Senses Sci (Educ Sci Tech) 2022: 9 (3) 1612-1635
doi: 10.14616/sands-2022-3-16121635

Article

Ultrasonographic correlation of fetal palatal length with fetal biometry

Samer Ahmed Aboumandour[1]*, Wafaa Moustafa Aboeleneen[2], Elsayed Elbadawy Mohammed[3], Tamer Mamdouh Abdeldayem[4], Ayman Bukhari[5]

[1]Assistant Lecturer of Obstetrics and Gynecology, Department of Obstetrics and Gynecology, Faculty of Medicine, Alexandria University, Egypt

[2]Professor of Obstetrics and Gynecology, Department of Obstetrics and Gynecology, Faculty of Medicine, Alexandria University, Egypt

[3]Professor of Obstetrics and Gynecology, Department of Obstetrics and Gynecology, Faculty of Medicine, Alexandria University, Egypt

[4]Assistant professor of Obstetrics and Gynecology, Department of Obstetrics and Gynecology, Faculty of Medicine, Alexandria University, Egypt

*Correspondence: Samer Ahmed Aboumandour, Assistant Lecturer of Obstetrics and Gynecology, Department of Obstetrics and Gynecology, Faculty of Medicine, Alexandria University, Egypt.

Abstract. *Background*: Accurate calculation of gestational age is of utmost importance to determine whether fetal growth is appropriate-for-gestational age. Fetal weight estimation by ultrasound using fetal biometric scales is the most agreed and popular fetal growth tracking standard. Several formulas (based on regression analysis) have been developed for estimation of fetal weight. *Objective*: The primary aim of this work was to assess if there is a correlation of fetal palatal length with fetal biometry using ultrasonography, to assess the relationship between length of fetal hard palate and gestational age, to assess the relationship between length of fetal hard palate and fetal size, and to assess feasibility of incorporation of these findings into new formulas to predict fetal weight and gestational age from the measurement of hard palate. *Methods:* observational prospective cohort study conducted for 225 pregnant women between 20-36 weeks of gestation, with low risk pregnancies. Measurement of length of fetal hard palate was done by different ultrasound techniques. *Results:* there was a statistically significant correlation between fetal palatine length and fetal growth along gestational age. Equations were developed to estimate gestational age and fetal weight using length of fetal palate. *Conclusion:* it was concluded that there was a linear correlation between fetal palatine length and gestational age and fetal weight which was statistically significant between 20-36 weeks of gestation.

Incorporation of fetal palatine length into equations to estimate gestational age and fetal weight was feasible, applicable and showed an excellent level of agreement with the widely used Hadlock formulas.

Keywords*:* fetal palate, fetal growth, ultrasound, Hadlock formula.

Introduction

The palate constitutes the roof of the mouth. It can be divided into two regions; the hard palate anteriorly and soft palate behind (1). Formation of the palate almost occurs during the period from the 7th to the 14th week of gestation (2). The palate forms by fusion of the **primary palate** and the **secondary palate**. The secondary palate is formed from two palatine processes those develop from the sides of the fetal mouth and then grow towards the midline (3). These palatine processes fuse together centrally to form the secondary palate which fuses anteriorly with the primary palate and superiorly with the nasal septum to form the hard palate, soft palate and uvula.(4)

Accurate calculation of gestational age is of utmost importance to determine whether fetal growth is appropriate-for-gestational age (5). Currently, foetal ultrasound assessment is essential for correct gestational age estimation, assessment of foetal growth, and diagnosis of foetal growth abnormalities(6). Ultrasound is the tool of choice, since it is extremely reproducible and accurate (7).

Ultrasonographic techniques for adequate assessment of the palate, upper lip and alveolus, are well described in many sonography literatures(8). These studies highlight the importance of examining and evaluating the echogenic, continuous, smooth, horseshoe-shaped curvy structure of the tooth-bearing alveolar ridge, the labial soft tissue smoothly overlying the maxilla; and the anterior four tooth buds which arise from the premaxilla(9).

Conventional 2D (two dimensional) examination of the face requires obtaining the mid-sagittal plane and a series of ultrasound images in the anterior coronal plane by probe manipulation and moving out smoothly from the nose through the oral cavity to the lips so as for obtaining the nose-mouth view(10). However, the most common method is obtaining serial transverse (axial) images from the nose downwards through the oral cavity to the mandible(11). By this technique, the alveolar ridge, palate, mandible, and tongue can be clearly visualised.(12)

Three-dimensional (3D) and four-dimensional (4D) ultrasound technology can be easily applied for prenatal diagnosis and can provide better images of the fetal face which cannot be achieved with 2D ultrasound(13).

