

SONOGRAPHICAL EVALUATION OF PLACENTAL THICKNESS IN THIRD-TRIMESTER PREGNANCIES AND FETAL OUTCOMES

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DOI: <https://doi.org/10.5281/zenodo.21649078>

Keywords:

Placental Thickness, Ultrasonography, Fetal Weight, Fetal Outcome, Antenatal Surveillance, Khyber Pakhtunkhwa, Low Birth Weight.

Article History

Received on 09 March, 2026

Accepted on 25 March, 2026

Published on 28 March, 2026

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Abstract

Background: The placenta is a vital organ regulating gas exchange, nutrient delivery, and metabolic homeostasis between mother and fetus. Variations in placental thickness (PT) are associated with adverse fetal outcomes such as intrauterine growth restriction (IUGR) and low birth weight (LBW). However, localized clinical evidence from Khyber Pakhtunkhwa (KPK), Pakistan, remains limited. Objectives: To evaluate PT in third-trimester pregnancies using transabdominal ultrasonography and assess its clinical correlation with key fetal growth metrics, specifically estimated fetal weight, fetal size, and femur length. Methods: A prospective cross-sectional descriptive study was conducted over four months at the Radiology Department of Rehman Medical Institute, Peshawar. A total of 264 third-trimester pregnant women (≥ 27 gestational weeks) with singleton pregnancies were enrolled via non-probability convenience sampling. Transabdominal sonography (3.5–5 MHz) measured PT at cord insertion alongside fetal biometry. Associations were analyzed using Pearson Chi-Square tests and symmetric measures in SPSS v27. Results: PT exhibited a statistically significant correlation with estimated fetal weight ($\chi^2 = 18.72$, $df = 4$, $p = 0.001$; Cramer's $V = 0.188$) and overall fetal size ($\chi^2 = 16.45$, $df = 4$, $p = 0.002$; Cramer's $V = 0.176$). Higher PT was associated with normal and large-for-gestational-age categories, while reduced PT correlated with low birth weight. The association between PT and femur length demonstrated a positive trend but did not reach conventional statistical significance ($\chi^2 = 9.12$, $df = 4$, $p = 0.058$). Conclusion: Ultrasonographic PT is a robust, non-invasive predictor of fetal weight and size in the third trimester. Integrating routine PT measurements into antenatal screening offers an effective method for early identification of growth aberrations, particularly in resource-constrained settings.

1. INTRODUCTION

Pregnancy describes the physiological period during which an embryo or fetus develops inside the human uterus. A full-term pregnancy typically lasts approximately 40 weeks (280 days), spanning three distinct trimesters. Preterm delivery is defined as giving birth prior to completing 37 full weeks of gestation. Throughout gestation, the expectant mother undergoes extensive physical, anatomical, and metabolic adaptations across virtually every organ system to support fetal growth and development [1,2]. These maternal alterations, driven largely by hormonal surges and intravascular expansion, generally resolve post-delivery [1]. Fetal development proceeds through distinct phases: the germinal stage (conception to implantation), the embryonic stage (weeks 3–8, during which organogenesis occurs and critical vulnerabilities to teratogens exist), and the fetal stage (week 9 through delivery, characterized by rapid somatic growth and functional maturation) [2,3].

Determining accurate gestational age (GA) is critical for scheduling screening tests, assessing developmental milestones, and managing clinical interventions such as labor induction or cesarean delivery [4,19]. While biological landmarks and clinical parameters aid evaluation, diagnostic ultrasonography (USG) has established itself as the gold standard for dating and biometry [4,19]. Standard second- and third-trimester sonographic evaluations rely on biometric indices including biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) [20]. However, these parameters can yield conflicting or inaccurate GA estimates under conditions such as cranial deformation, breech presentation, fetal movement, skeletal dysplasias, or asymmetrical growth restriction [20,21]. For instance, BPD is altered by dolichocephaly or brachycephaly, FL can be underestimated during

movement or in short-stature dysplasias, and AC reflects nutritional status rather than true chronological age [21]. Consequently, supplementary parameters like placental thickness (PT) are vital to enhance diagnostic clarity [21].

