

Accuracy of Fetal Cerebellar Measurement in Predicting Gestational Age

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ABSTRACT

Background: An accurate prediction is the base of the correct decision regarding delivery management and delivery date. Conventionally biparietal diameter, head circumference, femur length, and abdominal circumference are utilized for gestational age estimation. Transverse cerebellar diameter (TCD) measurement has emerged as a reliable alternative, especially when the LMP is unknown.

Objective: To determine the predictive accuracy of transverse cerebellar diameter in determining gestational age taking the last menstrual period as the gold standard.

Methodology: This cross-sectional study was performed in the Radiology Department of CMH Bahawalpur from July 2022 to December 2022. After obtaining informed consent, an Ultrasound examination was performed to measure femur length (FL), biparietal diameter (BPD) and transverse cerebellar diameter. TCD, BPD and FL were measured according to the standard planes. Data analysis was conducted using SPSS version 25. Predictive accuracy was assessed using a regression model based on the squared correlation (R^2) between predicted age and estimated gestational age based on the last menstrual period.

Results: The mean maternal age was 30.26 ± 5.88 years and the mean gestational age was 24.62 ± 4.65 weeks based on the last menstrual period. Fetal measurements including FL ($\beta=3.511, 3.376-3.647$), BPD ($\beta=2.357, 95\% \text{ CI: } 2.267-2.447$), TCD ($\beta=0.382, 0.367-0.397$) and predicted age according to TCD ($\beta=0.948, 0.909-0.988$) revealed a significant relationship with gestational age based on LMP with R^2 values ranging from 0.910 to 0.922 ($p < 0.001$).

Conclusion: This study showed a strong correlation between transverse cerebellar diameter and gestational age based on LMP.

Keywords: Gestational age, TCD, LMP, fetal parameters, pregnancy management, obstetric ultrasound.

INTRODUCTION

An accurate prediction is the base of the correct decision regarding delivery management and delivery date. The consequences of miscalculated gestational age include an increased risk of preterm birth or post-date pregnancy [1-4]. Conventionally biparietal diameter, head circumference, femur length, and abdominal circumference are utilized for gestational age estimation. The inconsistency in the determination of the gestational age with these parameters increases with the duration of the pregnancy [5-7].

Transverse cerebellar diameter (TCD) measurement has emerged as a reliable alternative, especially when the last menstrual period (LMP) is unknown. The fetal cerebellum can be visualized in the posterior fossa of the fetal skull as early as 10-11th week and its diameter shows a linear relationship with the gestational age from the second trimester. It can be used for gestational age assessment even in late pregnancy [8-10]. In a study by Ebeisy *et al.*, TCD had 98.7% accuracy in the early second trimester, 91.6% in the late second trimester 82% in the early third trimester, and 68.1% in the late

third trimester [11]. In a study by Alalfy *et al.*, the transcerebellar diameter (0.43 mm) was examined in comparison with biparietal diameter (1.27 mm), head circumference (1.0 mm), abdominal circumference (1.56 mm), and femur length (1.28 mm) and concluded that discrepancy between menstrual and sonographic gestational ages was the least when measured with TCD [12].

This study aimed to determine the predictive accuracy of transverse cerebellar diameter in determining gestational age taking the LMP as the gold standard. This provided a valuable tool for obstetricians to determine accurate gestational age for fetal care and management of the pregnancy.

METHODOLOGY

This cross-sectional study was conducted at the Radiology Department of CMH Bahawalpur from July 2022 to December 2022 after approval from the hospital ethical committee. A total of 227 patients were included through non-probability consecutive sampling after calculating the sample size keeping a 95% confidence interval, 5% margin of error and anticipated accuracy of TCD at 82% [11].

Non-lactating pregnant women aged 20-40 years, with a regular menstrual cycle and a singleton pregnancy between 16 and 32 weeks of gestation, who attended the

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antenatal outpatient department for routine ultrasound examination, were included in the study. Participants had not used hormonal contraception before this pregnancy and were certain of the first day of their last menstrual period (LMP).

