Section: Radiodiagnosis

Original Research Article

ROLE OF FETAL SACRAL LENGTH MEASUREMENT IN THE ASSESSMENT OF FETAL GESTATIONAL AGE BY ULTRASONOGRAPHY

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Abstract

Background: Accurate gestational age assessment is crucial to providing good maternity care. Failure to make an accurate assessment can result in iatrogenic prematurity or postmaturity, increased perinatal morbidity, and mortality. Obstetric sonography plays an important role in the accurate determination of intrauterine gestational age. The present study is undertaken to validate the fetal sacral length measurement as an additional morphological measurement of fetal growth in the South Indian population and to assess if fetal sacral length can be used in clinical situations like abnormal cranial shapes, oligohydramnios, an engaged head in the third trimester, etc. **Materials and Methods:** The study group consists of 100 antenatal cases between 15 and 40 weeks of gestation from the department of radiodiagnosis at the Sapthagiri Institute of Medical Sciences. Obstetric ultrasonography was performed using a GE Voluson S8 BT18 ultrasound scanner using a 3.5 MHz convex probe, and fetal biometric parameters like BPD, HC, AC, FL, and sacral length were obtained. **Results:** In this study of 100 healthy pregnant women, the correlation of sacral length with gestational age was assessed. A statistically significant positive linear correlation was found during the second and third trimesters between the sacral length measured in cm and the gestational age in weeks. The sacral length correlated well with the gestational age in both the second and third trimesters. **Conclusion:** Fetal sacral length showed a positive linear correlation with the gestational age calculated from LMP and with other biometric parameters like bi-parietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). Sacral length can be used as a reliable parameter for the determination of gestational age. Sacral length can be used as a secondary parameter when the measurement of the traditional parameters is difficult in clinical scenarios like abnormal cranial shapes, oligohydramnios, an engaged head in the 3rd trimester, etc.

INTRODUCTION

Accurate assessment of the fetal gestation age is vital for providing good maternity care. A higher incidence of prematurity or postmaturity is seen when the gestational age assessment is inaccurate, which further leads to an increase in perinatal mortality and morbidity. Management strategies for various disorders are dependent on knowing the gestational age of the patient. Traditionally, before the use of ultrasonography, the dating of pregnancies was done by using Naegele’s rule—by adding 7 days and 9 months to the first day of the last menstrual period (LMP) in a patient with a regular menstrual cycle—and MacDonald's rule—by uterine size measurement, but these parameters are less accurate. There has been a shift from these older methods to the use of ultrasound as a diagnostic modality in the last few decades. This is mainly because of its nature of being non-invasive and having non-ionizing radiation. It is also extremely cost-effective and, hence, very widely acceptable.[1]

Obstetric sonography is very crucial in accurately determining the intrauterine gestational age. Ultrasonographic measurements of a vast number of fetal bony structures, such as the foot length, clavicle, scapula, mandible, iliac bone, etc., have been correlated with the fetal gestational age. [2–4] One can use these measurements to assist in the determination of appropriate gestational age**[5]** and also to assess fetal lung maturity. These measurements can also be used in other specific clinical situations, such as abnormal cranial shapes,[2,3] and oligohydramnios (making an accurate biparietal diameter and abdominal circumference measurement can be difficult due to the compression of the fetal head and abdomen in oligohydramnios). Associated congenital anomalies like sacrococcygeal teratoma, caudal regression syndrome, or sacral agenesis can also be easily detected.[6]

Renato Bareggi et al. (1993) examined 26 aborted human fetuses without malformations, using a double staining technique to demonstrate vertebral ossification patterns. They found centrum ossification starting at T10-L1 levels bidirectionally, while arches ossification proceeded cranio-caudally, suggesting a developmental age determinant.[7] Sherer et al. (1993) studied 506 antenatal women, proposing sacral length as an interchangeable ultrasonographic parameter for gestational dating when traditional parameters are unattainable due to fetal positioning or an abnormal cephalic index.**[2]** Ozat et al. (2011) analyzed 2184 antenatal women, emphasizing fetal sacral length's strong correlation with gestational age and other biometric measurements, suggesting its use in evaluating fetal growth and predicting gestational age.**[4]** Divya J. Tekani et al. (2015) studied 100 antenatal women, highlighting sacral length's independence from the fetal head and its utility in conditions like deeply engaged head or femur length deformities, proposing it as a reliable routine parameter and alternative in challenging scenarios.[5]

This study focuses on validating fetal sacral length as an additional parameter for gestational age estimation in the South Indian population, especially in challenging clinical scenarios like abnormal cranial shapes or oligohydramnios. The ease of obtaining sacral length measurements adds value to the gestational age estimation model, particularly when traditional biometric parameters pose challenges.