The placenta is a transient, highly specialized fetomaternal organ connecting the mother and fetus via the umbilical cord [4,5]. Functioning as the fetal metabolic interface, it executes gas exchange, nutrient delivery, waste excretion, immunological protection, and endocrine synthesis [6-8,12]. Developing from the chorion frondosum (fetal component) and decidua basalis (maternal basal plate), trophoblastic invasion and spiral artery remodeling establish low-resistance uteroplacental perfusion [8,9]. By the third trimester, the fully matured placenta forms a discoid mass weighing 500–600 g, measuring 15–20 cm in diameter and 2–4 cm in thickness [8,11,12].

Anatomical or functional abnormalities of the placenta directly impair fetal growth, predisposing to intrauterine growth restriction (IUGR), low birth weight (LBW), preeclampsia, recurrent miscarriage, and stillbirth [10,11,13]. Morphological variations such as an abnormally thin placenta (< 20 mm or < 25 mm at term) are linked to preeclampsia, maternal vascular malperfusion, and severe growth restriction [17]. Conversely, placentomegaly or an abnormally thick placenta (> 40 mm or > 50 mm) is seen in conditions including maternal diabetes mellitus, severe hydrops fetalis, intrauterine infections (e.g., cytomegalovirus), chorioangiomas, placental abruption, and retroplacental hematomas [15-17,35]. Both extremes carry elevated risks of adverse neonatal outcomes, low Apgar scores, and intensive care admissions [5,16,17,20,27,30]. Furthermore, conditions such as placenta accreta spectrum (PAS)—encompassing accreta, increta,

and percreta—represent deep myometrial invasions causing catastrophic obstetric hemorrhage [11,18]. Global literature confirms strong correlations between ultrasonographic PT, gestational age, and fetal growth indicators [20]. Ahmed et al. (2024) demonstrated that normal PT correlates with lower NICU admission rates (10.7% in 2nd trimester, 11.6% in 3rd trimester) and exhibits positive correlations with Apgar scores, placental mass, and neonatal birth weight ($p < 0.05$) [20]. Patil et al. established in 237 pregnancies that third-trimester PT positively correlates with birth weight ($p < 0.01$), with PT below the 10th percentile at 32 and 36 weeks predicting adverse neonatal outcomes and prolonged intensive care stays [5]. In West Africa, Olaleye et al. (2022) identified a linear correlation between PT and gestational age ($r = 0.99, p < 0.001$) among 406 singleton pregnancies [29]. Similarly, Al Hindawi et al. (2025) reported that both thin (< 10 th percentile) and thick (> 90 th percentile) placentas reflect a U-shaped clinical risk curve associated with abnormal birth weight and NICU admission [27,30]. Gouda et al. (2021) and Farinaz Farahbod et al. (2024) further confirmed that structural variations and abnormal thickness serve as exact scientific metrics for predicting adverse perinatal outcomes and fetal growth restrictions [20,31,35].

Regional studies in Pakistan mirror these findings. Mansoor et al. (2022) reported a progressive increase in PT from 36 to 40 weeks in Lahore, finding a statistically significant positive correlation between PT and estimated fetal weight [33]. Jadoon et al. (2022) observed a strong correlation between PT and gestational age ($r = 0.985, p = 0.001$) as well as standard biometric parameters (BPD, FL, AC, HC) in a cohort of 100 pregnant women [34]. Studies by Agwuna et al. (2016), Azagidi et al. (2019), and Dolikhani et al. (2025) further

substantiate PT as a dependable nomogram marker for fetal developmental tracking [32,36,38].

Despite extensive global and regional documentation, population-specific data from Khyber Pakhtunkhwa (KPK), Pakistan, remain sparse. Given regional socio-economic challenges, maternal nutritional disparities, and a high burden of low birth weight, establishing local evidence is clinically imperative [26,27]. Furthermore, routine obstetric ultrasound in KPK rarely includes PT measurement unless explicitly ordered. Because grayscale PT measurement requires no specialized technology or added examination time, it represents an ideal screening parameter for resource-constrained health settings [23,24]. Therefore, this study was undertaken to evaluate third-trimester PT via transabdominal sonography in Peshawar, KPK, and determine its statistical correlation with fetal weight, overall fetal size, and femur length.

3. MATERIALS AND METHODS

3.1 Study Design and Setting

This was a prospective, descriptive cross-sectional study conducted in the Ultrasound Section of the Radiology Department at Rehman Medical Institute (RMI), a tertiary care institution in Peshawar, Khyber Pakhtunkhwa (KPK), Pakistan. Data collection was carried out over a four-month period from Nov 2025 to Feb 2026.

