Original Research Article

Fetal kidney length as a parameter for gestational age determination and its comparative evaluation with other fetal biometric indices

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Abstract

Background: An accurate estimation of foetal gestation age is of utmost clinical significance owing to its vast clinical implications principally in management of high risk pregnancies.
Aim: To determine correlation and regression coefficient of foetal kidney length as a parameter for gestational age and to do its comparative evaluation with other foetal biometric indices.
Materials and methods: A Prospective observational study was conducted on 200 women aged between 18 to 35 years with normal singleton pregnancies, over a duration of six months from December 2015 to May 2016. Gestational age and fetal kidney length was determined using Ultrasound machine PHILIPS HD7 (2.0.1) with 3- 5 MHz curvilinear transducer. Statistical analysis was done using tests of correlation and simple linear regression. All analysis was done by using IBM SSPS statistics 24and MS excel.
Results: Pearson's correlation coefficient value of 0.99 and regression coefficient or slope 1.0 noted between gestational age and fetal kidney length with a significance P< 0.001.

Conclusions: Fetal kidney length shows a positive correlation with fetal gestational age, with a linear growth rate throughout pregnancy irrespective of underlying medical condition like intrauterine growth retardation. This study shall prove its worth in cases of engaged fetal head, where it is difficult to measure fetal bi parietal diameter and head circumference as well as in cases of intrauterine growth retardation, macrosomia and malformation where abdominal circumference measurement gives false values.

Key words

Correlation, Regression Coefficient, Fetal kidney length, Gestational age.

Introduction

An accurate estimation of foetal gestation age is of utmost clinical significance owning to its vast clinical implications principally in management of high risk pregnancies. In high risk pregnancies like preeclampsia, eclampsia, gestational diabetes mellitus, central placenta previa, Rh incompatibility, intrauterine growth retardation and chronic renal disease, termination of pregnancy is inevitable once the foetus attains its maturity, in cases of any unforeseen complications. Most of the ultrasound based screening tests, biochemical tests, serological tests are being carried at a specific gestational age, during pregnancy [1]. Expected date of delivery calculation based on last menstrual period has its own set of limitations leading to false calculations like vague menstrual history, pregnancy during lactational amenorrhea, first trimester bleeding per vagina and irregular menstrual cycle [2]. Symphysio fundal height in cm equals gestational age between 24 to 36 weeks, however a number of factor influences its measurement like gestational diabetes mellitus, multiple gestation, intrauterine growth retardation, and transverse foetal lie [3]. Among the various biometric indices for foetal gestational age assessment, most commonly used is Hadlock based composite gestational age assessment from bi parietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL). These biometric indices though most commonly used varies with underlying medical conditions like intrauterine growth retardation and shows potential discrepancies specially during assessment of gestational age in third trimester [4]. Fetal kidney length shows variation in its width and antero posterior dimensions, in some condition like intrauterine growth retardation, however its length shows no significant change with any underlying medical condition. Foetal kidney shows a steady growth of 1.7 mm throughout the pregnancy unaffected by any underlying growth abnormalities [5]. A number of independent studies carried out previously have shown a strong correlation with the gestational age in the third trimester. This prospective longitudinal study has been conducted emphasising on alleviating limitations of previous studies by taking both second and third trimester into account, left kidney and right kidney length variation, keeping it a double blind study and comparing its regression coefficient with other established biometric foetal indices for gestational age assessment.