MATERIALS AND METHODS

The present cross-sectional observation study consists of 100 antenatal cases between 15 and 40 weeks of gestation referred to the department of radiodiagnosis at the Sapthagiri Institute of Medical Sciences from March 2022 to March 2023. Obstetric ultrasonography was performed using a GE Voluson S8 BT18 ultrasound scanner using a 3.5 MHz convex probe, and fetal biometric parameters like BPD, HC, AC, FL, and sacral length were obtained. A written informed consent after explaining the purpose and design of the study would be obtained. Gestational age before 15 weeks, irregular menstrual cycles, multiple gestations, and fetal anomalies are excluded from the study. Prior to consent, the participants would be informed that their refusal to participate in the study would not affect further management adversely.

The plane used for measuring BPD and HC would be a transverse section when the shape of the fetal skull is ovoid and the midline echo from the falx cerebri is interrupted by the cavum septum pellucidi and the thalami.[8,9] AC would be taken in the plane showing the umbilical vein perpendicular to the fetal spine and the stomach bubble.[10-12] The FL would be obtained by aligning the transducer with the long axis of the diaphysis. Measurement cursors are placed at the junction of the cartilaginous epiphysis and bone, and the thin, bright reflection of the cartilaginous epiphysis should not be included. **[10-12]**

The fetal sacral length would be measured in the sagittal plane from the distal tip of the spine (S5) to the antero-superior aspect of S1. At times during the third trimester, a thin echogenic plate, clearly different from a vertebral body, would be visualized distal to the central ossification center of S5. This thin structure representing the unossified, cartilaginous coccyx should not be included in the sacral length measurement.[2]

Sacral length would then be compared with BPD, HC, AC, and FL values and gestational age. Regression analysis would be done to compare each ultrasonographically measured parameter, i.e., sacral length, BPD, HC, AC, and FL, with the gestational age of the fetus.

Correlation coefficients would then be derived to compare sacral length with BPD, HC, AC, and FL in normal pregnancies. Correlation coefficients would also be derived to compare GA by LMP and GA by USG with the sacral length and other sonographic parameters. The measured data would then be utilized to compare with the standard nomogram for estimating the gestational age of the fetus from ultrasonographically measured fetal sacral length.

RESULTS

A total of 100 pregnant women satisfying the inclusion and exclusion criteria were included in our study.

Out of the 100 pregnant women taken up for the study, 65 pregnant women presented in the 2nd trimester (i.e. 13 weeks and 0 days to 27 weeks and 6 days of gestation). 35 pregnant women who were taken up for the study presented in the 3rd trimester (i.e. 28 weeks 0 days to term). The youngest woman in the 2nd trimester was 19 years of age while the oldest was 34 years. The youngest woman in the 3rd trimester was 20 years of age while the oldest was 38 years.

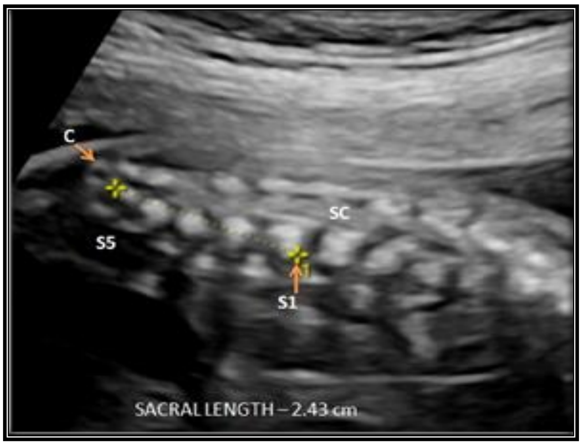

Figure 1: Sagittal section of fetal spine in 24 weeks 3-day of gestation depicting sacral length in cm. The sacral length is seen correlating with gestational age by LMP – 24 weeks 3 days. S1 – First sacral vertebra, S5 – Fifth sacral vertebra, S1-S5 – sacral length, C- Coccyx, SC – Spinal canal