Objective

The present study was conducted aimed to assess if there is a correlation of fetal palatal length with fetal biometry using ultrasonography.

Methods

Study design, setting and participants

The present study was an observational prospective study performed in the period from March 2021 to june 2022 performed in the ultrasound unit of Alexandria University Hospital, Egypt. The Institutional ethical review board approved the study protocol and informed written consent was obtained from all participants after discussing the nature of the study. Women with singleton pregnancies and gestational age between 20-36 weeks were enrolled in the study. After history taking and confirmation of dates, participants were assigned into one of the four groups according to their gestational age. **Group 1:** pregnant women with gestational age from 20 weeks to 23^{+6} weeks.**Group 2:** pregnant women with gestational age from 24 weeks to 27^{+6} weeks.**Group 3:** pregnant women with gestational age from 28 weeks to 31^{+6} weeks. **Group 4:** pregnant women with gestational age from 32 weeks to 36 weeks.

Exclusion criteria

Women with severe oligohydramnios, women in labour, Morbidly obese patients, women with other comorbidities which can affect fetal growth(diabetes, pre-eclampsia…) and pregnancies with altered fetal growth or fetal congenital anomalies were also excluded.

Sample size calculation

Sample size was performed for the primary outcome of the study which is finding a possible linear relationship between length of fetal hard palate and fetal biometry, but there were no previous similar studies assessing this relation, calculation was based on studies examining integrity of the fetal palate. Sample size was estimated using PASS Version 20 Program. The minimal hypothesized total sample size of 140 eligible pregnant women with different gestational ages [excluding those with any obstetric, medical or surgical risks affecting fetal growth during their late second trimester and early third trimester] (at least 35 participants per group) are needed to determine the presence and strength of association between fetal palatal length with fetal biometry using ultrasonography; taking in consideration 95% confidence level and 80% power using Correlational analysis.

Outcome measures

The primary outcomes of the study were finding a possible relationship between the length of fetal hard palate and fetal biometry (gestational age, fetal weight..) and possible use of this relationship as an estimator for fetal biometric parameters.

Statistical analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmogorov-Smirnov and Shapiro-Wilk test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

The used tests were:

1 - Paired t-test

For normally distributed quantitative variables, to compare between two stages.

2 - Pearson coefficient

To correlate between two normally distributed quantitative variables.

3 – Simple Linear Regression

For palatine length to predict GA and EFW.

4- Intra class Correlation coefficient

Was used for the agreement between the two stages The ICCs were classified using a system suggested by Koo and Li (2016) as follows: less than 0.50 Z poor agreement; 0.50 to less than 0.75 Z moderate agreement; 0.75 to 0.90 Z Good agreement; Above 0.90 Z Excellent agreement. A P value less than 0.05 was considered statistically significant.

5 – Bland Altman

For agreement was used Bland Altman plot and one sample t test (between the difference and zero) (if significant then there is fixed bias).

Results

Total number of cases was 225, they were divided into four groups. Cases ranged according to their gestational age from 20 weeks to 36 weeks with a mean value 26.46 weeks and a standard deviation ± 4.11 weeks. According to their estimated fetal weight, cases ranged from 280 grams to 2650 grams with a mean of 1062 grams and a standard deviation of ±652 grams. They also ranged according to measurement of fetal palatine length from 10.0 millimeters to 25.80 millimeters with a mean value 16.35 millimeters and a standard deviation ± 3.38 millimeters as shown in table (1).

Table (1): Comparison between the four studied groups according to EFW and palatine length

	Total (n = 225)	**Group A (20-<24) (n = 72)**	**Group B (24-<28) (n = 73)**	**Group C (28-<32) (n = 40)**	**Group D (32-<36) (n = 40)**
EFW					
Min. – Max.	280 – 2650	280 – 654	460 – 1145	820 – 1749	1816 – 2650
Mean ± SD.	1062 ± 652	501.0 ± 96.14	829.6 ± 128	1255 ± 200	2303 ± 238
Median (IQR)	824 (590 – 1279)	504.0 (424.5 – 588)	793.0 (732 – 923)	1264.0 (1086 – 1362)	2349 (2078 – 2506)
Palatine length (mm)					
Min. – Max.	10.0 – 25.80	10.0 – 16.90	14.30 – 18.50	16.70 – 18.90	18.30 – 25.80
Mean ± SD.	16.35 ± 3.38	13.12 ± 1.35	15.73 ± 0.71	17.59 ± 0.59	22.04 ± 2.47
Median (IQR)	15.80 (14.30 – 17.50)	13.30 (12.10 – 14.20)	15.70 (15.20 – 16.20)	17.30 (17.20 – 18.00)	21.97 (19.80 – 24.50)

IQR: **Inter quartile range**

SD: **Standard deviation**

Based on the data collected, and using the simple linear regression to predict the gestational age from palatine length, an equation was calculated to correlate these two variables (GA and Palatine length) in each subgroup and a general equation was calculated to be used in all the groups. This is shown in table (2).