Patients with no medical comorbidities, such as diabetes, hypertension, or cardiac disease, those unsure of their dates, as well as those with fetal anomalies, intrauterine death, or multiple gestations, were excluded from the study.

After obtaining written consent from the patients. The ultrasound examination was performed using the Canon Xario 100G Doppler USG machine. The TCD measurement was measured by gradually rotating the transducer horizontally in the axial plane through the posterior fossa including the midline thalamus, cerebellar hemisphere and cisterna magna (**Fig. 1**). The widest diameters of the cerebellum were obtained by placing on-screen callipers at the outer margins of the cerebellum. Predicted gestational age by TCD was calculated using published validated nomogram.

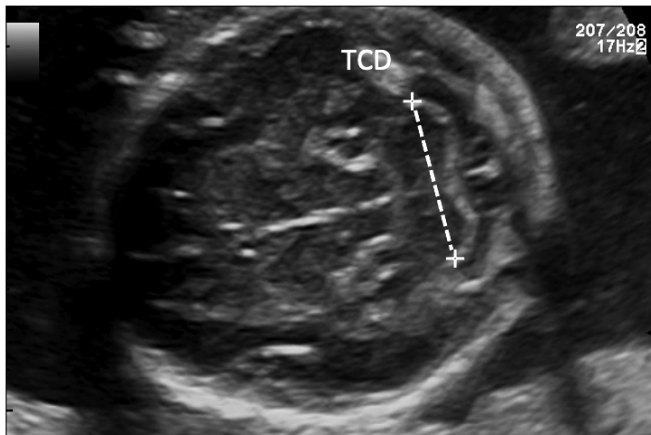


Fig. (1): Ultrasound axial image of the fetal head for measuring transverse cerebellar diameter.

The biparietal diameter was measured in the axial plane of the fetal head at the level of thalami and cavum septum pellucidum. Femur length was measured on the long axis of the femur including femoral diaphysis from end to end and excluding the epiphysis. Gestational age by BPD and FL was calculated by the ultrasound machine based on Hadlock tables [13].

The data was analyzed using the Statistical Package for Social Sciences version 25. The categorical variables have been presented as frequency and percentages. The numerical variables have been presented as mean and standard deviation. BPD, FL, and TCD were correlated with gestational age using regression analysis. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

The mean maternal age was 30.26 ± 5.88 years (median: 30 years, range: 20 to 40 years). In terms of gravidity, 29.1% were primigravida, 24.2% had a second pregnancy, 31.3% women had a third pregnancy, and 15.4% fourth pregnancy. The educational level of the women varied widely: 23.1% had completed only primary school, whereas 63.7% had attended secondary school. Regarding income level, the majority of women belonged to the middle-income class and were housewives (**Table 1**).

Table 1: Demographic overview of the study population.

Demographic Variables	Category	Frequency n (%)
Age	20-25 years	61 (26.9)
	26-30 years	58 (25.6)
	31-35 years	56 (24.7)
	36-40 years	52 (22.9)
Gravidity	Primigravida	66 (29.1)
	Gravida 2	55 (24.2)
	Gravida 3	71 (31.3)
	Gravida 4	35 (15.4)
Parity	Parity 1	55 (24.2)
	Parity 2	71 (31.3)
	Parity 3	35 (15.4)
Education level	Primary school	54 (23.1)
	Secondary school	152 (63.7)
	Bachelor's degree	18 (7.5)
	Master's degree	3 (1.3)
Family size	Women with 1 Child	10 (4.2)
	Women with 2 Children	65 (27.0)
	Women with 3 Children	83 (34.6)
	Women with 4 Children	39 (16.3)
	Women with 5 Children	30 (12.5)
Income level	Low income	95 (39.6)
	Middle income	110 (45.8)
	High income	22 (9.2)
Occupation	Housewives	203 (84.6)
	Employed (Jobians)	24 (9.9)
Linguistic Background	Punjabi	52 (21.7)
	Siraiki	65 (27.0)
	Urdu	21 (8.7)
	Pashto	77 (31.9)
	Sindhi	12 (5.0)

