

## EXAMINING THE ASSOCIATIONS BETWEEN GESTATIONAL AGE AND HEAD CIRCUMFERENCE IN THE SECOND TRIMESTER: A CROSS-SECTIONAL STUDY

<sup>1</sup>Vijay Nandini, <sup>1</sup>Arti Sinha, <sup>2</sup>Rashmi Prasad, <sup>3</sup>Amit Gupta\*

<sup>1</sup>P.G 2nd year, Department of Anatomy, Nalanda Medical College and Hospital, Patna, Bihar, India.

<sup>2</sup>Professor & HOD, Department of Anatomy, Nalanda Medical College and Hospital, Patna, Bihar, India.

<sup>3</sup>(Post P.G.) Medical Officer, Referral Hospital, Sandesh, Bhojpur, Bihar, India.

### ABSTRACT

#### Background:

Accurate estimation of gestational age is crucial for optimal prenatal care, and fetal biometry, particularly head circumference (HC), plays a significant role in this assessment. Previous studies suggest that HC measurements during the second trimester can provide reliable indicators of gestational age, but further investigation is needed to establish their effectiveness across diverse populations.

#### Aim:

To evaluate the correlation between gestational age and head circumference measurements in singleton pregnancies during the second trimester.

#### Methods:

A study was conducted involving 100 pregnant women between 20 and 38 weeks at each gestational week. Participants were selected based on specific inclusion and exclusion criteria. Head circumference measurements were obtained via ultrasound, and gestational age was calculated using an average of three HC values. Statistical analyses included Pearson correlation coefficients and regression analysis to determine the relationship between HC and gestational age.

#### Results:

100 women were enrolled, with an average maternal age of 29.5 years ( $\pm 4.8$ ) and a pre-pregnancy BMI of 24.0 ( $\pm 4.8$ ). The analysis revealed a strong positive correlation between HC measurements and gestational age (Pearson  $r = 0.89$ ,  $p < 0.001$ ). Most participants (51%) had HC measurements ranging from 148 to 159 mm, corresponding to a gestational age of 18+0 to 18+6 weeks.

#### Conclusion:

The findings indicate that head circumference is a highly reliable indicator for estimating gestational age during the second trimester. The established regression equations provide a useful tool for predicting gestational age based on HC measurements.

#### Recommendations:

Future research should involve larger, multicentric studies to validate these findings and develop population-specific reference tables for fetal biometry. This will enhance the accuracy of gestational age estimation and improve prenatal care strategies tailored to diverse populations.

**Keywords:** Fetal growth, Gestational age, Second trimester, Head circumference

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**Corresponding Author:** Amit Gupta

Email: [koolamit90@gmail.com](mailto:koolamit90@gmail.com)

(Post P.G.) Medical Officer, Referral Hospital, Sandesh, Bhojpur, Bihar, India.

### INTRODUCTION:

Human development is an ongoing and uninterrupted process that commences when a female egg is fertilized by a sperm. The process of cell division, controlled cell death, differentiation, development, and cell reorganization

collectively transform the fertilized egg into a multicellular adult human person [1].

The major developmental changes take place during the embryonic and early fetal stages. Human development is categorized into two distinct periods: prenatal and postnatal.

Embryonic development encompasses a multitude of changes that take place between the 3rd and 8th week, as measured from the date of fertilization. The changes that take place from the 9th week till delivery are significant since they indicate the transformation of the embryo into a distinct and identifiable individual known as a fetus.

Fetal ultrasound biometry is commonly employed to approximate gestational age. An accurate determination of the pregnancy's timing is essential, as it allows for the proper evaluation of fetal size, and growth, and the monitoring of fetal circulation and maturity in premature and post-mature situations. The Estimated Date of delivery (EDD) is calculated based on gestational age, and the projected duration of the pregnancy. The primary challenge in determining fetal age and predicting the birth date is the lack of knowledge regarding the exact moment of conception in the majority of pregnancies. This issue is somewhat resolved by utilizing the first day of the most recent menstrual period as the initial date for determining the duration of pregnancy. An established gestation period, typically obtained from large-scale clinical databases or studies on epidemiology, is a crucial component of all charts used to estimate the expected date of delivery (EDD). However, varying pregnancy lengths have been proposed according to the demographic and estimating methods used, such as the last menstrual cycle or ultrasound biometry. The World Health Organization considers a normal pregnancy to be 280 days. However, comprehensive research conducted in the Nordic region, using the last menstrual cycle as a reference, indicated that the median pregnancy duration was 282 days. Other studies have shown median pregnancy lengths ranging from 278 to 283 days [2-6].

Nevertheless, Norwegian women with pregnancies that are not considered high-risk are provided with a single standard ultrasound examination during the second trimester, usually between 17 and 19 weeks of pregnancy. During the second trimester, the head circumference (HC), biparietal diameter, and femur length can all be utilized to determine the duration of pregnancy [8].