Pearson coefficient (r) was higher in group C than other groups, and was lowest in group B. However it had the highest value in the general equation. Consequently, the level of variation (R^2)was the highest in the general equation. In other words, the general equation showed more linear correlation to predict the gestational age from palatine length. Furthermore, it is to be noted that all correlations between fetal palate and gestational age were statistically significant (p value ≤ 0.05) as shown in table (2).

Table (2): Simple linear regression for palatine length to predict gestational age

	N	r	p	Equation	R^2
Group A (20-24)	**72**	0.821	<0.001*	GA= 0.626* Palatine length + 14.131	0.674
Group B (24-28)	**73**	0.757	<0.001*	GA= 0.942* Palatine length + 10.549	0.574
Group C (28-32)	**40**	0.897	<0.001*	GA= 1.304* Palatine length + 5.772	0.804
Group D (32-36)	**40**	0.876	<0.001*	GA= 0.403* Palatine length + 24.742	0.768
Overall	**225**	0.960	<0.001*	GA= 1.167* Palatine length + 7.390	0.921

r: Pearson coefficient

R^2: Coefficient of determination

***: Statistically significant at $p \le 0.05$**

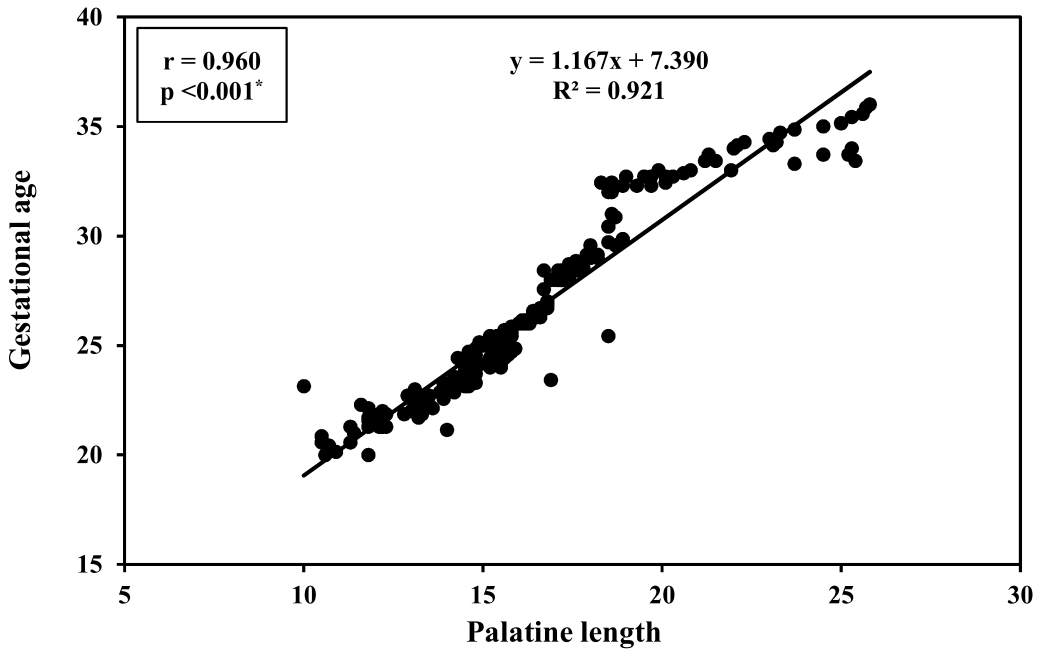


Figure (1): Simple linear regression for palatine length to predict gestational age in Overall

Figure (2): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (3): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (4): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (5): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (6): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (7): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (8): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (9): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (10): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (11): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (12): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (13): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (14): 2D ultrasound image of the fetal head in mid-sagittal plane showing measurement of hard palate length.

Figure (15): 2D ultrasound image of the fetal palate in axial plane showing measurement of hard palate length.

Figure (16): 2D ultrasound image of the fetal palate in axial plane showing measurement of hard palate length.

Figure (17): 2D ultrasound image of the fetal palate in axial plane showing measurement of hard palate length.

Figure (18): 2D ultrasound image of the fetal palate in axial plane showing measurement of hard palate length.