Materials and methods

A prospective observational study was conducted on 200 women aged between 18 to 35 years with normal singleton pregnancies whose gestational age were confirmed by early ultrasound, over duration of six months from December 2015 to May 2016. Study was approved by institutional ethics committee and consent was obtained from all study participants. Ultrasound was performed on PHILIPS HD7 (2.0.1) using a 3- 5 MHz curvilinear transducer. Ultrasound was conducted by two radiologists with ample experience and under defined scanning parameters. All cases were scanned twice by ultrasound. Radiologist one determined the average gestational age using Hadlock's formula from foetal biometric indices viz, abdominal circumference, head

circumference, femur length, bi parietal diameter, as well as carried out foetal anomaly scan of all cases. Radiologist two measured the renal length. Both were unaware of the study.
Exclusion criteria included:

- Oligohydramnios or polyhydramnios
- >90th percentile or < 10th percentile of estimated fetal weight as per last menstrual period
- Dilated renal pelvis (> 4 mm)
- Chromosomal and congenital anomalies
- Abnormal renal morphology (nephromegaly, agenesis, hypoplasia, cyst, polycystic kidney, hydronephrosis etc.)
- Obscured adrenal and renal borders or margins
- Multiple pregnancies
- Gross maternal obesity
- Gestational diabetes mellitus
- Preeclampsia

Renal pelvic dilation up to 10 mm can be seen in normal fetus with no evidence of obstruction and vesico ureteric reflux; however more than 4 mm renal pelvic dilatation were excluded to avoid false positive and spuriously high renal length estimation [6]. Renal evaluation by ultrasound is difficult in first and second trimester, as there is an obscured renal margin, however it being a limitation factor in previous studies, all women with gestational age more than equal to 18 weeks were included in the study. Moving the probe caudally in transverse section just below the level for abdominal circumference measurement, kidneys are identified. Once kidneys are located probe was rotated longitudinally till full length of kidney was identified for its length calculation. Length was determined for both left and right kidney. The average of their length in millimeter was recorded as final measurement. The fetal kidney was measured from outer to outer margin as depicted in **Figure - 1 and 2** [7]. Statistical analysis was done using statistical package for social science (SPSS 24). Pearson's correlation and regression coefficient was calculated between gestational age and renal length as well as between gestational age and other fetal biometric indices. P value <0.05 was taken as significant.

Figure – 1: Kidneys are identified, moving the probe caudally in transverse section just below the level for abdominal circumference measurement. Once kidneys are located probe is rotated longitudinally till full length of kidney was identified for its length calculation. The fetal kidney was measured from outer to outer margin. Here the fetal kidney length was calculated as 17.8 mm and Hadlock based average gestational age was 18 weeks.

Figure – 2: Fetal kidney length measured from outer to outer margin was 33.2mm and Hadlock based average gestational age was 32 weeks and 4 days.

Results

Kidney length gives a reliable estimate of fetal gestational age. We noticed that the renal length in millimeters at any given gestational age corresponds to the gestational age of the fetus. It can be of immense significance in gestational age

determination without use of any software. Kidney shows a uniform increase in its length approximately by 1.7 mm every fortnightly. Both right and left kidneys were measured and its average was used for computation of renal length. Those cases where either of the kidneys was not adequately visualized were excluded from the study. In the present study mean fetal kidney length was 31.5 ± 5.7 mm with a range from 18 mm to 39.2 mm. We calculated Pearson's correlation coefficient between gestational ages determined by Hadlock formula with the fetal kidney length (**Table - 1**). There was a positive correlation between mean kidney length and gestational age as predicted by BPD, FL, AC and HC (P< 0.001). The correlation between gestational age and mean fetal kidney length is highly significant with Pearson's correlation coefficient value of 0.99 and significance being P< 0.001 as shown in **Table - 1**. **Table - 1** also illustrates an extremely strong correlation with other variables as well like with AC (r = 0.901), HC (r = 0.995), BPD (r = 0.990) and FL (r = 0.998). Scatter plots were drawn between gestational age (independent variable) and with all the dependent fetal biometric indices, to depict the best fit line, linear regression equation, its slope and intercept.

Table - 1: Correlation of gestational age with that of kidney length, abdominal circumference, head circumference, bi parietal diameter and femur length.