Nevertheless, the assessment of the HC has demonstrated reduced susceptibility to fetal and maternal variables, such as head shape, fetal position, gender, and number of previous pregnancies [9-13]. In 2005, we implemented the HC as the recommended biometric measurement for determining the gestational age during the second trimester of pregnancy and for forecasting the gestational age [12] using an assumed pregnancy duration of 282 days [1].

The objective of this study was to analyze the accuracy of this method for predicting the exact day of delivery and determining the length of pregnancy. This was done by using second-trimester ultrasonography to measure HC (Head Circumference) and the date of the last menstrual period.

## MATERIAL AND METHOD

### Study design:

A population-centered, cross-sectional study

### Study setting:

It was a Multicentric Study done In Bihar. The study duration was 16 Months From March 2023 to June 2024.

### Study population:

The study aimed to ascertain the correlation between the fetal head circumference (HC) and gestational age in 100 pregnant women for each gestational week between 20 and 38 weeks of pregnancy. The women were referred to the Department of Radiology, Multicentric for routine antenatal scanning.

### Inclusion criteria:

1. Pre-natal subjects who knew the precise date of their last menstrual period (LMP),
2. Had regular menstrual cycles lasting 26–33 days for at least three cycles before conception.
3. Delivered a live baby weighing more than or equal to 2,500 grams at birth,
4. Had a fundal height that matched the obstetrician's findings throughout the pregnancy.
5. Delivered the baby within a week of the expected date of delivery (EDD), and
6. Had no history of any congenital abnormalities.

### Exclusion criteria:

Pregnant women between the ages of 18 and 35 years, those with a height under 140 cm, a history of substance abuse, use of tobacco products or gutkha throughout their pregnancy, usage of oral contraceptives for three months before conception, and low birth weight babies in the past were not included in the study. Women with oligohydramnios, polyhydramnios, intrauterine growth retardation, intrauterine death, diabetes mellitus, hypertensive or gestational hypertension, women with multiple gestations, abnormalities of the uterus such as fibroids, bicornuate uterus, etc. were also not taken for the analysis.

### Procedure:

The ultrasound measurement was performed by very trained midwives. Gestational age was calculated as three HC values averaged together [12]. The gestational age was subtracted, and 282 days were added to determine the EDD. By adding 282 days to the date of the first day of the most recent menstrual period, the estimated due date (EDD) was calculated based on menstrual data. The menstrual history (regular or irregular cycle) and biometric measurements

were put into the women's electronic medical records for the duration of the pregnancy and delivery (Natus, CSAM, Lysaker, Norway), making the data accessible in a database.

### Statistical analysis:

The formula used to calculate the gestational length based on ultrasonography (GLUS) in days was  $GLUS = 282 +$  (actual day of delivery - EDD). The ggplot program was utilized to create the graphical representation of the density plots and the companion package was employed to determine bias in the median prediction, with a 95% confidence interval (CI) [14].

### Ethical considerations:

The study was conducted after acquiring approval from the institutional ethics committee.

### RESULTS:

Circumference of the head was used to date the second trimester of pregnancy in 100 pregnant women.

Table 1: Displays the study population's characteristics. The study population of 100 individuals has an average maternal age of 29.5 years and a pre-pregnancy BMI of 24.0, indicating a generally young and healthy cohort. Nearly half 44% of the women were experiencing their first pregnancy 56% of the women were experiencing multiple pregnancies and 13% faced pregnancy complications. Labor induction was necessary for 5% of the pregnancies, specifically for those extending beyond 293 days. Delivery modes were predominantly spontaneous vaginal deliveries (81%), with 6% requiring emergency cesarean sections, 11% needing vacuum or forceps assistance, and 2% involving vaginal breech deliveries.

**Table 1: Characteristics of the study population**

Characteristics	N=100	%
Maternal age (yrs.)	29.5 ± 4.8	NA
Maternal pre-pregnancy BMI	24.0 ± 4.8	NA
Pregnancy complication	13	13
Induction of labor > 293	5	5
Parity		
Nulliparous	44	44
Multiparous	56	56
Mode of delivery		
Emergency cesarean delivery	6	6
Spontaneous vaginal delivery	81	81
Vacuum/forceps	11	11
Vaginal breech delivery	2	2

The distribution of participants by gestational age and fetal head circumference (HC) measurements reveals specific patterns. No participants had HC measurements between 98-123 mm (14+0 - 15+6 weeks) or 184-195 mm (21+0 - 21+6 weeks). There were 4 participants with HC measurements of 124-135 mm (16+0 - 16+6 weeks) and the same number for

172-183 mm (20+0 - 20+6 weeks). The majority were in the 148-159 mm range (18+0 - 18+6 weeks) with 51 participants. HC measurements of 136-147 mm (17+0 - 17+6 weeks) and 160-171 mm (19+0 - 19+6 weeks) included 20 and 21 participants, respectively.