Figure (19): 3D ultrasound image reconstruction of the fetal palate showing measurement of hard palate length.

Figure (20): 3D ultrasound image reconstruction of the fetal palate showing measurement of hard palate length.

Similarly, the simple linear regression was used to predict the fetal weight from palatine length, an equation was calculated to correlate these two variables (fetal weight and Palatine length) in each subgroup and a general equation was calculated to be used in all the groups. This is shown in table (3).

Pearson coefficient (r) was higher in group A than other groups, and was lowest in group B. However, it had the highest value in the general equation. Consequently, the level of variation (R^2) was the highest in the general equation. In other words, the general equation showed more linear correlation to predict the fetal weight from palatine length. Furthermore, it is to be noted that all correlations between fetal palate and gestational age were statistically significant (p value ≤ 0.05) as shown in table (3).

Table (3): Simple linear regression for palatine length to predict EFW

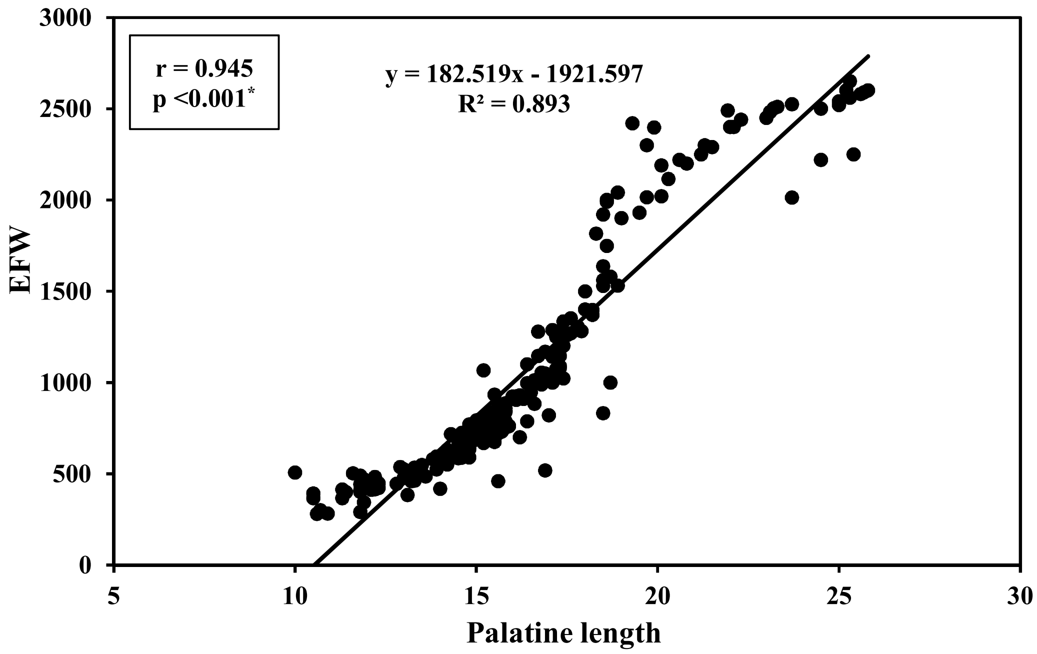
	N	r	p	Equation	R^2
Group A (20-24)	**72**	0.811	<0.001*	EFW = 57.643* Palatine length – 254.979	0.658
Group B (24-28)	**73**	0.641	<0.001*	EFW = 115.562* Palatine length – 988.536	0.411
Group C (28-32)	**40**	0.716	<0.001*	EFW = 243.797* Palatine length – 3034.423	0.512
Group D (32-36)	**40**	0.789	<0.001*	EFW = 76.169* Palatine length + 624.752	0.622
Overall	**225**	0.945	<0.001*	EFW = 182.519* Palatine length – 1921.597	0.893

r: Pearson coefficient

R^2: Coefficient of determination

***: Statistically significant at p ≤ 0.05**

Figure (21): Simple linear regression for palatine length to predict EFW in Overall.



According to these new equations, gestational age and fetal weight can be predicted in any of the four groups either by the equation specific to this group as shown in table (4a), or by using the overall equation as shown in table (4b).

