Original Research Article

Sonological estimation of gestational age by measuring length of fetal kidney after 20 weeks of pregnancy in healthy women with uncomplicated pregnancy

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Abstract

Back ground and Objectives: In pregnant women accurate estimation of gestational age and dating is of paramount importance influencing the management. Methods to estimate the date of delivery in pregnancies should be simple and straightforward, irrespective of gestational age. Obstetrics sonography, because of its accuracy, plays a significant role in determination of gestational age. Fetal kidney length is emerging and claiming to be a new parameter and also it is more accurate in certain situations. **Methods:** This study was conducted in department of obstetrics and gynaecology, Institute of maternal & child health, Kozhikode during the period from December 2012 to October 2013. Obstetric sonography was performed in 179 women with uncomplicated pregnancy to evaluate the efficacy of FKL as a measure to calculate the predicted gestational age. Gestational age ranges from 20weeks to term. Only patients within inclusion criteria were taken for the study. Fetal biometry evaluated includes BPD, HC, AC, FL, FKL (Fetal kidney Length). **Results:** FKL correlate well with clinical gestational age, even though the correlation coefficient is slightly less than the other parameters. Overall in combined second and third trimester, FK GA correlates with gestational age with high correlation coefficient of 0.95 along with other parameters (BPD, HC, AC,FL) as the accurate parameters for assessing the gestational age. **Conclusion:** FKL correlated with other fetal biometric parameters and clinical gestational age. The correlation was found to be significant. Nomogram of the FKL shows that there is a linear relationship between the fetal kidney length growth and the gestational age. So FKL can be used as a reliable parameter for determination of gestational age along with other parameters.

Key Words: gestational age, Fetal kidney Length, BPD, HC, AC.

Introduction

Accurate assessment of gestational age is pivotal, to give quality maternity care. Failure can result in iatrogenic prematurity or post maturity of fetus, both being associated with increased perinatal morbidity and mortality. Obstetric sonography plays an important role in accurate estimation of intrauterine gestational age[1].

The last two decades have seen a tremendous progress in application of ultrasound as a diagnostic modality revolutionizing the management towards better care. This is particularly due to its noninvasive and non-ionizing nature besides its cost effectiveness leading to wider acceptability. The exemplary safety record of diagnostic ultrasound is probably an important reason that it has become so widely used[2].

Ultrasound is safe for the patient, the fetus and the sonologist. There is no reported risk of ionizing radiations as in X-rays[3], or any other known biological or embryo toxic effect. It does not require the injections such as radio opaque dyes as sometimes needed in radiology[4]. The single or repeated intrauterine exposure to ultrasound, early or late in pregnancy does not carry the risk of development of lymphatic or myeloid childhood leukemia[5], as is an adverse of x -rays. It is not associated with any harm to early fetal life, growth and vision or hearing during childhood[6]. Similarly no adverse effects have been observed on neurological development and subsequent school performance of the children[7].

Since the introduction of diagnostic ultrasound, more reliable approaches to the dating of pregnancies have developed. These include gestational sac diameter and crown rump length measurement in the first trimester, crown rump length measurement has been described to predict gestational age accurately with ± 4.7 days. In the second trimester, most commonly used biometric indices for dating pregnancies are the fetal biparietal diameter, head circumference, abdominal circumference and femur length, have also been used. Most of these methods can predict gestational age with a high degree of accuracy in the early second trimester.

However, as gestational age progress, they become increasingly unreliable because of the biological variability of size in relation to age. Accurate dating of pregnancies in the late second trimester or in the third trimester therefore remains a problem especially in women who consult late for maternity care and are uncertain of the date of their LMP.

There are conditions like oligohydramnios, multiple gestation, breech presentation, polyhydramnios, and intrauterine growth restriction (IUGR) that can alter the shape of the fetal skull which in turn can affect the BPD and increase the variability. Multiple gestations and IUGR can also affect the abdominal circumference and femur length measurements[6].

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The present study is undertaken to validate the fetal kidney length measurement as an additional morphological measurement of fetal growth with less variability. This measurement is easy to take and can therefore be easily incorporated in to the model for dating pregnancies.

