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Crown-Rump Length is an Effective Parameter for Estimating Gestational Age of First Trimester Fetuses

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ABSTRACT

Background: Accurate estimation of gestational age (GA) is important for antenatal diagnostic procedures and management of high-risk pregnancies, but the last menstrual period (LMP) may be uncertain or unreliable. Ultrasonographic assessment, particularly crown-rump length (CRL), provides a reliable method for estimating GA during the first trimester. This study evaluated the relationship between CRL and menstrual age (MA) in first-trimester Indian pregnancies and assessed its potential for accurate estimation of GA.

Methods: Ultrasonographic examination was performed in 50 randomly selected women with singleton normal pregnancies, known LMP, regular menstrual cycles, and no maternal or fetal pathological conditions. CRL was measured using Robinson's technique with real-time transvaginal or transabdominal ultrasonography. Transvaginal scanning was performed below 7 weeks, while transabdominal scanning was used from 7 to 13 weeks. Linear regression assessed the relationship between CRL and MA.

Results: A strong linear correlation was observed between CRL and MA, with a correlation coefficient (r) of 0.94 and r^2 of 0.88. The regression equation was Y = 43.9 + 0.81X, where X represented CRL in millimetres and Y represented menstrual age in days. The 95% confidence limit was approximately ±4 days. The difference between the present study and Hadlock's study was not statistically significant ($p>0.05$).

Conclusion: CRL demonstrated a strong linear relationship with menstrual age and can be used to estimate gestational age accurately when the LMP is unknown or unreliable. The findings support the use of European CRL nomograms in an Indian/Asian obstetrical population up to approximately 10 weeks of gestation.

Key-words: Crown-rump length; Gestational age; LMP; Menstrual age; Ultrasonography

INTRODUCTION

Accurate knowledge of the gestational age (GA) and maturity of a foetus is important for a variety of reasons, including the timing of chorionic villous sampling in the 1st trimester, amniocentesis in the 2nd trimester, differentiation between term and pre-term labour, distinguishing normal from pathological foetal development, and deciding the most favourable time for delivery of the foetus.

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The best method of assessing GA is to record an accurate menstrual history; however, in many subjects, menstrual cycles are irregular or the date of the last menstrual period (LMP) is uncertain. Thus, menstrual data are not always reliable, pointing to a need for devising a method to assess the GA of the foetus accurately, even in the absence of LMP.

Accurate estimation of gestational age is important in pregnancy, and ultrasound measurement of fetal CRL during the first trimester is a reliable method for pregnancy dating. CRL shows a strong relationship with gestational age and is therefore widely used for estimating gestational age during early pregnancy.[1]

Robinson first recommended the use of measured CRL by means of pulsed ultrasound to estimate GA.[2] Robinson *et al.* employed weighted non-linear regression to obtain a curve of best fit between the 6th and 14th

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gestational weeks and concluded that the 95% confidence interval for predicting menstrual age with CRL was ±5 days.[3] Drumm *et al.* conducted another pulsed ultrasound study in Ireland and confirmed the accuracy of CRL in patients whose dates of conception were known on the basis of basal body temperature records.[4]

Recent evidence continues to support the reliability of CRL for first-trimester gestational-age assessment. International standards based on large multicentre datasets have demonstrated a consistent relationship between CRL and gestational age and have provided standardized reference values for early pregnancy dating [5]. Population-based data from 11,041 pregnancies have further demonstrated the high precision of CRL for first-trimester pregnancy dating, supporting its continued clinical utility in contemporary obstetric practice [6]. More recent reference charts based on pregnancies with accurately known gestational age have also shown that CRL remains a useful biometric parameter for early pregnancy dating, while highlighting differences between spontaneous and assisted-reproductive-technology pregnancies and deviations of traditional dating curves at the extremes of gestation [7].

McGregor *et al.* [8] evaluated patients with known dates of conception and reported that conventional CRL dating curves could underestimate gestational age. More recent investigations have continued to demonstrate a strong relationship between CRL and gestational age and have evaluated updated CRL-based models for first-trimester pregnancy dating [9]. Hadlock developed measurement tables that established menstrual age for CRLs as large as 12 cm [10].

The purpose of this study was to reaffirm the accuracy of the correlation between the GA, as assessed by accurate menstrual history, of Indian foetuses and the CRL, as measured by ultrasonography, between 6 and 12 weeks of pregnancy, and to assess whether the European nomograms currently in practice can be used to measure GA in an Indian population.

