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ULTRASOUND EVALUATION OF FETAL NECK CIRCUMFERENCE FOR ESTIMATING GESTATIONAL AGE IN INDIAN POPULATION

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ABSTRACT

Background: Accurate gestational age (GA) estimation is crucial for antenatal care, especially in India, where early scans are often unavailable. Traditional ultrasound biometry becomes less reliable in late pregnancy due to biological and maternal variation. **Aim:** We evaluated the usefulness of fetal neck circumference (NC) as a sonographic marker for estimating gestational age (GA) in the Indian population and to see how it correlates with other standard fetal biometric parameters across 15-40 weeks of gestation. **Methods:** A cross-sectional observational study was done at MGM Medical College, Indore. A total of 400 pregnant women from 15–40 weeks were enrolled after approval. NC was measured on axial scan at the largest neck level using 2D ultrasound, along with standard biometry (BPD, HC, AC, FL). Pearson correlation and linear regression were used to assess the relationship of NC with GA and other parameters. A nomogram was developed for GA prediction from NC. **Results:** NC showed a strong positive correlation with GA ($R^2 = 0.895$, $p < 0.001$). The regression equation was GA = 0.203 × NC + 2.882. NC also had significant correlation with BPD (r = 0.870), HC (r = 0.863), AC (r = 0.855), and FL (r = 0.835). Comparison with standard dating methods showed strong correlation with dating scan ($R^2 = 0.846$), LMP ($R^2 = 0.842$), and final GA ($R^2 = 0.896$).

Conclusion: NC can serve as a reliable sonographic marker for GA in the second and third trimesters, especially useful where early dating is missed.

Key words: Gestational age, Fetal neck circumference, Biparietal diameter, abdominal circumference, femur length

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Introduction:

Accurate assessment of gestational age (GA) is crucial for effective prenatal care and timely interventions in obstetric practice. (1). Traditional sonographic parameters like Crown-Rump Length (CRL), Biparietal Diameter (BPD), Head Circumference (HC), Abdominal Circumference (AC), and Femur Length (FL) are widely used for GA estimation (2,3). However, their accuracy may decline in the later stages of pregnancy due to variations in fetal growth influenced by genetic, nutritional, or pathological factors (4,5).

Recent research has identified Fetal Neck Circumference (NC) as a promising biometric parameter for GA estimation. NC follows a steady and predictable growth trajectory throughout pregnancy, making it a reliable marker, especially in the second and third trimesters. Advances in two-dimensional (2D) ultrasonography have enabled precise and straightforward measurement of NC, enhancing its clinical utility in estimating GA (6-8).

NC is particularly valuable in pregnancies complicated by fetal growth restriction (FGR), macrosomia, or congenital anomalies, where traditional parameters may be less reliable (9, 10). When used alongside established markers, NC can improve the accuracy of GA determination and aid in the early detection of fetal conditions, including chromosomal abnormalities like Down syndrome, Turner syndrome, and Noonan syndrome (11,12). Standardized protocols for NC measurement can further enhance its reproducibility and clinical applicability, offering a robust tool for fetal assessment and monitoring in routine obstetric care (13,14).

This study aims to develop a fetal Neck Circumference (NC) nomogram to estimate gestational age in the Indian population. The primary objective is to evaluate the application and accuracy of fetal NC measurements in determining the gestational age of the fetus and to analyze its correlation with other biometric parameters. Additionally, the study aims to assist in the early diagnosis of significant fetal growth anomalies during pregnancy, contributing to improved prenatal care and monitoring.

Materials & Methods:

Our study was a hospital-based, time-bound, and cross-sectional observational study done in the Department of Radiodiagnosis of M.G.M. Medical College and M. Y. Hospital, Indore, Madhya Pradesh, India, after getting approval from the ISRB (Institutional Scientific Review Board). The duration of this study was one year from ethics committee clearance. A total of 400 patients referred to our department for antenatal scan between 15 weeks to 40 weeks were included in the study. We conducted an observational study in the Department of Radiodiagnosis, MGM Medical College, Indore, with a total of 400 patients, fulfilling the inclusion criteria.