Correlations						
Variables	**Test statistics**	**AC**	**HC**	**BPD**	**Femur length**	**Kidney length**
Gestational age	Pearson Correlation	0.901**	.995**	.990**	.998**	.999**
	Sig. (2-tailed)	<0.001	<0.001	<0.001	<0.001	<0.001
	Number of subjects	200	200	200	200	200

**. Correlation is significant at the 0.05 level (2-tailed).

Regression coefficient or slope of kidney length is 1.0, abdominal circumference 1.04, head circumference 0.87, femur length 0.22, and bi parietal diameter 0.24 with respect to fetal gestational age as shown in **Graph – 1 to 5**.

Discussion

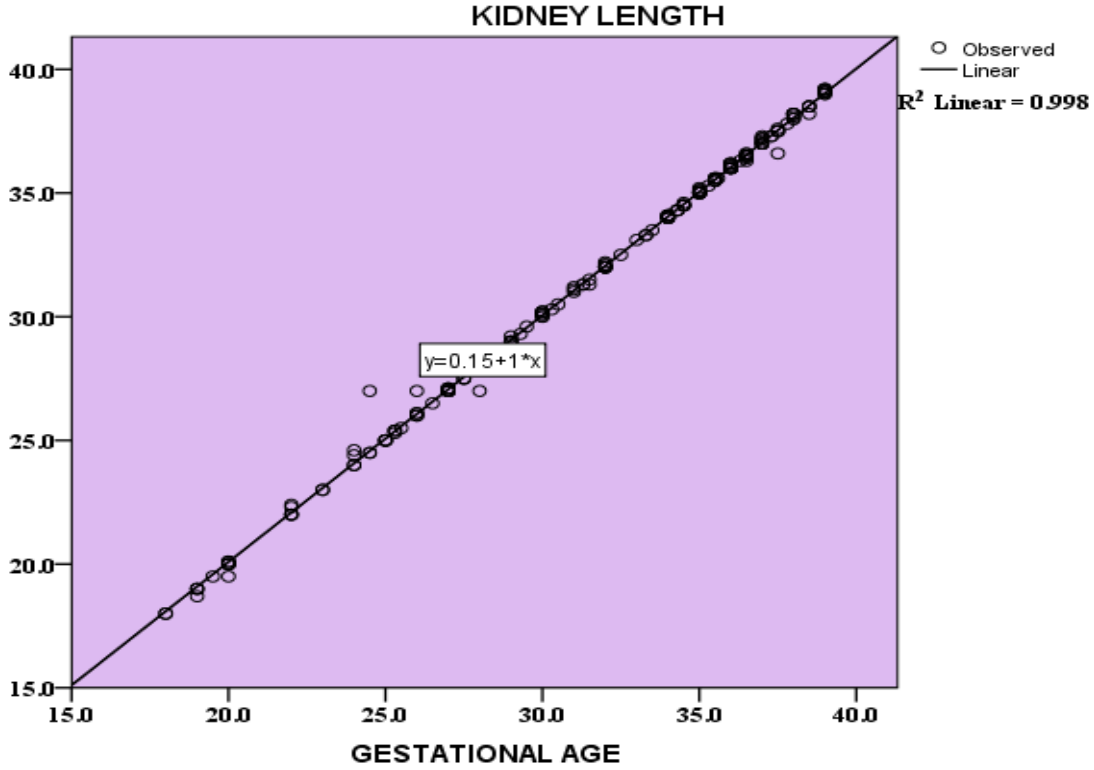
Estimation of an accurate gestational age is of utmost significance with varied clinical implications. It has been emphasized since long for a fetal biometric indices, which is not formula based, accurate, easy to calculate with hassle free interpretation and reproducible. Fetal growth variation affects all the organs including the anterio-posterior and transverse dimensions of kidney; however its length more or less remains constant [8, 9]. Even though on most of the cases the length of both the kidneys were almost similar, we preferred taking their average length into account for ruling out discrepancies due to right and left side length variation. The renal length in the present study showed a positive Pearson's correlation coefficient value of 0.99 and regression coefficient of 1.0 with that of gestational age determined by taking all other fetal biometric indices into account. This study shall prove its worth in cases of engaged fetal head, where it is difficult to measure fetal bi parietal diameter and head circumference as well as in cases of intrauterine growth retardation, macrosomia and malformation where abdominal circumference measurement gives false values. In above enlisted clinical scenarios measurement of fetal kidney length shall give an accurate, hassle free, estimation of fetal gestational age. We compared the intercept and regression coefficient (slope) between previous and present study as illustrated in **Table - 2**. The present showed a positive Pearson's correlation and regression coefficient between kidney length and gestational age as compared to previous studies.