Table (4a): Calculated GA and EFW from palatine length (according to the predicted equation for each subgroup)

GA (weeks)	Palatine length (mm)	EFW
20 - 20^{+6}	9.4 – 10.7	285.6 – 364.5
21 – 21^{+6}	11.0 – 12.3	377.7 – 456.6
22 – 22^{+6}	12.6 – 13.9	469.8 – 548.7
23 – 23^{+6}	14.2 – 15.5	561.9 – 640.8
24 – 24^{+6}	14.3 – 15.2	661.3 – 766.5
25 – 25^{+6}	15.3 – 16.2	784.0 – 889.2
26 – 26^{+6}	16.4 – 17.3	906.8 – 1012
27 – 27^{+6}	17.5 – 18.4	1029 – 1135
28 – 28^{+6}	17.0 – 17.7	1122 – 1283
29 – 29^{+6}	17.8 – 18.5	1309 – 1469
30 – 30^{+6}	18.6 – 19.2	1496 – 1656
31 – 31^{+6}	19.3 – 20.0	1683 – 1843
32 – 32^{+6}	18.0 – 20.1	1997 – 2159
33 – 33^{+6}	20.5 – 22.6	2186 – 2348

34 – 34^{+6}	23.0 – 25.1	2375 – 2537
35 – 36	25.5 – 27.6	2564 – 2726

Table (4b): Calculated GA and EFW from palatine length (according to the predicted general equation) (n = 225)

GA (weeks)	Palatine length (mm)	EFW
20 - 20^{+6}	10.8 – 11.5	50.16 – 184.2
21 – 21^{+6}	11.7 – 12.4	206.5 – 340.6
22 – 22^{+6}	12.5 – 13.3	362.9 – 497.0
23 – 23^{+6}	13.4 – 14.1	519.3 – 653.4
24 – 24^{+6}	14.2 – 15.0	675.7 – 809.7
25 – 25^{+6}	15.1 – 15.8	832.1 – 966.1
26 – 26^{+6}	15.9 – 16.7	988.5 – 1123
27 – 27^{+6}	16.8 – 17.5	1145 – 1279
28 – 28^{+6}	17.7 – 18.4	1301 – 1435
29 – 29^{+6}	18.5 – 19.3	1458 – 1592
30 – 30^{+6}	19.4 – 20.1	1614 – 1748
31 – 31^{+6}	20.2 – 21.0	1770 – 1904
32 – 32^{+6}	21.1 – 21.8	1927 – 2061
33 – 33^{+6}	21.9 – 22.7	2083 – 2217
34 – 34^{+6}	22.8 – 23.5	2240 – 2374
35 – 36	23.7 – 24.4	2396 – 2530

Furthermore, the palatine length was incorporated into Hadlock-3 formula to predict fetal weight using four variables (head circumference, femur length, abdominal circumference and palatine length) in each group and in a general equation to all groups as shown in table (5). Yet, the level of variation (R^2) was higher in group A than other groups, and was lowest in group C. However, it had the highest value in the general equation. In other words, the general equation showed more linear correlation to predict the fetal weight from the four variables than using a group specific equation.

Table (5): Simple linear regression for palatine length, HC, FL and AC to predict EFW

	N	Equation	R^2
Group A (20-24)	**72**	**EFW=** 13.639* Palatine length+ 4.429* HC+ 89.691* FL+ 35.621* AC –741.39	0.889
Group B (24-28)	**73**	**EFW=** 0.365* Palatine length+ 14.680*HC+ 174.487*FL+ 60.188*AC – 1606.8	0.817
Group C (28-32)	**40**	**EFW=** 62.628* Palatine length+ 40.720*HC+ 214.357*FL+ 17.196*AC – 2549.6	0.627
Group D (32-36)	**40**	**EFW=** 69.925* Palatine length+ 42.349*HC – 128.488*FL+ 25.463*AC – 467.87	0.695
Overall	**225**	**EFW=** 66.351* Palatine length+ 8.395*HC+ 153.6*FL+ 50.720*AC – 2104.1	0.940

R^2: Coefficient of determination

***: Statistically significant at $p \le 0.05$**

By using the Intra class Correlation coefficient (ICC), it was also found that there was a significant agreement between the estimated fetal weight (EFW) as calculated by Hadlock-3 formula and both categories of equations (those dependent on palatine length only and those dependent on the four variables). The strength of agreement was excellent comparing the EFW calculated by Hadlock-3 formula (as a standard) and both general overall equations (Above 0.90). However, it was higher with the general overall equation using the four variables (head circumference, femur length, abdominal circumference and palatine length).