Pregnant females were referred to the Department of Radiodiagnosis for antenatal scans between 15 to 40 weeks of gestation. Informed consent was obtained after providing a complete description of the study and handing over a patient information document. Following the completion of the necessary formalities under the PC-PNDT Act, obstetric ultrasound examinations were performed. All patients were examined in the supine position using a Philips ClearVue 350 ultrasound machine equipped with a low-frequency transducer (3–5 MHz). The fetus was evaluated for viability and screened for any gross congenital defects. An axial scan was utilized to locate the fetal neck at an angle perpendicular to the cervical spine, and the measurement of Neck Circumference (NC) was performed at the level where the fetal neck appeared largest (Figure 1). (6,13). In addition to NC, routine biometric parameters, including Biparietal Diameter (BPD), Femur Length (FL), Abdominal Circumference (AC), and Head Circumference (HC), were also measured to assess Gestational Age (GA) (9).

Figure 1: Fetal neck circumference measurement.

Statistical analysis:

Data were tabulated in a Microsoft Excel sheet for systematic analysis and further represented in the form of various tables and charts. Statistical analysis was conducted using SPSS software. Key metrics such as mean, standard deviation (SD), and percentiles of Neck Circumference (NC) for each gestational age (GA) were calculated. Pearson correlation analysis was performed to assess the relationship between NC and GA. Furthermore, linear regression analysis was applied to develop a nomogram and explore the correlations between NC and other fetal biometric parameters, including Biparietal Diameter (BPD), Head Circumference (HC), Abdominal Circumference (AC), and Femur Length (FL). (18)

RESULTS:

TABLE 1: Maternal Demographic Characteristics (n = 400)

Variables	Category	Frequency (%)
Age (years)	18–25	153 (38.25%)
	26–30	130 (32.50%)
	Others	117 (29.25%)
Weight (kg)	63–66 kg	117 (29.25%)
	59–62 kg	99 (24.75%)
	67–70 kg	95 (23.75%)
Height (cm)	149–150 cm	108 (27.00%)
	145–146 cm	88 (22.00%)
	151–152 cm	76 (19.00%)
Gravida	G1	76 (19.00%)
	G2	149 (37.25%)
	G3	123 (30.75%)
	G4	52 (13.00%)
BMI Category	Normal	192 (48.00%)
	Underweight	108 (27.00%)
	Overweight	64 (16.00%)
	Obese	36 (9.00%)

TABLE 2: Fetal Neck Circumference Values Across Gestational Age

Gestational Age(weeks)	Frequency (n)	5th Centile (mm)	50th Centile (mm)	95th Centile (mm)	Mean ± SD (mm)
15	4	53.43	55.73	58.03	55.73 ± 1.40
16	1	64.00	64.00	64.00	64.00 ± 0.00
17	5	65.80	69.72	73.64	69.72 ± 2.38
18	1	84.30	84.30	84.30	84.30 ± 0.00
19	6	70.70	82.28	93.86	82.28 ± 7.04
20	17	82.05	88.47	94.89	88.47 ± 3.90
21	28	83.80	92.90	102.00	92.90 ± 5.53
22	24	89.33	99.66	109.99	99.66 ± 6.28
23	17	93.85	102.73	111.61	102.73 ± 5.40
24	11	95.53	107.65	119.77	107.65 ± 7.37
25	12	102.51	115.92	129.33	115.92 ± 8.15
26	9	105.59	117.12	128.65	117.12 ± 7.01
27	10	112.37	121.60	130.83	121.60 ± 5.61
28	9	115.15	125.78	136.41	125.78 ± 6.46
29	16	113.86	128.88	143.90	128.88 ± 9.13
30	17	118.85	134.56	150.27	134.56 ± 9.55
31	34	124.49	140.18	155.87	140.18 ± 9.54
32	31	127.44	141.74	156.04	141.74 ± 8.69
33	33	128.27	145.18	162.09	145.18 ± 10.28
34	36	131.92	148.39	164.86	148.39 ± 10.01
35	43	135.99	152.16	168.33	152.16 ± 9.83
36	21	144.90	159.10	173.30	159.10 ± 8.63
37	12	150.48	168.10	185.72	168.10 ± 10.71
38	2	162.81	173.50	184.19	173.50 ± 6.50
39	3	164.33	180.50	189.41	180.50 ± 7.62
40	2	171.32	185.00	194.46	185.00 ± 7.30

TABLE 3: Pearson Correlation Between Neck Circumference and Standard Biometry

Biometric Parameter	Pearson Correlation (r)	R^2	p-value
Biparietal Diameter (BPD)	0.870	0.757	<0.001
Abdominal Circumference (AC)	0.855	0.733	<0.001
Head Circumference (HC)	0.863	0.745	<0.001
Femur Length (FL)	0.835	0.698	<0.001