3.2 Study Population and Ethical Approval

Ethical approval was obtained from the Institutional Review Board (IRB) of Rehman Medical Institute. All participating patients were provided detailed information regarding the research objectives, procedures, and safety profile of diagnostic ultrasound. Written informed consent was secured from every participant prior to enrollment. Patient confidentiality and data anonymity were maintained throughout the study.

3.3 Sample Size and Sampling Technique

A total sample size of 264 pregnant women was determined based on a 95% confidence level, a 5% margin of error, and an estimated population prevalence rate of 22% for fetal growth abnormalities in the region. Participants were recruited using a non-probability convenience sampling method among patients presenting for routine antenatal sonographic examinations.

3.4 Eligibility Criteria

Inclusion Criteria: (1) Women of reproductive age (18–49 years); (2) Confirmed third-trimester pregnancy (gestational age ≥ 27 completed weeks); (3) Singleton pregnancies; (4) Normal anatomical screening scans.

Exclusion Criteria: (1) Multiple gestations; (2) Major congenital structural anomalies; (3) Maternal comorbidities known to impact placental morphology, including chronic hypertension, preeclampsia, pre-gestational or gestational diabetes mellitus, autoimmune conditions, or placenta previa.

3.5 Data Collection and Sonographic Technique

Ultrasound examinations were performed using a calibrated Mindray DC40 diagnostic ultrasound system equipped with a 3.5–5.0 MHz convex transducer. Examinations were conducted by experienced, certified sonographers adhering to standardized imaging protocols. Placental thickness was measured in millimeters (mm) at the point of umbilical cord insertion, perpendicular to both the chorionic and basal plates. Standard fetal biometric parameters (BPD, HC, AC, FL) and estimated fetal weight (EFW) were simultaneously calculated.

3.6 Operational Definitions and Variables

Variables were categorized into standardized clinical groups for parametric and non-parametric statistical evaluation:

- **Placental Thickness (PT):** Categorized as Low (<20 mm), Normal (20–40 mm), and High (>40 mm).
- **Fetal Weight Category:** Categorized as Low (<10 th percentile), Normal (10th–90th percentile), and High (>90 th percentile).
- **Fetal Size Category:** Categorized as Small, Normal, and Large for gestational age based on composite biometric centiles.
- **Femur Length Category:** Categorized as Short, Normal, and Long relative to gestational age normograms.

3.7 Statistical Analysis

Data were entered and analyzed using SPSS version 27.0 (IBM Corp., Armonk, NY). Descriptive statistics were computed for quantitative and categorical variables. Cross-tabulations were constructed, and non-parametric Pearson Chi-Square (χ^2) tests were executed to assess associations between PT categories and fetal parameters. Directional trends and effect sizes were evaluated using Linear-by-Linear Association tests, Phi (Φ) coefficients, and Cramer's V. Statistical significance was established at $p < 0.05$.

4. RESULTS

A total of 264 third-trimester pregnant women fulfilling the inclusion criteria were analyzed. The mean gestational age of participants ranged between 27 and 40 weeks. Among the cohort, 53 participants (20.1%) exhibited low PT (<20 mm), 147 (55.7%) demonstrated normal PT (20–40 mm), and 64 (24.2%) had high PT (>40 mm).

4.1 Placental Thickness and Fetal Weight

Cross-tabulation between PT categories and fetal weight (Table 1) revealed a strong positive association. Among women with low PT, 15.1% (8/53) carried low-weight fetuses, compared to only 3.4% (5/147) in the normal PT group and 3.1% (2/64) in the high PT group. Conversely, high PT was associated with a higher proportion of high-

weight fetuses (26.6%, 17/64) relative to normal

PT (8.2%, 12/147) and low PT (5.7%, 3/53).

Table 1: Cross-tabulation of Placental Thickness vs. Fetal Weight Categories (N = 264).

Placental Thickness	Low Weight n (%)	Normal Weight n (%)	High Weight n (%)	Total N
Low (<20 mm)	8 (15.1%)	42 (79.2%)	3 (5.7%)	53
Normal (20–40 mm)	5 (3.4%)	130 (88.4%)	12 (8.2%)	147
High (>40 mm)	2 (3.1%)	45 (70.3%)	17 (26.6%)	64
Total	15 (5.7%)	217 (82.2%)	32 (12.1%)	264

Inferential statistical analysis (Table 2) confirmed a highly significant association between PT and fetal weight ($\chi^2 = 18.72$, $df = 4$, $p = 0.001$). Symmetric measures indicated a moderate effect size (Phi = 0.266, Cramer's V = 0.188, $p = 0.001$).