It may be due better quality of ultrasound machines with better resolution, observer bias. In future an average gestational can be computed taking all biometric indices into account including kidney length. With advancing gestational age renal outline becomes more distinctive due to increased deposition of echogenic perinephric fat [10]. Renal outline delineation may be cumbersome in case of maternal obesity and as well as due to obscuration from lower ribs and adrenal glands [11, 12]. Fetal kidney length (mean ± 2SD) predicted by gestational age calculated on the basis of linear regression equation was as per **Table – 3**.

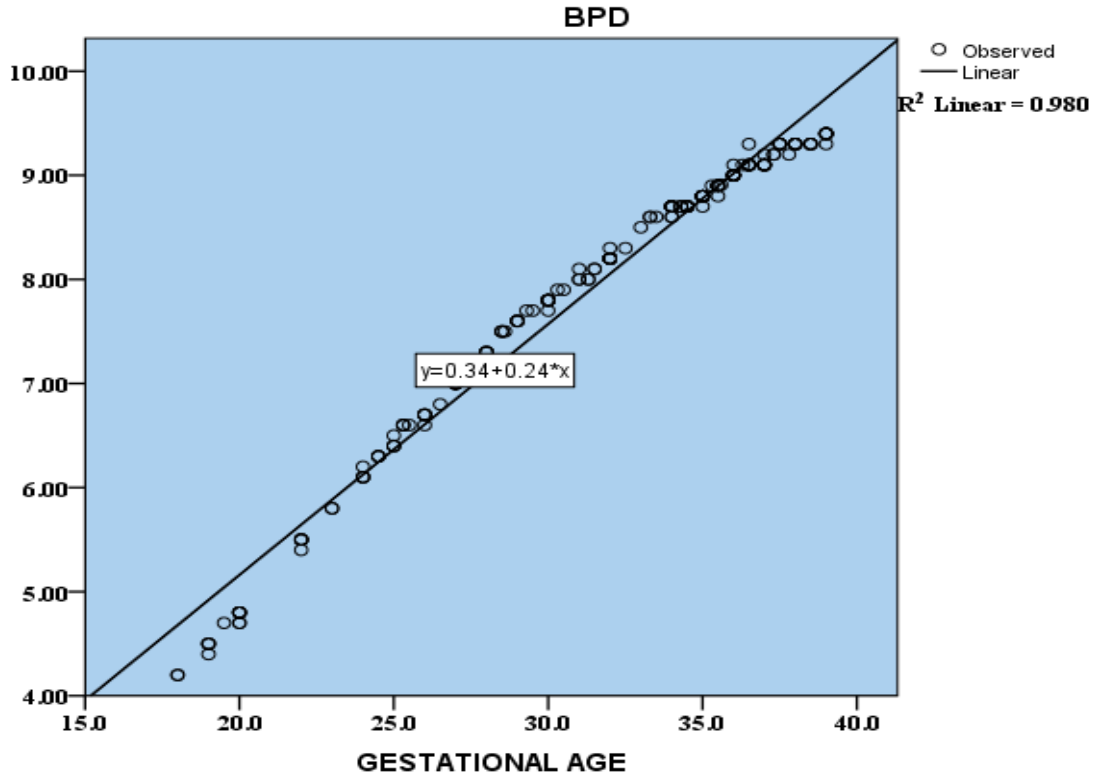
Table - 2: Comparison of intercept and regression coefficient of linear regression equation of kidney length and gestational age between present and past studies.