TABLE 4a: Regression Statistics Showing Association Between Neck Circumference and Gestational Age

Regression Statistics	Value
Multiple R	0.946
R^2	0.895
Adjusted R^2	0.895
Standard Error	1.879
Observations (n)	400

TABLE 4b: Regression Model Output for Predicting Gestational Age Based on Neck Circumference

ANOVA	df	SS	MS	F	Significance F
Regression	1	12030.127	12030.127	3406.894	<0.001
Residual	398	1405.383	3.531		
Coefficient	SE	t Stat	p-value	95% CI Lower	95% CI Upper
Intercept	2.882	0.458	6.294	<0.001	1.982
Neck Circumference (mm)	0.203	0.003	58.369	<0.001	0.196

Regression Equation: GA = 0.203 × NC + 2.882

TABLE 5: Comparison of Neck Circumference Accuracy with Other Gestational Age Estimation Methods

GA Comparison	Pearson Correlation (r)	R^2
NC vs Dating Scan (USG)	0.9197	0.846
NC vs LMP	0.9178	0.842
NC vs Final Gestational Age	0.9463	0.896

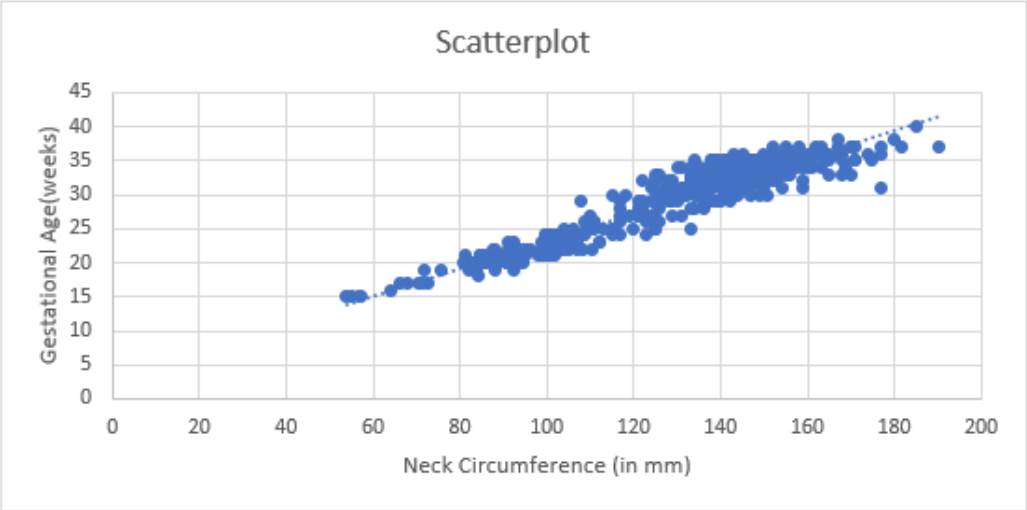

Figure 2: Scatterplot between Gestational age and Neck Circumference

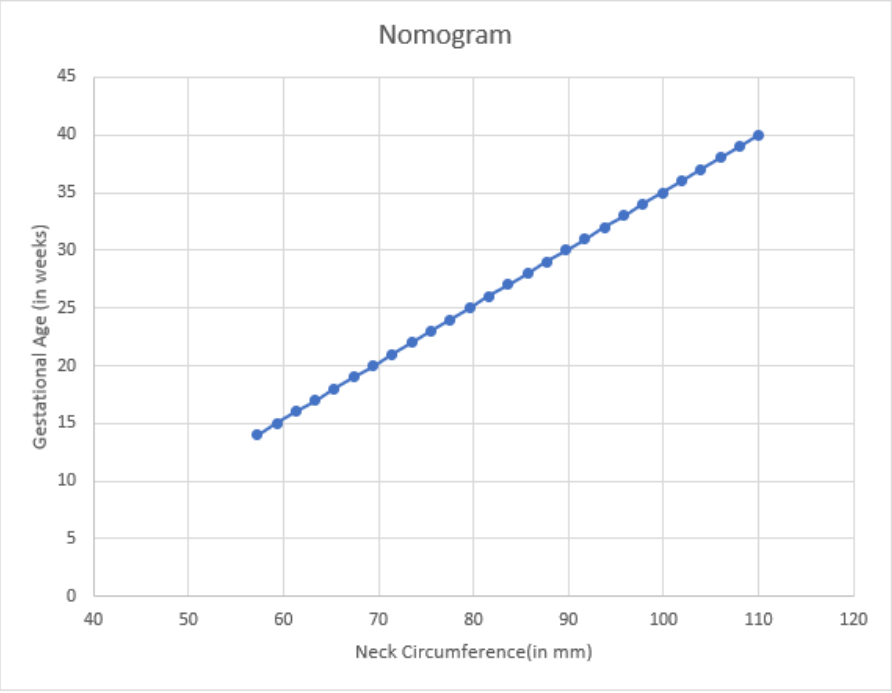

Fig. 3: Nomogram showing the relationship between Neck Circumference and Gestational Age (GA)

Discussion:

Accurate estimation of gestational age (GA) is a very important part of antenatal care. It helps in fetal growth monitoring, timely intervention, and preventing risks of preterm or post-term deliveries. Conventional ultrasound biometry, like biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL), is commonly used for this. But these parameters become less reliable in the second and third trimesters due to biological variation, fetal growth disturbances, and maternal factors (15,16).

In the present study, neck circumference (NC) was evaluated as an alternative marker for GA estimation in the Indian population. Maternal characteristics of the study participants are shown in Table 1. NC showed strong positive correlation with GA (R^2 = 0.895, $p < 0.001$) with regression equation GA = 0.203 × NC + 2.882(Table 4a &b). These results are better than Abdulkadir et al. (R^2 = 0.799) in the Nigerian population and Avci et al. (R^2 = 0.8403) in the Turkish group (13,17). This may suggest a stronger association of NC with GA in Indian fetuses, indicating a population difference.

Fetal neck circumference also increased steadily across gestation, as shown in Table 2. NC also correlated well with other biometrics like BPD (r = 0.870), HC (r = 0.863), AC (r = 0.855), and FL (r = 0.835), all had $p < 0.001$(Table 3). Similar results were shown by Abdulkadir et al., where NC had good correlation with BPD (R^2 = 0.859), FL (R^2 = 0.842), and HC (R^2 = 0.662). This shows NC grows proportionally with other fetal parameters (13).