MATERIALS AND METHODS

Place of the Study- The study was conducted in the Department of Ultrasonography, Bombay Hospital Institute of Medical Research and P.G. Training, Mumbai, India**.**

Study Design- This was a cross-sectional observational study conducted among pregnant women in the first trimester. A total of 80 patients were scanned, of whom 50 were randomly selected according to the predefined selection criteria.

Study Population- Urban females in the first trimester of pregnancy with a singleton normal foetus were considered for the study.

Inclusion Criteria- Participants were included if they had a single normal foetus, regular menstrual cycles, a known date of LMP, no history of vaginal bleeding since conception, no maternal disease likely to affect foetal size, and no use of oral contraceptives during the three months preceding pregnancy.

Exclusion Criteria- Women who did not fulfil the above selection criteria were excluded from the study. The manuscript does not provide a separately specified exclusion-criteria list.

Ultrasonographic Procedure- Real-time ultrasonographic examination was performed in all selected participants. For patients below 7 weeks of gestation, transvaginal ultrasonography was performed using a 7.5 MHz probe, while patients between 7 and 13 weeks were examined transabdominally using a 3.5 MHz convex probe. The crown-rump length (CRL) was measured using the Robinson technique, with the measurement taken as the linear distance between the crown and rump of the fetus. The measured CRL was recorded in millimetres and used for assessment of menstrual age and gestational age.

Statistical Analysis- Linear regression analysis was used to assess the relationship between CRL and menstrual age. The correlation coefficient, coefficient of determination, regression equation, mean and standard deviation were evaluated. The findings were compared with Hadlock's study, and the difference was reported as statistically non-significant ($p>0.05$).

RESULTS

A total of 50 randomly selected women with singleton normal pregnancies were included in the study. Crown-rump length (CRL) was measured by real-time ultrasonography using the Robinson technique.

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A strong linear correlation was observed between CRL and menstrual age, with a correlation coefficient (r) of 0.94 and coefficient of determination (r^2) of 0.88. The regression equation obtained was Y = 43.9 + 0.81X, where X represented CRL in millimetres and Y represented menstrual age in days. The 95% confidence limit was approximately ±4 days.

The gestational age calculated from the regression equation using the measured CRL corresponded with the menstrual age calculated from the known last menstrual period. Thus, CRL could be used to assess gestational age in days when menstrual age was unavailable or unknown.

The mean gestational age in the present study was 65.6 ± 14.21 days. The coefficient of variation was 21.66%, and the 95% confidence limit ranged from approximately ±3.9 to 4 days. The difference between the present study and Hadlock's study was not statistically significant (p>0.05).

The ultrasound measurement of CRL is demonstrated in Fig. 1, where the measurement was obtained by placing one point on the fetal head and the other on the rump. The CRL shown in the figure was 2.45 cm.

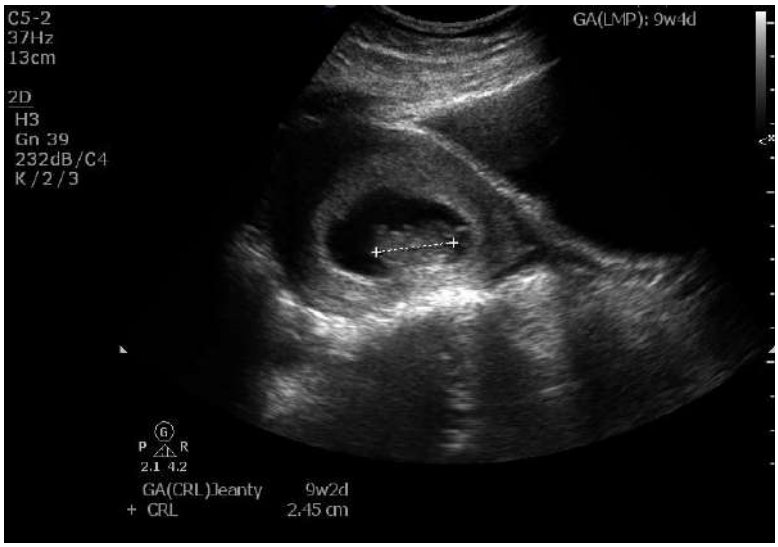

Fig. 1: Real-time ultrasound showing measurement of crown-rump length (CRL) of 2.45 cm by placing one point on the head and the other on the rump.

Measurement of crown-rump length (CRL) in an embryo, illustrating the linear distance between the crown (head) and rump, which represents the fetal CRL used for assessment of gestational age during the first trimester.