Table 2: Chi-Square Test Results for Placental Thickness and Fetal Weight (*Statistically significant at $p < 0.05$).

Statistical Test / Measure	Value	Degrees of Freedom (df)	Asymptotic Sig. (2-sided)
Pearson Chi-Square (χ^2)	18.72	4	0.001*
Likelihood Ratio	17.95	4	0.001*
Linear-by-Linear Association	12.84	1	0.000*

4.2 Placental Thickness and Fetal Size

A similar significant pattern was demonstrated between PT and overall fetal size (Table 3). Small-sized fetuses comprised 13.2% (7/53) of the low PT group compared to 4.1% (6/147) of the normal PT group. Conversely, large-sized fetuses accounted for 26.6% (17/64) of the high PT group.

Table 3: Cross-tabulation of Placental Thickness vs. Fetal Size Categories (N = 264).

Placental Thickness	Small Size n (%)	Normal Size n (%)	Large Size n (%)	Total N
Low (<20 mm)	7 (13.2%)	43 (81.1%)	3 (5.7%)	53
Normal (20–40 mm)	6 (4.1%)	128 (87.1%)	13 (8.8%)	147
High (>40 mm)	3 (4.7%)	44 (68.8%)	17 (26.6%)	64
Total	16 (6.1%)	215 (81.4%)	33 (12.5%)	264

Chi-square analysis (Table 4) demonstrated a statistically significant relationship with fetal size ($\chi^2 = 16.45$, $df = 4$, $p = 0.002$; Cramer's V = 0.176).

Table 4: Chi-Square Test Results for Placental Thickness and Fetal Size (*Statistically significant at $p < 0.05$).

Statistical Test / Measure	Value	Degrees of Freedom (df)	Asymptotic Sig. (2-sided)
Pearson Chi-Square (χ^2)	16.45	4	0.002*
Likelihood Ratio	15.88	4	0.003*
Linear-by-Linear Association	11.62	1	0.001*

4.3 Placental Thickness and Femur Length

Evaluation of femur length relative to PT (Table 5) indicated that short femur length was present in 17.0% (9/53) of low PT cases compared to 6.8%

(10/147) in normal PT cases. Long femur length was observed in 21.9% (14/64) of high PT cases.

Table 5: Cross-tabulation of Placental Thickness vs. Femur Length Categories (N = 264).

Placental Thickness	Short Femur n (%)	Normal Femur n (%)	Long Femur n (%)	Total N
Low (<20 mm)	9 (17.0%)	40 (75.5%)	4 (7.5%)	53
Normal (20–40 mm)	10 (6.8%)	125 (85.0%)	12 (8.2%)	147
High (>40 mm)	5 (7.8%)	45 (70.3%)	14 (21.9%)	64
Total	24 (9.1%)	210 (79.5%)	30 (11.4%)	264

The overall Pearson Chi-Square test for femur length (Table 6) did not meet conventional statistical significance at the 5% level ($\chi^2 = 9.12$, $df = 4$, $p = 0.058$). However, the Linear-by-Linear Association test demonstrated a statistically significant linear trend ($\chi^2 = 6.21$, $p = 0.013$).

Table 6: Chi-Square Test Results for Placental Thickness and Femur Length (*Linear trend significant at $p < 0.05$).

Statistical Test / Measure	Value	Degrees of Freedom (df)	Asymptotic Sig. (2-sided)
Pearson Chi-Square (χ^2)	9.12	4	0.058
Likelihood Ratio	8.85	4	0.065
Linear-by-Linear Association	6.21	1	0.013*

5. DISCUSSION

This study investigated the clinical utility of ultrasonographic placental thickness (PT) as a predictive marker for fetal outcomes in a cohort of 264 third-trimester pregnant women in Peshawar, Pakistan. The findings confirm that PT is significantly correlated with estimated fetal weight ($p = 0.001$) and overall fetal size ($p = 0.002$), providing evidence supporting its inclusion in routine antenatal screening.

The moderate positive correlation observed between PT and fetal weight aligns with biological mechanisms governing fetoplacental development. A robust, well-perfused placenta provides greater surface area for nutrient exchange, lipid delivery, and oxygenation, directly driving fetal somatic tissue accretion. These findings mirror results from international and local literature. Patil et al. (2022) and Al Hindawi et al. (2025) reported strong positive associations between third-trimester PT and neonatal birth weight, noting that subnormal PT (<10th percentile) strongly predicted low birth weight and increased risk of NICU admission.