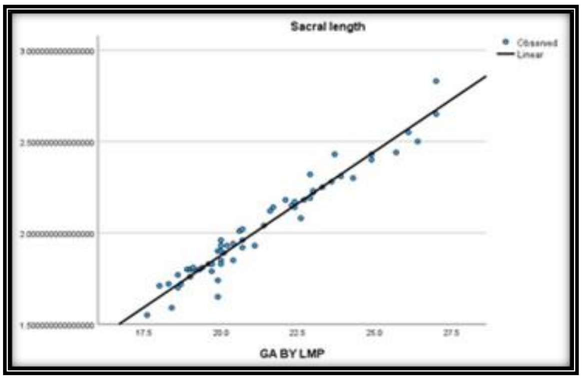

Figure 2: Linear regression graph depicting correlation of Sacral length with GA by LMP in the 2nd trimester.

2nd Trimester Correlation

For the 65 pregnant women which presented in 2nd trimester, all the parameters i.e. Head circumference (HC), Bi-Parietal Diameter (BPD), Abdominal Circumference (AC) and Femur Length (FL) and sacral length were measured in centimeters by sonography.

Regression analysis was carried out to find the correlation of sacral length with the gestational age calculated from the last menstrual period (GA by LMP). R2 (Pearson coefficient) and p values were calculated using Spss. Further a linear equation was derived for sacral length estimation using gestational age. Sacral length measurements showed a statistically significant (p <0.001) positive linear correlation (R2= 0.952) with the gestational age in the 2nd trimester [Table 1, Figure 1,2].

Linear regression equation for deriving sacral length in the 2nd trimester

Sacral length = [Slope(b1) x GA by LMP] + Y intercept(c)

Sacral length = [0.114 x GA by LMP] - 0.396

GA by LMP = [8.772 x Sacral length] + 3.474

Sacral length was also compared with other biometric parameters taken in 2nd trimester using regression analysis and R2 (Pearson coefficient) and p values were calculated using Spss.

Sacral length in the 2nd trimester showed a statistically significant positive linear correlation with the other biometric parameters like Head circumference (HC), Bi-Parietal Diameter (BPD), Abdominal Circumference (AC) and Femur Length (FL) [Table 2, Figure 3].

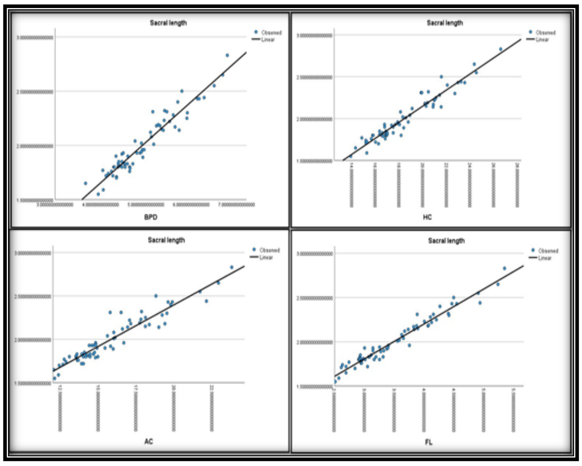

Figure 3: Linear regression graph depicting correlation of Sacral length with GA by BPD, HC, AC and FL in the 2nd trimester.

3. Trimester Correlation

For the 35 pregnant women which presented in 3rd trimester, all the parameters i.e. Head circumference (HC), Bi-Parietal Diameter (BPD), Abdominal Circumference (AC) and Femur Length (FL) and sacral length were measured in centimeters by sonography.

Like done for 2nd trimester, regression analysis was carried out to find the correlation of sacral length and gestational age calculated from the last menstrual period (GA by LMP). R2 (Pearson coefficient) and p values were calculated using Spss.

A linear equation was derived for sacral length estimation using gestational age.Sacral length measurements showed a statistically significant (p <0.001) positive linear correlation (R2= 0.958) with the gestational age in the 3nd trimester [Table 3, Figure 4,5].