The measurement is demonstrated on the embryo using the standard crown-to-rump anatomical landmarks (Fig. 2).

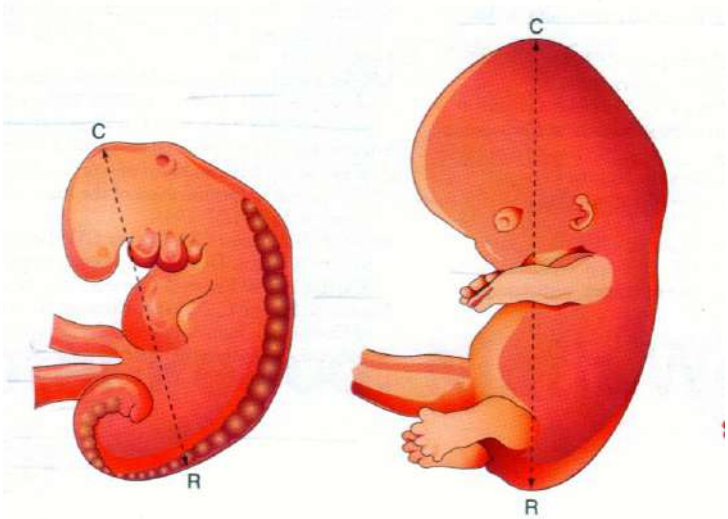

Fig. 2: Measurement of crown-rump length (CRL) in an embryo.

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The scatter diagram presented in Fig. 3 demonstrates the strong linear co-relationship between CRL and gestational age, supporting the use of CRL for estimation of gestational age during the first trimester.

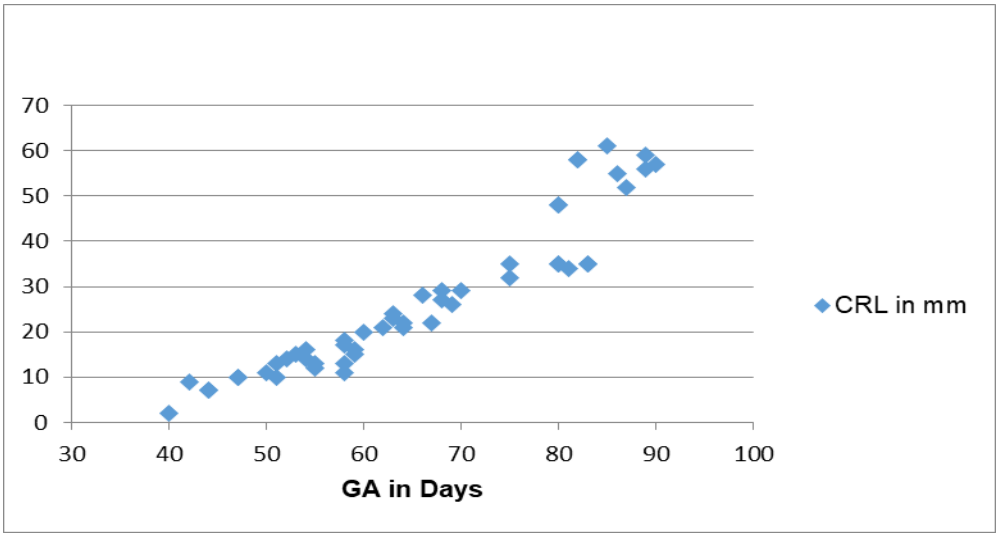

Fig. 3: Scatter diagram showing the strong linear co-relationship between crown-rump length (CRL) and gestational age.

DISCUSSION

Since its introduction in 1973, a number of studies have demonstrated that menstrual age can be effectively estimated by measuring crown-rump length (CRL) during the first trimester of pregnancy. The use of CRL in this regard has been recommended by the American Institute of Ultrasound Medicine and also by the American College of Radiology (Leopold G – Antepartum Obstetrical Ultrasound Examination Guidelines).

The mean gestational age in the present study was 65.6 days, with a standard deviation of 14.21 days, compared with 64.18 days and 13.11 days, respectively, in Hadlock's study [10]. The difference between the present study and Hadlock's study was not statistically significant ($p>0.05$), indicating close agreement between the two studies (Table 1).