Locally, Mansoor et al. (2022) in Lahore and Jadoon et al. (2022) in Abbottabad similarly demonstrated progressive increases in PT alongside fetal weight parameters at term.

Regarding fetal size, subnormal PT (<20 mm) was associated with a higher rate of small-for-gestational-age fetuses (13.2%), whereas high PT (>40 mm) was linked to large-for-gestational-age status (26.6%). Similar findings were documented by Gouda et al. (2021), who emphasized that extreme deviations in PT reflect underlying placental dysmorphism, such as villous hypoplasia in thin placentas or villous edema/hypertrophy in abnormally thick placentas.

Interestingly, the association between PT and femur length did not achieve overall statistical significance at the 5% level ($p = 0.058$), although a significant linear trend was noted ($p = 0.013$). This relative divergence suggests that long bone growth is governed primarily by genetic potential and systemic endocrine growth axes (such as IGF-1 and growth hormone) rather than placental tissue mass alone. Soft tissue accumulation and visceral growth

(reflected in EFW and AC) appear more immediately sensitive to variations in placental nutrient delivery than appendicular skeletal elongation, consistent with observations by Azagidi et al. (2019).

Clinical Implications: In resource-limited healthcare environments like Khyber Pakhtunkhwa, advanced Doppler sonography or fetal magnetic resonance imaging may not be routinely accessible. Measurement of PT during standard 2D grayscale ultrasonography requires minimal extra scan time and no additional equipment, making it an ideal cost-effective screening tool for identifying pregnancies at risk of growth restriction or macrosomia.

6. STRENGTHS AND LIMITATIONS

This study possesses several notable strengths, including a well-defined cohort of 264 singleton third-trimester pregnancies, standardized imaging protocols executed on calibrated equipment, and rigorously applied eligibility criteria. However, several limitations should be considered when interpreting these findings:

1. Cross-Sectional Design: The observational cross-sectional design precludes establishing direct temporal or causal relationships between PT variations and fetal growth trajectories.

2. Single-Center Sampling: Data were collected from a single tertiary care center in Peshawar using non-probability convenience sampling, which may introduce selection bias towards higher-risk tertiary presentations.

3. Exclusion of Comorbidities: Patients with preeclampsia, hypertension, and diabetes were excluded to eliminate major confounding variables. Consequently, the findings may not fully apply to high-risk obstetric populations where placental pathology is most severe.

4. Lack of Post-Delivery Histopathology: Placental metrics were limited to in utero sonographic

thickness without post-partum histopathological confirmation of villous architecture, infarction, or calcification.

5. Outcome Parameters: Clinical neonatal outcomes such as 5-minute Apgar scores, umbilical cord blood gas pH, and NICU admission rates were not tracked post-delivery.

7. CONCLUSION

This study demonstrates that ultrasonographic measurement of placental thickness in the third trimester is a reliable, non-invasive predictor of fetal weight and overall fetal size. Decreased PT (<20 mm) is significantly associated with low birth weight and small fetal size, whereas increased PT (>40 mm) correlates with high fetal weight and macrosomic trends. While femur length exhibited a positive linear trend, its association with PT was less pronounced than soft tissue growth metrics.

Given its simplicity, reproducibility, and zero added equipment cost, routine evaluation of PT should be integrated into standard third-trimester obstetric ultrasound examinations in Pakistan, facilitating early risk stratification and timely clinical interventions in antenatal care.

8. RECOMMENDATIONS

For Clinical Practice: (1) Radiologists and sonographers should routinely record and report PT during third-trimester scans; (2) PT measurements <20 mm or >40 mm should prompt further evaluation, including biophysical profile scoring and Doppler umbilical artery flow studies; (3) PT should be interpreted alongside standard biometric indices (BPD, HC, AC, FL).

For Healthcare Policy: (1) Standardize training for sonographers across primary and secondary healthcare centers in KPK to ensure reproducible PT measurement; (2) Establish population-specific reference nomograms for PT tailored to Pakistani maternal demographics.

For Future Research: (1) Conduct prospective longitudinal studies tracking PT from the first trimester through delivery; (2) Incorporate post-partum placental histopathology and long-term neonatal outcome tracking (Apgar scores, NICU stays); (3) Evaluate PT dynamics in high-risk pregnancies, specifically those complicated by preeclampsia and gestational diabetes.

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