The mean gestational age according to the last menstrual period was 24.62 ± 4.65 weeks (median: 24.40 weeks, range: 17.10 to 33 weeks). The mean FL was 4.24 ± 1.27 cm (median: 4.30 cm, range: 1.90 to 6.60 cm), the mean BPD was 6.32 ± 1.89 cm (median: 6.40 cm, range: 2.80 to 9.80 cm) and the mean TCD was 38.63 ± 11.65 mm (median: 38.67 mm, range: 16.93 to 61.19 mm). The predicted age according to TCD was 25.14 ± 4.67 weeks (median: 25.15 weeks, range: 16.13 to 35.30 weeks). The gestational age based on the last menstrual period and the predicted

Table 2: Stratification of gestational age (LMP) and predicted gestational age (TCD) according to maternal age groups, gravidity, and parity.

Parameter		N (%)	Gestational Age (LMP) Mean ± SD	Predicted Age (TCD) Mean ± SD
Maternal Age	20-25 years	61 (26.9)	23.96±4.27 weeks	24.50±4.31 weeks
	26-30 years	58 (25.6)	24.97±4.77 weeks	25.50±4.88 weeks
	31-35 years	56 (24.7)	24.31±4.83 weeks	24.70±4.87 weeks
	36-40 years	52 (22.9)	25.36±4.75 weeks	25.96±4.62 weeks
Gravidity	1	66 (29.1)	24.52±4.85 weeks	25.04±4.82 weeks
	2	55 (24.2)	24.39±4.60 weeks	24.99±4.33 weeks
	3	71 (31.3)	25.01±4.46 weeks	25.71±4.65 weeks
	4	35 (15.4)	24.41±4.87 weeks	24.39±5.05 weeks
Parity	1	55 (24.2)	24.39±4.60 weeks	24.99±4.33 weeks
	2	71 (31.3)	25.01±4.46 weeks	25.71±4.65 weeks
	3	35 (15.4)	24.41±4.87 weeks	24.39±5.05 weeks

age according to TCD have been compared across different categories, including maternal age, gravidity, and parity (Table 2).

The regression analysis showed a significant relationship between the gestational age based on the last menstrual period and other fetal measurements *i.e.*, femur length, biparietal diameter, transverse cerebellar diameter, and predicted age based on these measurements was strongly correlated with gestational age ($R^2=0.921, 0.922, 0.918$ and 0.910 respectively) (Table 3, Fig. 2).

Table 3: Regression analyses: Gestational age based on the LMP & fetal measurements.

Variables	R ²	Beta Coefficients	95% CI	p-value
Femur Length	0.921	3.511	3.376-3.647	<0.001
Biparietal Diameter	0.922	2.357	2.267-2.447	<0.001
Transverse Cerebellar Diameter	0.918	0.382	0.367-0.397	<0.001
Predicted Age according to TCD	0.910	0.948	0.909-0.988	<0.001

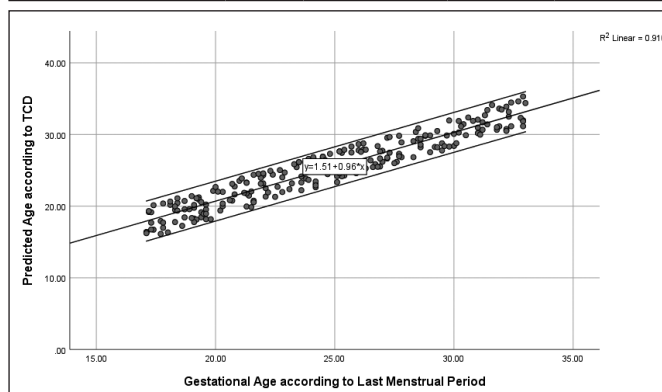


Fig. (2): Scatter plot: Age based on the LMP and predicted age according to TCD.