Table (6): Intra class Correlation coefficient

	EFW Hadlock VS EFW using Palatine length only			**EFW Hadlock VS EFW using the 4 variables equation**		
	ICC coefficient	**95% C.I (LL-UL)**	**^tp**	**ICC coefficient**	**95% C.I (LL-UL)**	**^tp**
Group A (20-24)	0.791	0.685 – 0.864	<0.001*	0.987	0.979 – 0.992	<0.001*
Group B (24-28)	0.665	0.515 – 0.776	<0.001*	0.997	0.996 – 0.998	<0.001*
Group C (28-32)	0.518	0.249 – 0.712	<0.001*	0.690	0.486 – 0.823	<0.001*
Group D (32-36)	0.364	0.063 – 0.604	0.010*	0.568	0.315 – 0.746	<0.001*
Overall	0.915	0.891 – 0.934	<0.001*	0.967	0.958 – 0.975	<0.001*

CI: Confidence interval

LL: Lower limit

UL: Upper Limit

p: p value for **Paired t-test** for comparing between **EFW Hadlock** vs **Palatine length** and **Equation**

*: Statistically significant at $p \le 0.05$

Value of ICC	Strength of agreement[#]
Below 0.50	Poor
0.50 and <0.75	Moderate
0.75 and 0.90	Good
Above 0.90	Excellent

Discussion

Fetal growth monitoring is a fundamental component in modern obstetrics. Accurate calculation of gestational age is extremely important to determine whether fetal growth is appropriate-for-gestational age (AGA).(5) Several methods were used in clinical practice including abdominal palpation, symphyseal-fundal height measurements, and obstetric ultrasonography. Of these, obstetric ultrasonography remains the most objective and reliable way to monitor fetal growth.(14)

The fetal biometric parameters most commonly used are head circumference (HC), biparietal diameter (BPD), femur diaphysis length (FL) and abdominal circumference (AC). These biometric measurements can be measured to estimate fetal weight using various different formulas.(15)

Several formulas (based on regression analysis) have been developed for estimation of fetal weight.(16) These formulas include different combinations of ultrasound biometric parameters.

This ultrasonographic estimation of fetal weight is then analyzed and compared to the nomograms for fetal gestational age in order to highlight and identify fetal growth abnormalities. However, there is still no general consensus on which model yielding the best ultrasonographic fetal weight estimation.(17)

Many other studies have tried to monitor fetal growth by using several ultrasonographic parameters like placental thickness, kidney size, clavicle length, liver dimension, cerebellar diameter, upper arm soft tissue thickness, femur volume, and cheek-to-cheek diameter and many other parameters. Yet, applicability and reproducibility of these studies are not well established (18)

Unfortunately, being dependent on regularity of menstrual cycle and normal fetal growth , some of these parameters are nonspecific; for example, AC, BPD, FL, and head circumference (HC), are adversely affected in fetuses with uteroplacental insufficiency, with redistribution of cardiac output and propable brain-sparing effect with growth restriction.(19) Moreover, after 26 weeks of gestation, BPD may not be reliable in fetuses with brachycephaly or dolichocephaly(20); FL is also shorter in fetuses with achondroplasia. Abnormalities in the amniotic fluid volume may also decrease the accuracy of ultrasound measurements.(21) Fortunately, the cerebellum is not affected in fetuses with IUGR due to the brain-sparing effect.(22) Therefore, transcerebellar diameter (TCD) has been used as a reliable estimator of GA in late pregnancy.(23)

In our research, the idea was to examine the integrity of the fetal palate, to measure the length of fetal hard palate and to make use of this measurement as a parameter that could be incorporated in formulas by which one can predict gestational age and fetal weight.

225 cases were recruited to participate in such research after fulfilling inclusion criteria. Then, fetal palate was examined by different ultrasonographic techniques. Cases were further divided

into four groups according to their gestational age to examine if there is a linear correlation between length of fetal hard palate from one side and gestational age and fetal size on the other side, and if such correlation is stronger in different age groups than others.

In this study, based on the data collected, and using the simple linear regression to predict the gestational age from palatine length, an equation was calculated to correlate these two variables (GA and Palatine length) in each subgroup and a general equation was calculated to be used in all the groups. There was a linear correlation between gestatinal age and fetal palatal length in all age groups in the study. Furthermore, this correlation was more evident in group A (20 weeks to 23^{+6} weeks), than group B (24 weeks to 27^{+6} weeks), but less than in group D (32 weeks to 36 weeks). Group C (28 weeks to 31^{+6} weeks) showed a higher linear correlation than all other groups. However, the strongest correlation was present in the overall equation relating the palatine length with all age groups included in the study.

In our study, through the data derived about gestational age and palatine length, prediction of gestational age and fetal weight was made possible and applicable by tables designed according to these new equations.

Similarly, the simple linear regression was used to predict the fetal weight from palatine length, an equation was calculated to correlate these two variables (fetal weight and Palatine length) in each subgroup and a general equation was calculated to be used in all the groups. There was a linear correlation between gestational age and fetal palatal length in all age groups in the study. Furthermore, this correlation was more evident in group C than group B, but less than in group D. Group A showed a higher linear correlation than all other groups. However, the strongest correlation was present in the overall equation relating the palatine length with estimated fetal weight in all age groups included in the study.