In late pregnancy, traditional markers like BPD and HC may be affected by head shape anomalies like dolichocephaly and brachycephaly, which reduce accuracy (15). FL may be affected in skeletal dysplasias. NC, being a soft tissue marker, remains stable and less influenced by these. Elashry et al. also showed a similar advantage of posterior cranial markers like transverse cerebellar diameter (TCD) for third-trimester GA estimation (18). NC, being located away from cranial molding zones, shares this stability.

Our study compared NC with standard dating methods. NC showed strong correlation with dating scan (R^2 = 0.846, Table 5), LMP (R^2 = 0.842), and final gestational age (R^2 = 0.896). The scatterplot and nomogram showing this relationship are depicted in Figure 2 and Figure 3, respectively. This suggests NC may work as a reliable alternative when LMP is not known or an early scan has not been done. Abdulkadir et al. also reported that NC is useful when an early scan is missing or LMP is inaccurate in the Nigerian population (13). Ethnic variation becomes important. Abdulkadir et al. found no major difference between Nigerian and Caucasian charts, but in our study, NC values were slightly higher, needing Indian nomograms for more accurate clinical application (13).

Maternal obesity alters fetal growth from the early second trimester, mostly affecting AC, HC, and FL (19). Since NC is not directly reflecting fat deposition or skeletal length, it may remain more stable in such pregnancies. But this still needs further confirmatory studies.

The strength of our study is a large sample size, prospective data, and a population-based regression model. Limitations are a single center, the absence of high-risk pregnancies like IUGR, macrosomia, or twins, and no interobserver reproducibility has been tested. Also, fewer cases were available at very early (15–17 weeks) and late (39–40 weeks) gestation, which may limit curve stability. Larger multicentric studies with a wider gestation range are required to validate findings.

Hence, NC strongly correlates with GA and can be added as a useful parameter, especially for second and third-trimester dating. Its simplicity, reproducibility, and stability make it a valuable adjunct for improving dating accuracy where early dating is uncertain.

Conclusion:

Our study validates NC as a robust and reliable marker for estimating gestational age and assessing fetal growth, especially in clinical scenarios where traditional measures may be less reliable. Its strong correlation with other biometric parameters underscores its potential as a complementary tool in routine prenatal assessments.

Conflict of interest: NIL

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