DISCUSSION

The results of our study show that there are strong and significant correlations between fetal measurements and gestational age. With R^2 values ranging from 0.910 to 0.922, the regression models exhibited a high degree of correlation. Our study and the study conducted by Prasad *et al.* [14] share several similarities in their findings regarding the accuracy of TCD for estimating gestational age which reported a high accuracy of transverse cerebellar diameter with an R-square value of 0.989 ($p < 0.001$), while our study shows that TCD, biparietal diameter, and femur length had R-squared values (0.918, 0.922, and 0.921 respectively). Both studies have shown that TCD can serve as an alternate parameter for predicting gestational age. The findings of our study and those of George *et al.* [15] highlight the robustness and accuracy of fetal parameters particularly TCD as valuable tools for estimating gestational age in the clinical setting as they found strong correlations between gestational age and each parameter, with high R-square values ranging from 0.991 to 0.995 ($p < 0.001$) which is similar to our findings.

The results of our study are also comparable to the study conducted by Adeyekun *et al.* [16] reporting TCD values varying from 11.9 mm to 59.7 mm and yielded a higher accuracy value of $96.9\% \pm 12$ days for TCD compared to biparietal diameter and abdominal circumference. In a study by Ebeisy *et al.*, TCD had 98.7% accuracy in the early second trimester, 91.6% in the late second trimester, 82% in the early third trimester, and 68.1% in the late third trimester [11]. In a study by Alalfy *et al.*, the transcerebellar diameter (0.43 mm) was examined in comparison with biparietal diameter (1.27 mm), head circumference (1.0 mm), abdominal circumference (1.56 mm), and femur length (1.28 mm) and concluded that discrepancy between

menstrual and sonographic gestational ages was the least when measured with TCD [12]. The results of this study indicate that TCD can be a more reliable parameter for the estimation of the gestational age compared to other fetal measurements, especially in the third trimester or when the differences between menstrual and sonographic gestational ages are taken into account.

Mishra *et al.* [17] demonstrated a statistically significant relationship between TCD and gestational age reporting a similar R^2 value with our study (R^2 value of 0.92) hence confirming it as a reliable prediction factor. In the same way, Reddy *et al.* [18] found a high correlation coefficient of 0.997 between TCD and gestational age in the 15-28 week period. Reece *et al.* [19] ultrasonography study reported a significant correlation between TCD, biparietal diameter, head circumference, and gestational age that highlighted the importance of TCD as a reliable and accurate measure even in the case of variations of fetal head shape. Patil *et al.* [20] reported strong evidence of the direct relationship between gestational age and TCD, while Ravindernath *et al.*'s [21] findings also confirmed the significant correlation between TCD and other parameters used for gestational age estimation. These researches highlight the role of TCD as paramount in the accurate prediction of fetal gestational age and fetal growth.

LIMITATIONS OF THE STUDY

While efforts were made to minimize bias by performing ultrasound examinations under the supervision of experienced radiologists, the potential for interobserver variability in measurements cannot be entirely ruled out.

CONCLUSION

Estimation of gestational age by TCD shows a strong correlation with the last menstrual period. TCD can be used as a reliable predictor of fetal age offering a valuable tool for prenatal care even in women when LMP is uncertain.

LIST OF ABBREVIATIONS

BPD	Biparietal Diameter
FL	Femur Length
LMP	Last Menstrual Period
TCD	Transverse Cerebellar Diameter

ETHICS APPROVAL

Ethical approval of the study has been granted by the ethical review board (ERB) of CMH Bahawalpur (Approval no. EC-31-2024). All procedures performed in studies involving human participants were following

the ethical standards of the institutional and/ or national research committee and the Helsinki Declaration.

CONSENT FOR PUBLICATION

An informed consent form was signed by the patients presenting in the radiology department.

AVAILABILITY OF DATA

The data set will be available from the corresponding authors upon a reasonable request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORS' CONTRIBUTION

MSN guarantor of integrity of the entire study. MSN and MA generate study concepts and design. NS did literature research, and ST collected data. NS and MA analyze the data. MSN and NS prepared a manuscript. The manuscript was critically reviewed and revised by MA, NS & ST. All authors have read and approved the manuscript.

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