Study	Intercept estimate	Slope estimate	P value	R2
Present study	0.15	1.0	<0.001	0.99
Nahid Yusuf, et al. [13]	(intercept and slope not calculated) Pearson's correlation = 0.99		<0.001	0.99
Kansaria and Parulaker [5]	2.964	0.832	<0.001	0.90
Konje, et al. [14]	3.821	0.858	<0.001	0.97
Kuldeep Kumar, Rakhi Lalwani [15]	9.577	0.652	<0.001	0.97

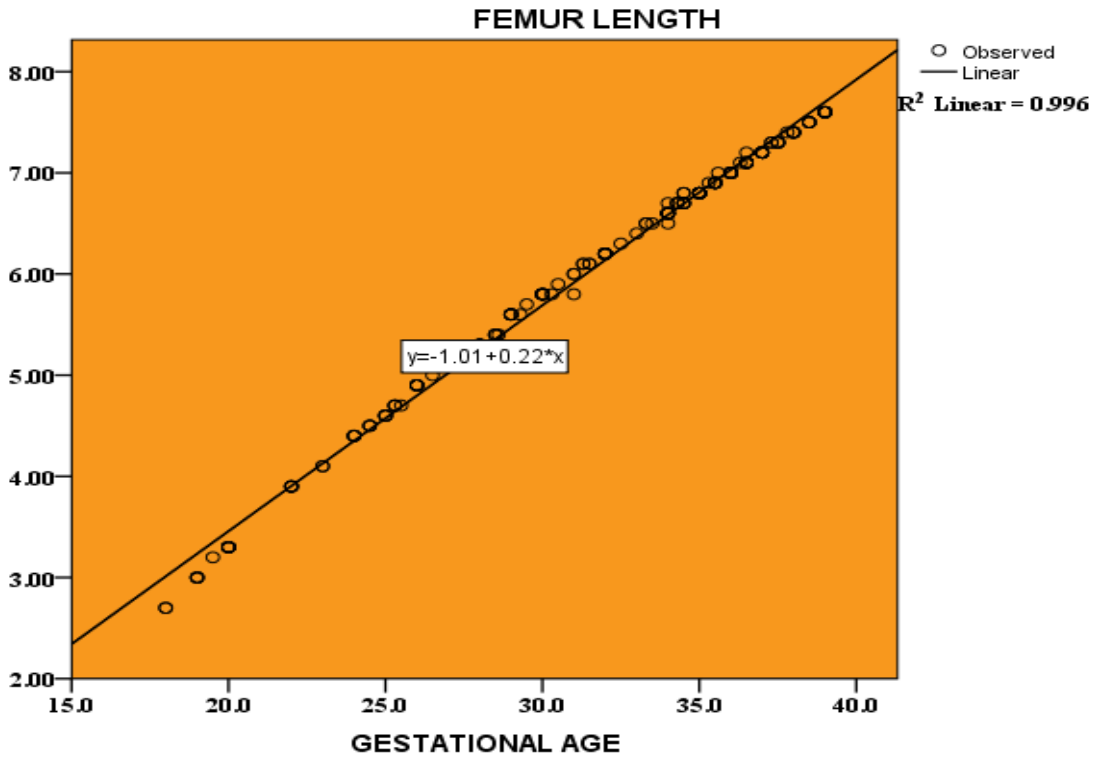
Graph – 1: Scatter plot between gestational age (independent variable) in weeks and kidney length (dependent variable) in mm, showing the best fit line with a linear regression equation of y = 0.15 +1x, where 0.15 is the intercept and 1 is the slope of regression coefficient.