Table 1: Comparison of Mean and Standard Deviation

Study	Mean Gestational Age (days)	Standard Deviation
Present study	65.6	14.21
Hadlock's study [10]	64.18	13.11

McGregor *et al.* [8] based their analysis on known dates of conception in women who had become pregnant following infertility treatment and suggested that the original studies of Robinson *et al.* [3] and Drumm *et al.* [4] likely underestimated menstrual age. In an attempt to explain the observed differences, Koornstra *et al.* [11] noted that women with known dates of conception following infertility treatment have a prolonged pre-ovulatory phase of their menstrual cycle. However, Tan *et al.* [9] published results that were virtually identical to those of Robinson *et al.* [3] and Drumm *et al.* [4] during the time frame of 7–9 weeks of gestational age. Tan *et al.* [9], based on high-resolution vaginal scanning in women with known dates of conception, and supported the validity of these studies. Hadlock *et al.* [10] analysed 117 patients at <9 weeks' gestation and were also in agreement with the original models.

The agreement between these studies is notable, considering the geographic and population differences among the patients and the differences in ultrasound methodology. The older studies used static scans, whereas the more recent reports were based on linear as well as sector real-time instruments (Table 2).

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Table 2: Comparison of Different Studies with the Present Study

Parameter	Robinson [2,3]	Drumm [4]	McGregor [8]	Hadlock [10]	Present study
Site	Scotland	Ireland	USA	USA	Mumbai
Scanner	Static	Static	Real-time	Real-time	Real-time
Technique	TA	TA	TA	TA, TV	TA, TV
Number	80	253	72	452	50
Analysis	Mixed	Mixed	Cross-sectional	Cross-sectional	Cross-sectional
Weeks	6–14	6.7–14.4	7.7–13.3	5–18	5.5–12.5
Dates	LMP	LMP	KCD	LMP	LMP
95% C.I.	±4.7 days	±3 days	±7.4 days	±8.3 days	±4 days

C.I. *= Confidence interval;* ***LMP*** *= Last menstrual period;* ***Mixed*** *= Cross-sectional analysis in a longitudinal manner;* ***TA*** *= Trans-abdominal;* ***TV*** *= Trans-vaginal;* ***KCD*** *= Known conception date.*

Our data on women who were 7–10 weeks of gestational age were in close agreement with those of Robinson *et al.* [2,3], Drumm *et al.* [4], McGregor *et al.* [8], and Hadlock *et al.* [10]. The comparison of CRL measurements and predicted gestational age among these studies and the present study is presented in Table 3.

Table 3: Comparison of CRL Measured and Predicted Gestational Age in Different Studies

CRL (mm)	Robinson [2,3] GA (weeks)	Drumm [4] GA (weeks)	McGregor [8] GA (weeks)	Hadlock [10] GA (weeks)	Present study GA (weeks)
2	ND	ND	ND	5.7	6.5
10	7.0	6.9	7.7	7.1	7.4
20	8.6	8.5	8.7	8.7	8.6
30	9.8	9.7	9.9	9.9	9.7
40	10.8	10.8	10.9	10.9	10.9
50	11.5	11.6	11.7	11.7	12.0
60	12.6	12.4	12.6	12.5	13.1
70	13.4	13.2	13.3	13.2	14.3
80	14.1	13.8	ND	14.0	15.5

ND *= Not determined.*

Our data focused on the middle of the first trimester of pregnancy and were in close agreement with findings based on the LMP. The findings also showed relatively good agreement with the average data based on known dates of conception.

However, our data differed slightly from those of the other studies for women who were beyond 12 weeks of gestational age. Regression models typically have the greatest inaccuracies at the extremes of the curve, which is consistent with this finding.

Overall, the findings of the present study showed close agreement with the previously reported observations during the first trimester, particularly between 7 and 10 weeks of gestation. The findings support the use of CRL for estimating gestational age during this period.

CONCLUSIONS

In high-risk pregnancies, gestational age can be estimated accurately by measuring fetal crown–rump length (CRL), even when the last menstrual period is unknown, owing to the strong linear relationship between CRL and gestational age. The present study

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demonstrates that ethnic differences in fetal size are not apparent during early pregnancy, supporting the use of European CRL nomograms in Asian/Indian obstetric populations up to 10 weeks of gestation. After 10 weeks, increasing fetal curvature and biological variability reduce the reliability of CRL measurements; therefore, other fetal parameters, such as biparietal diameter and femur length, should be used for gestational age assessment. Accurate early dating by CRL is particularly valuable in the management of high-risk pregnancies, including those complicated by Rh sensitization. Once gestational age is established, subsequent ultrasound assessment can help evaluate fetal growth and identify deviations from expected growth patterns.

CONTRIBUTION OF AUTHORS

One author has only contributed to this article.

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