<u>Linear regression equation for deriving sacral length in the 3rd trimester</u>

Sacral length = [Slope (b1) x GA by LMP] + Y intercept(c)

Sacral length = [0.107 x GA by LMP] - 0.264

GA by LMP = [9.346 x Sacral length] + 2.467

Like for the 2nd trimester, Sacral length was compared with other biometric parameters taken in 3rd trimester using regression analysis and R^2 (Pearson coefficient) and p values were calculated using Spss. Sacral length in the 3rd trimester showed a statistically significant positive linear correlation

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with the other biometric parameters like Head circumference (HC), Bi- Parietal Diameter (BPD), Abdominal Circumference (AC) and Femur Length (FL).

Sacral length when compared with other parameters showed Pearson coefficients as given in the table allow which suggested statistically significant positive correlation [Table-4, Figure – 6].

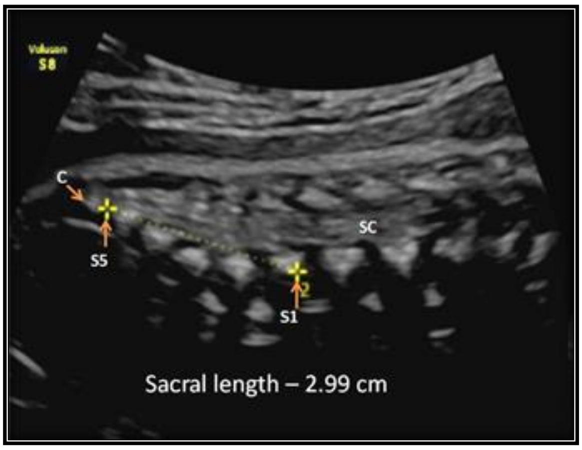

Figure 4: Sagittal section of fetal spine in 30 weeks 3day of gestation depicting sacral length in cm. The sacral length is seen correlating with gestational age by LMP – 30 weeks 3 days. S1 – First sacral vertebra, S5 – Fifth sacral vertebra, S1-S5 – sacral length, C- Coccyx, SC – Spinal canal

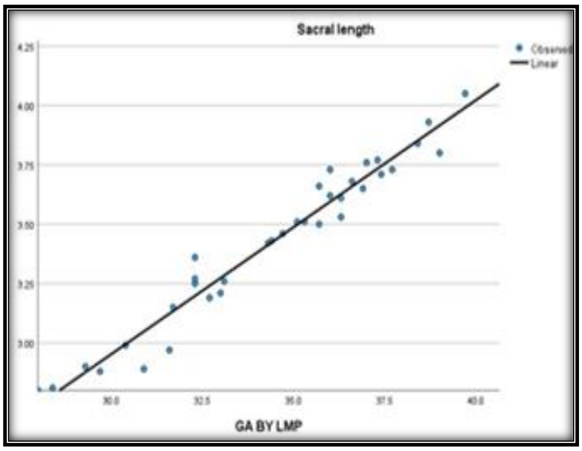

Figure 5: Linear regression graph depicting correlation of Sacral length with GA by LMP in the 3rd trimester.

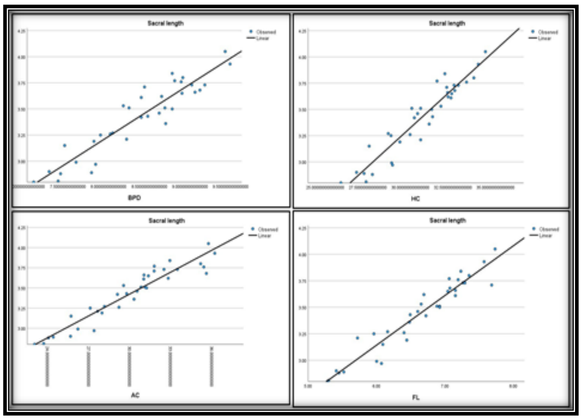

Figure 6: Linear regression graph depicting correlation of Sacral length with GA by BPD, HC, AC and FL in the 3rd trimester.

Table 1: Correlation of Sacral length with GA by LMP in 2nd trimester.

Pearson coefficient R2	Significance p value	Y intercept (C)	Slope (b1)
0.952	< 0.001	-0.396	0.114

Dependent variable is sacral length and Independent variable is GA by LMP

Table 2: Correlation of Sacral length with BPD, HC, AC and FL in 2nd trimester.

Parameters	Pearson coefficient (R2)	Significance (P value)
Sacral length vs BPD	0.917	< 0.001
Sacral length vs HC	0.931	< 0.001
Sacral length vs AC	0.897	< 0.001
Sacral length vs FL	0.954	< 0.001

Table 3: Correlation of Sacral length with GA by LMP in 3rd trimester.