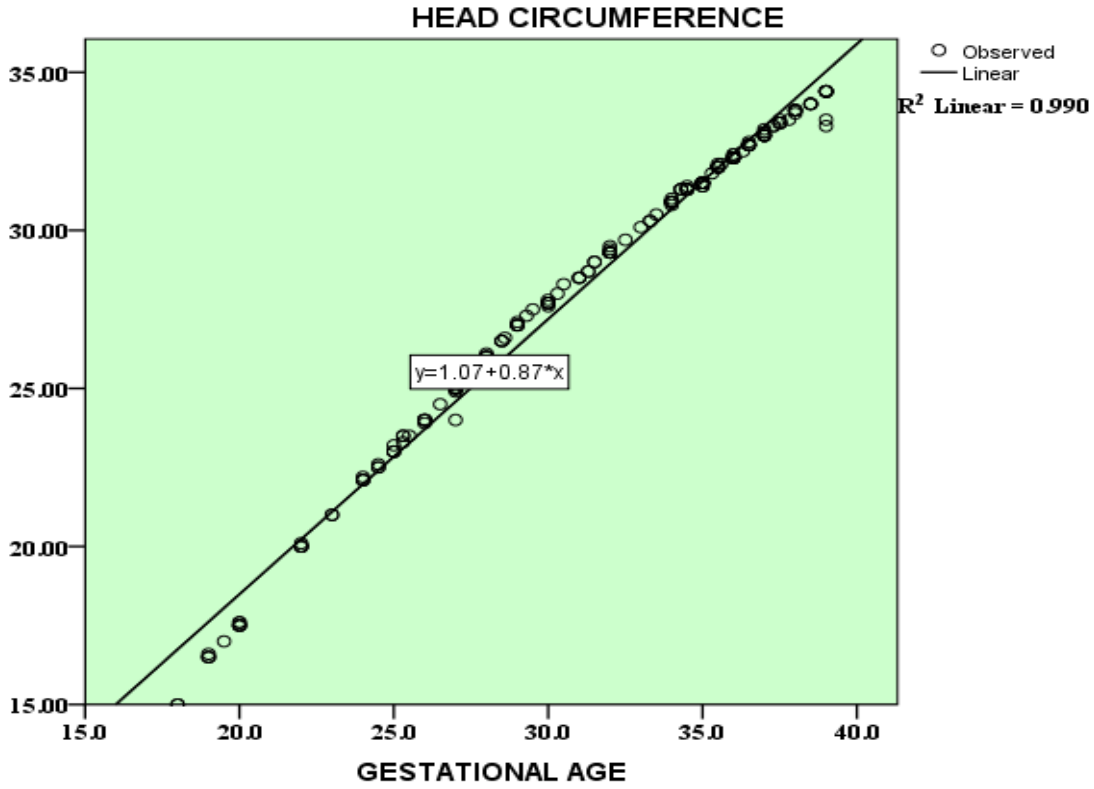
Graph – 2: Scatter plot between gestational age (independent variable) in weeks and bi parietal diameter (dependent variable) in cm, showing the best fit line with a linear regression equation of y = 0.34 +0.24x, where 0.34 is the intercept and 0.24 is the slope of regression coefficient.



Graph – 3: Scatter plot between gestational age (independent variable) in weeks and femur length (dependent variable) in cm, showing the best fit line with a linear regression equation of y = 1.01 +0.22x, where 1.01 is the intercept and 0.22 is the slope of regression coefficient.



Graph – 4: Scatter plot between gestational age (independent variable) in weeks and head circumference (dependent variable) in cm, showing the best fit line with a linear regression equation of y = 1.07 +0.87x, where 1.07 is the intercept and 0.87 is the slope of regression coefficient.



Graph – 5: Scatter plot between gestational age (independent variable) in weeks and abdominal circumference (dependent variable) in cm, showing the best fit line with a linear regression equation of y = 5.48 +1.04x, where 5.48 is the intercept and 1.04 is the slope of regression coefficient.