Moreover, the palatine length was incorporated into Hadlock-3 formula to predict fetal weight using four variables (head circumference, femur length, abdominal circumference and palatine length) in each group and in a general equation to all groups. This four-variable equation showed a stronger correlation in group A than all other groups. Even though, the strongest correlation was found in the general overall equation relating the four variables with the estimated fetal weight.

By using the Intra class Correlation coefficient (ICC), it was also found that there was a significant agreement between the estimated fetal weight (EFW) as calculated by Hadlock-3 formula and both categories of equations (those dependent on palatine length only and those dependent on the four variables). The strength of agreement was excellent comparing the EFW calculated by Hadlock-3 formula (as a standard) and both general overall equations (Above 0.90). However, it was higher with the general overall equation using the four variables (head circumference, femur length, abdominal circumference and palatine length) than that one using the palatine length only.

JD Shaheen et al(24), compared two fetal weight estimation formulas generated by Hadlock, a formula that includes head circumference parameter (H1), and another (H2) which excludes this parameter. This was done to test if head circumference is an essential parameter or not. They reported that by using Bland-Altman analysis, the 95% limits of agreement between both formulas were (-142.03) to 231.79grams with a mean of 44.88grams. Factors found to influence significantly on H2 formula were long femur length and low maternal age. They concluded that H1 formula was more accurate than H2 formula in predicting fetal weight at term. However, the accuracy difference was found to be small. Therefore, if ultrasonographic evaluation of HC is technically difficult, Hadlock formula that excludes head circumference can be used with confidence. However, caution should be paid with higher values of femur length.(24)

In our study, using Bland-Altman analysis, the 95% limits of agreement between both formulas were (-301.8) to 358.0 grams with a mean of 28.1 grams. Furthermore, the highest level of agreement was with the general overall equation dependent on palatine length only (ICC coefficient 0.915) and even more with that one using the 4 variables (ICC coefficient 0.967).
In the future, more studies are needed to evaluate these new equations, especially near delivery time and using actual birth weight to compare their accuracy and precision versus the classically used Hadlock formulas.

Limitations of the study were technical difficulties to take a good image for the fetus which can be used for standard measurements, this was marked in some positions of the fetus, such as occipitoanterior or oblique positions of the fetal head, cases of oligohydramnios, and if there was a fetal limb in front of the face. Additionally, it was more difficult to image a fetus approaching term (more than 32 weeks).

Conclusion

From the present study we can conclude that there was a linear correlation between fetal palatine length and gestational age which was statistically significant between 20-36 weeks of gestation. Also, there was a linear correlation between fetal palatine length and fetal weight which was statistically significant between 20-36 weeks of gestation. Moreover, incorporation of fetal palatine length into equations to estimate gestational age and fetal weight was feasible, applicable and showed an excellent level of agreement with the widely used Hadlock formulas.

Fund

No financial support was gained from any organization, and no one contributed to this work other than the authors

Conflict of interest

None

References

1. Shastry A, Ravindranath Y, Ravindranath R. Analysis of Fetal Palate to Assist Pre-natal Ultrasound. Journal of Clinical and Diagnostic Research: JCDR. 2016 Oct;10(10):AC10.
2. Adserias-Garriga J, Visnapuu V. The neonatal line as evidence of live birth. InAge Estimation 2019 Jan 1 (pp. 161-168). Academic Press.