Pearson coefficient R2	Significance p value	Y intercept (C)	Slope (b1)
0.958	< 0.001	-0.264	0.107

Dependent variable is sacral length and Independent variable is GA by LMP

Table 4: Correlation of Sacral length with BPD, HC, AC and FL in 3rd trimester.

Parameters	Pearson coefficient (R2)	Significance (P value)
Sacral length vs BPD	0.865	< 0.001
Sacral length vs HC	0.897	< 0.001
Sacral length vs AC	0.906	< 0.001
Sacral length vs FL	0.923	< 0.001

DISCUSSION

Accurate estimation of the gestational age is extremely important in the management of pregnancies. The techniques used to calculate the gestational age should be precise and easily reproducible among various observers as well. The accuracy of the sonographic fetal biometric parameters for gestational age estimation is an important factor in deciding its practical use. The use

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of additional parameters to estimate the gestational age becomes pertinent when the traditional parameters cannot be used or in circumstances where the traditional parameters are not accurate.

In this study of 100 healthy women with uncomplicated pregnancies, the correlation of sacral length with gestational age was assessed. A statistically significant linear correlation was found during the second and third trimesters between the sacral length measured in cm and the gestational age in weeks.

In the second trimester, we find a Pearson coefficient (R2) of 0.952 with a p value < 0.001 between sacral length (in cm) and gestational age (in weeks) calculated from the LMP. This signifies a positive linear correlation of sacral length with gestational age. Thus, the fetal sacral length can be used as a parameter to predict the gestational age of the fetus in the second trimester.

Similarly, in the third trimester, we find a Pearson coefficient (R2) of 0.958 with a p value < 0.001 between sacral length (in cm) and gestational age (in weeks) calculated from the LMP. This also signifies a positive linear correlation of sacral length with the gestational age, and like in the second trimester, it implies that sacral length can be used as a parameter to predict the gestational age in the third trimester as well.

The present study showed similar results when compared with the study conducted by Sherer et al. in 1993.[2] In this study, 506 cases with normal intrauterine growth in the gestational age range of 15 to 41 weeks were studied. The study revealed a similar linear correlation between sacral length and gestational age, with a Pearson coefficient of 0.959 and a significant p value of < 0.001.[2]

Their study also included 40 large for gestational age (LGA) fetuses (weight > 90th percentile) and 40 small for gestational age (SGA) fetuses (weight < 10th percentile), which were compared with a nomogram obtained from the fetuses with normal growth. They also demonstrated a similar linear relationship between sacral length and gestational age in fetuses with abnormal growth. Therefore, their study suggested that the sacral length may be used as a predictor of gestational age in cases of abnormal growth when other parametric measurements would underestimate or overestimate the gestational age.[2]

The study conducted by Karabulat et al. in 2001 also revealed comparable results to the present study.[3] A linear correlation was present between sacral length and gestational age, with a Pearson coefficient of 0.93 and a significant p value of < 0.001. There was a decrease in the linearity degree from the second (R2 = 0.97) to the third trimester (R2 = 0.94). However, the present study showed a mild increase in the linearity degree from the second (R2 = 0.952) to the third trimester (R2 = 0.958).[3]

Ozat et al. (2010) studied 2184 pregnant women with gestational ages in the range of 16 to 40 weeks, which also revealed comparable results to the present study. The study showed a positive linear correlation with a Pearson coefficient of 0.98, p value < 0.001, in the 2nd trimester and a Pearson coefficient of 0.96, p value < 0.0014.

Studies conducted by Divya et al. in 2015 (R2 = 0.997) and Quader et al. in 2016 (R2 = 0.99) also showed a statistically significant (p<0.001) positive linear correlation between sacral length and gestational age, similar to the present study.[5,6]

CONCLUSION

The study reveals that fetal sacral length exhibits a positive linear correlation with gestational age calculated from the last menstrual period (LMP). Additionally, there is a positive correlation between sacral length and other fetal biometric parameters such as bi-parietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). The findings suggest that sacral length can serve as a reliable parameter for gestational age determination. Moreover, it can be considered a valuable secondary parameter in clinical scenarios where traditional measurements may be challenging, such as cases involving abnormal cranial shapes, oligohydramnios, or an engaged head in the third trimester.

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