, Umeh UA. Relationship between sonographic placental thickness and gestational age in normal singleton fetuses in Enugu, Southeast Nigeria. Ann Med Health Sci Res 2016;6:335-40.
31. Robinson ED, Alasia OS. Foetal Weight Determination Using Sonographic Measurement of Placenta Thickness. Available from: https://www.academia.edu/28011747/FOETAL_WEIGHT_DETERMINATION_USING_SONOGRAPHIC_MEASUREMENT_OF_PLACENTA_THICKNESS. [Last accessed on 2018 Dec 08].
32. Afrakhteh M, Moeini A, Taheri MS, Haghighatkhah HR. Correlation between placental thickness in the second and third trimester and fetal weight. Rev Bras Ginecol Obstet 2013;35:317-22.
33. Babiker MS, Eisa RA. Placenta thickness measurements during gestational age progress. J Appl Med Sci 2014;3:31-7.
34. Tiwari A, Chandnani K. A study to evaluate gestational age with the help of placental thickness. Int J Reprod Contracept Obstet Gynecol 2016;2:503-5.
35. Nagwani M, Sharma P, Singh U, Rani A, Mehrotra S. Ultrasonographic measurement of placental thickness and its correlation with gestational age – A cross sectional ultrasonographic study. Int J Adv Res 2014;2:354-60.
36. Baghel P, Bahel V, Rashmi Paramhans PS, Onkar S. Correlation of placental thickness estimated by – Ultrasonography with gestational age and fetal outcome. Indian J Neonat Med Res 2015;3:19-24.
37. La Torre R, Nigro G, Manuela Mazzocco M, Best SP. The ultrasonic changes in the maturing placenta. Am J Obstet Gynecol 1979;42:915.
38. Kapoor A, Dudhat MD. Sonographic evaluation of placental thickness – An indicator of gestational age. J Evid Based Med Healthc 2016;3:305-10.
39. Ravi N. Correlative study of placental thickness with respect to the gestational age and fetal weight by ultrasonological evaluation. J Evol Med Dent Sci 2013;2:3262-75.
40. Durnwald C, Mercer B. Ultrasonographic estimation of placental thickness with advancing gestational age. Am J Obstet Gynecol 2004;191:S178.
41. Lee AJ, Bethune M, Hiscock RJ. Placental thickness in the second trimester: A pilot study to determine the normal range. J Ultrasound Med 2012;31:213-8.
42. Adhikari R, Deka PK, Chettri PK. Ultrasonographic evaluation of placental thickness in normal singleton pregnancies for estimation of gestational age. Int J Med Imaging 2015;3:143-7.
43. Adeyekun AA, Ikubor JE. Relationship between two – Dimensional ultrasound measurement of placental thickness and estimated fetal weight. Sahel Med J 2015;18:4-8.
44. Habib FA. Prediction of low birth weight infants from ultrasound measurement of placental diameter and placental thickness. Ann Saudi Med 2002;22:312-4.
45. Kunlmann RS, Warsof S. Ultrasound of the placenta. Clin Obstet Gynecol 1996;39:519-34.