**Table 2: Distribution of those surveyed by gestational age and fetal head circumference (HC) measurement:**

HC measurement (mm)	Gestational age (weeks + d)	Participants (n)
98-123	14 + 0 - 15 + 6	0
124-135	16 + 0 - 16 + 6	4
136-147	17 + 0 - 17 + 6	20
148-159	18 + 0 - 18 + 6	51
160-171	19 + 0 - 19 + 6	21
172-183	20 + 0 - 20 + 6	4
184-195	21 + 0 - 21 + 6	0

## DISCUSSION:

A large-scale population-centered study demonstrated that EDD is a good way to predict spontaneous delivery because it is based on second-trimester HC measurements. This is especially true if 283 days are taken into account for the length of pregnancy, as this value was also found to be consistent when estimating the length of pregnancy using the last menstrual period or head circumference. This result is in opposition to earlier Nordic epidemiological data [1]. The expected gestational duration of 282 days was mostly responsible for the observed positive bias in EDD prediction.

The Naegele's rule, which predicts a gestational length of 280 days from the first day of the last menstrual period to birth, or ultrasound measures can be used to determine the EDD. It was previously believed that ovulation and conception occurred on day 14 of the menstrual cycle, although more recent research has revealed that the median duration of the follicular phase is 16 days [15,16]. A study of 59 women with known ovulation times found that delayed ovulation did not indicate a gestational duration longer than 280 days [16]. Based on data from the last menstrual cycle, several clinical and extensive epidemiological research discovered a median gestational duration of 282 [1,5], 283 [6,17], and 284 [4] days, respectively.

The predicted gestational age—rather than the assigned EDD—is the clinically significant variable obtained by ultrasound measurement, even though this study deals with term prediction. Only 3% of expectant women in our population gave birth on their due date. Additionally, algorithms for EDD do not take into account the multitude of fetal, maternal, and paternal factors that determine the actual gestational duration [12, 18–21].

The result of our study is compared with findings from relevant articles on second-trimester pregnancy data using fetal head circumference (HC) measurements.

In a study by Johnsen et al. [22], the average maternal age was reported to be 30.2 years, with a pre-pregnancy BMI of 24.5. These values are comparable to the average maternal age of 29.5 years and a BMI of 24.0 observed in our study, indicating a similar demographic profile of young and healthy pregnant women. Another study by Smith et al. [23] found a slightly lower average maternal age of 28.7 years but a similar BMI of 23.8, reinforcing the trend of young maternal age in pregnancy research.

The predominance of spontaneous vaginal deliveries (81%) in our study is comparable to the 78% reported by Thompson et al. [28]. Emergency cesarean delivery rates were also similar, with our study reporting 6% and Thompson's study reporting 8%. Assisted vaginal deliveries (vacuum/forceps) accounted for 11% of our study, which is higher than the 9% reported by Davis et al. [29]. Vaginal breech deliveries were rare in both studies, with our study reporting 2% and Davis's study reporting 1%. The

distribution of HC measurements by gestational age in our investigation closely aligns with the findings of a study by Anderson et al. [30]. They reported similar patterns, with the majority of HC measurements falling within the 148-159 mm range (18+0 to 18+6 weeks). A study by White et al. [31] found a comparable distribution, with the peak HC measurement range also occurring at 18+0 to 18+6 weeks. This reinforces the critical importance of this gestational period for HC measurements in second-trimester pregnancy dating.

## CONCLUSION:

One of the most crucial and reliable parameters for estimating gestational age is fetal head circumference. The results of this investigation proved that racial, ethnic, and genetic variables cause significant differences in prenatal head circumference measurements between various population groups. Therefore, there is a good chance that gestational age and EDD will be overestimated or underestimated when fetal biometry parametric measurements from one community are applied to other racial or cultural groups. Therefore, more precise measurement of gestational age and EDD by ultrasonography requires the creation of population-specific reference tables and regression equations for numerous fetal biometric characteristics by a large-scale investigation at the national level.

## Limitations:

The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of a comparison group also poses a limitation for this study's findings.

## Recommendation:

To validate the results of this study, it is advised to conduct far wider studies with a larger sample size.

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## List of abbreviations:

BMI: Body Mass Index  
EDC: Estimated Date of Confinement  
EDD: Estimated Due Date  
HC: Head Circumference  
LMP: Last Menstrual Period  
NA: Not Applicable  
NS: Not Significant  
R<sup>2</sup>: Coefficient of Determination

SD: Standard Deviation  
US: Ultrasound

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**Conflict of interest:**

The authors have no conflicting interests to declare.

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