3. Abramyan J, Richman JM. Recent insights into the morphological diversity in the amniote primary and secondary palates. Developmental Dynamics. 2015 Dec;244(12):1457-68.
4. Zajac DJ, Vallino LD. Evaluation and management of cleft lip and palate: A developmental perspective. Plural Publishing; 2016 Feb 15.
5. Salomon LJ, Alfirevic Z, Da Silva Costa F, Deter RL, Figueras F, Ghi TA, Glanc P, Khalil A, Lee W, Napolitano R, Papageorghiou A. ISUOG Practice Guidelines: ultrasound assessment of fetal biometry and growth. Ultrasound in obstetrics & gynecology. 2019 Jun;53(6):715-23.
6. Figueras F, Caradeux J, Crispi F, Eixarch E, Peguero A, Gratacos E. Diagnosis and surveillance of late-onset fetal growth restriction. American journal of obstetrics and gynecology. 2018 Feb 1;218(2):S790-802.
7. Mourtzakis M, Parry S, Connolly B, Puthucheary Z. Skeletal muscle ultrasound in critical care: a tool in need of translation. Annals of the American Thoracic Society. 2017 Oct;14(10):1495-503.
8. James JN, Schlieder DW. Prenatal counseling, ultrasound diagnosis, and the role of maternal-fetal medicine of the cleft lip and palate patient. Oral and Maxillofacial Surgery Clinics. 2016 May 1;28(2):145-51.
9. Nagarajan M, Sharbidre KG, Bhabad SH, Byrd SE. MR imaging of the fetal face: comprehensive review. Radiographics. 2018 May;38(3):962-80.
10. Merz E, Abramovicz J, Baba K, Blaas HG, Deng J, Gindes L, Lee W, Platt L, Pretorius D, Schild R, Sladkevicius P. 3D imaging of the fetal face–recommendations from the International 3D Focus Group. Ultraschall in der Medizin-European Journal of Ultrasound. 2012 Apr;33(02):175-82.
11. Parkarwar PC, Khairnar S, Bhagwat V. Advanced Imaging In Dentistry. OrangeBooks Publication; 2021 Dec 21.
12. Hwang S, Jeong S, Choi YJ, Chung CJ, Lee HS, Kim KH. Three-dimensional evaluation of dentofacial transverse widths of adults with various vertical facial patterns. American Journal of Orthodontics and Dentofacial Orthopedics. 2018 May 1;153(5):692-700.
13. Kim SH, Choi BI. Three-dimensional and four-dimensional ultrasound: techniques and abdominal applications. Journal of medical Ultrasound. 2007 Jan 1;15(4):228-42.
14. Wanyonyi SZ, Mutiso SK. Monitoring fetal growth in settings with limited ultrasound access. Best practice & research Clinical obstetrics & gynaecology. 2018 May 1;49:29-36.
15. Salomon LJ, Alfirevic Z, Berghella V, Bilardo C, Hernandez-Andrade E, Johnsen SL, Kalache K, Leung KY, Malinger G, Munoz H, Prefumo F. Practice guidelines for performance of the routine mid-trimester fetal ultrasound scan. Ultrasound in Obstetrics & Gynecology. 2011 Jan;37(1):116-26.
16. Hadlock FP, Harrist RB, Sharman RS, Deter RL, Park SK. Estimation of fetal weight with the use of head, body, and femur measurements—a prospective study. American journal of obstetrics and gynecology. 1985 Feb 1;151(3):333-7.
17. Basha AS, Abu-Khader IB, Qutishat RM, Amarin ZO. Accuracy of sonographic fetal weight estimation within 14 days of delivery in a Jordanian population using Hadlock formula 1. Medical Principles and Practice. 2012;21(4):366-9.

18. Yang SW, Chae SH, Kim SR, Hong YH, Dong M, Kim HS, Kwon HS, Sohn IS, Hwang HS. Clinical Significance of Fetal Subcutaneous Thickness via Ultrasonography Biometry in the Third Trimester for Estimating Fetal Birth Weight. Perinatology. 2019 Dec 1;30(4):187-92.
19. Larkin JC, Hill LM, Speer PD, Simhan HN. Risk of morbid perinatal outcomes in small-for-gestational-age pregnancies: customized compared with conventional standards of fetal growth. Obstetrics & Gynecology. 2012 Jan 1;119(1):21-7.
20. Chambliss LR, Clark SL. Paper gestational age wheels are generally inaccurate. American Journal of Obstetrics and Gynecology. 2014 Feb 1;210(2):145-e1.
21. Goel P, Singla M, Ghal R, Jain S, Budhiraja V, Babu CR. Transverse cerebellar diameter-a marker for estimation of gestational age. Journal of anatomical society of India. 2010 Dec 1;59(2):158-61.
22. Louis GM, Grewal J, Albert PS, Sciscione A, Wing DA, Grobman WA, Newman RB, Wapner R, D’Alton ME, Skupski D, Nageotte MP. Racial/ethnic standards for fetal growth: the NICHD Fetal Growth Studies. American journal of obstetrics and gynecology. 2015 Oct 1;213(4):449-e1.
23. Davies MW, Swaminathan M, Betheras FR. Measurement of the transverse cerebellar diameter in preterm neonates and its use in assessment of gestational age. Australasian radiology. 2001 Aug 15;45(3):309-12.
24. Shaheen JD, Hershkovitz R, Mastrolia SA, Charach R, Eshel R, Tirosh D, Shaheen N, Baron J. Estimation of fetal weight using Hadlock's formulas: Is head circumference an essential parameter?. European Journal of Obstetrics & Gynecology and Reproductive Biology. 2019 Dec 1;243:87-92.