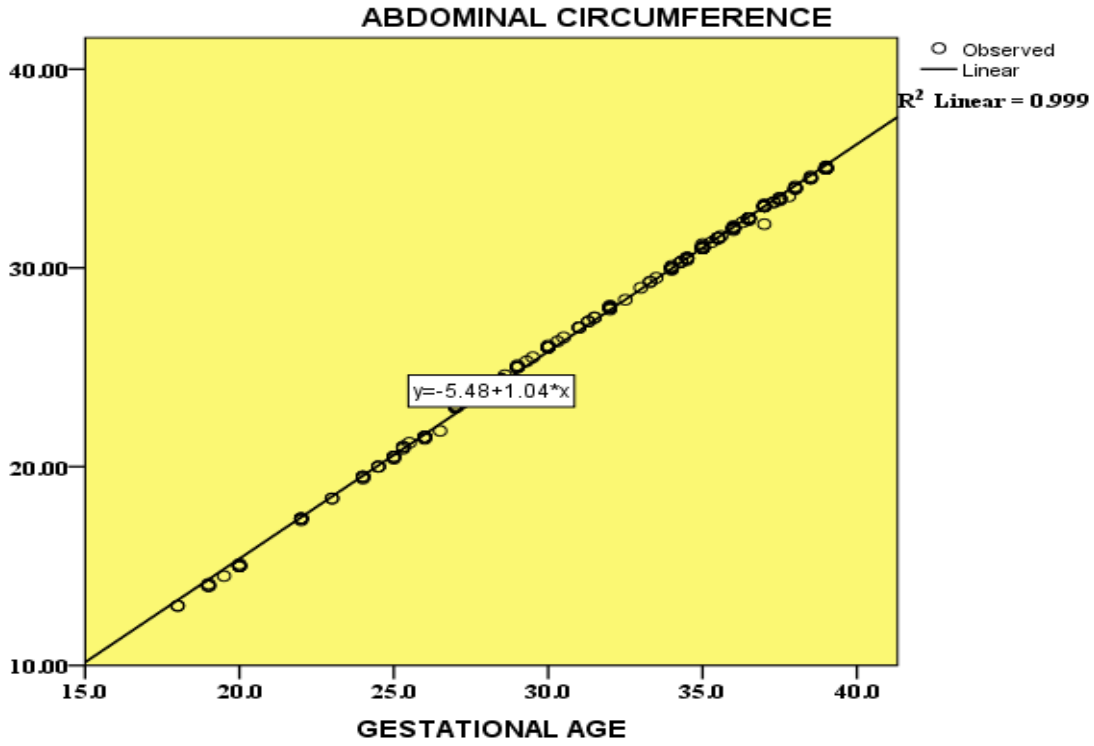


Table - 3: Fetal kidney length (mean ± 2SD) predicted by gestational age calculated on the basis of linear regression equation y= 0.15 + 1(x), where y is kidney length in mm, x is gestational age in weeks, 0.15 is the intercept and 1 is the regression coefficient and standard deviation (SD) is 6.5.

Gestational age (weeks)	Fetal kidney length (mm)		
	Mean - 2SD	Mean	Mean + 2SD
18	5.15	18.15	31.15
19	6.15	19.15	32.15
20	7.15	20.15	33.15
21	8.15	21.15	34.15
22	9.15	22.15	35.15
23	10.15	23.15	36.15
24	11.15	24.15	37.15
25	12.15	25.15	38.15
26	13.15	26.15	39.15
27	14.15	27.15	40.15
28	15.15	28.15	41.15
29	16.15	29.15	42.15
30	17.15	30.15	43.15
31	18.15	31.15	44.15
32	19.15	32.15	45.15
33	20.15	33.15	46.15
34	21.15	34.15	47.15
35	22.15	35.15	48.15
36	23.15	36.15	49.15
37	24.15	37.15	50.15
38	25.15	38.15	51.15
39	26.15	39.15	52.15

Conclusions

Fetal kidney length shows a strong correlation with fetal gestational age, with a steady growth rate throughout pregnancy irrespective of underlying medical condition like intrauterine growth retardation. This study shall prove its worth in cases of engaged fetal head, where it is difficult to measure fetal bi parietal diameter and head circumference as well as in cases of intrauterine growth retardation, macrosomia and malformation where abdominal circumference measurement gives false values.

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