Materials and methods

Prospective study was done in 179 healthy women with uncomplicated pregnancy between 20 weeks of gestation to term, from Institute of Maternal and Child Health, Government Medical College, Kozhikode. The study period is for 10 months from December 2012 to October 2013.

Measurements are obtained in the sagittal plane, when full length of kidney with renal pelvis is visualized, maximum length of anyone single fetal kidney is measured from upper pole to lower pole atleast thrice and mean of the measurement is taken.

Inclusion Criteria

Healthy women with uncomplicated pregnancy between 20 weeks of gestation to term.

Exclusion Criteria

- Before 20 weeks of gestational age.
- Unknown or inaccurate date of last menstrual period.
- Oligohydramnios.
- Polyhydramnios.
- Diabetic mother.
- Pregnancy induced hypertension.
- Pre eclampsia.
- Multiple gestations.
- Fetal chromosomal abnormalities.
- Fetal anomalies.
- Intrauterine growth restriction.

Ethical Clearance

The study required to perform obstetric ultrasonography on normal pregnant women. Ethical clearance was obtained from the institutional ethical review committee of Government Medical College, Kozhikode.

Examination Method

All relevant clinical history was obtained and the correct LMP was confirmed. An ultrasonography was performed in the Department of Radio diagnosis, Institute of Maternal and Child Health, Government Medical College, Kozhikode, using SIEMENS ACUSON X 300 and MINDRAY DP 50 ultrasound scanner with a 3.5 MHZ convex probe.

Figure 1: Siemens Acuson X 300

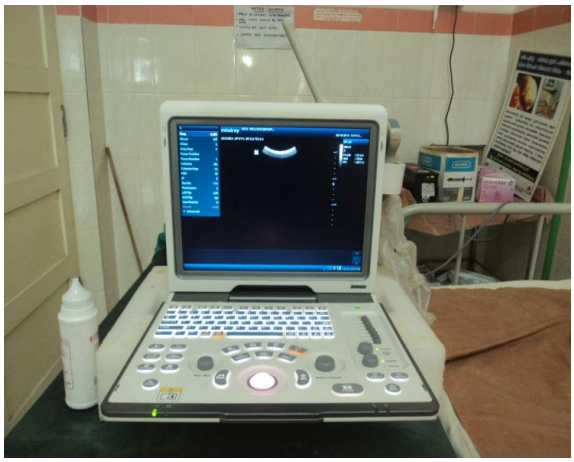

Figure 2: Mindray DP 50

In all the patients following parameters were obtained. They are BPD, HC, AC, FL, FKL, Fetal heart rate, estimated fetal weight, AFI and placental position.

Plane used for measuring BPD and HC were sections through the third ventricle and thalami. Cavum septi pellucidum must be visible in the anterior portion of the brain and the tentorial hiatus must be visible in the posterior portion of the brain. The cursors are positioned in outer edge of near calvarial wall to inner edge of far calvarial wall for BPD. For HC the cursor are positioned in outer edge of the near calavarial wall and the outer edge of the far calvarial wall.

AC was taken in the plane showing the umbilical vein perpendicular to the fetal spine and the stomach bubble.

The FL was obtained by aligning the transducer to the long axis of the diaphysis. Measurement cursors are placed at the junction of the cartilaginous epiphysis and bone and thin bright reflection of the cartilaginous epiphysis should not be included.

Fetal kidney length was obtained in the sagittal plane, when full length of kidney with renal pelvis is visualized. Maximum length of anyone single fetal kidney is measured from upper pole to lower pole at least thrice and mean of the measurements is taken.

Statistical methods

Descriptive statistical analysis has been carried out in the present study. Results on continuous measurement are presented on mean ± SD (Min-Max) and results on categorical measurements are presented in number (%). Gestational age obtained using fetal kidney was compared with gestational age obtained from individual parameters such as biparietal diameter, head circumference, abdominal circumference and femoral length using Student's 't' test and correlation among these parameters was assessed by using the Pearson's correlation coefficient. A two-tailed p-value less than 0.05 were considered as significant.

Results

Table 1: Maternal age distribution

Age (years)	Frequency	Percentage
<20	3	1.7 %
20-24	102	57.0 %
25-29	57	31.8 %
30-34	12	6.7 %
>34	5	2.8 %
Total	179	100%

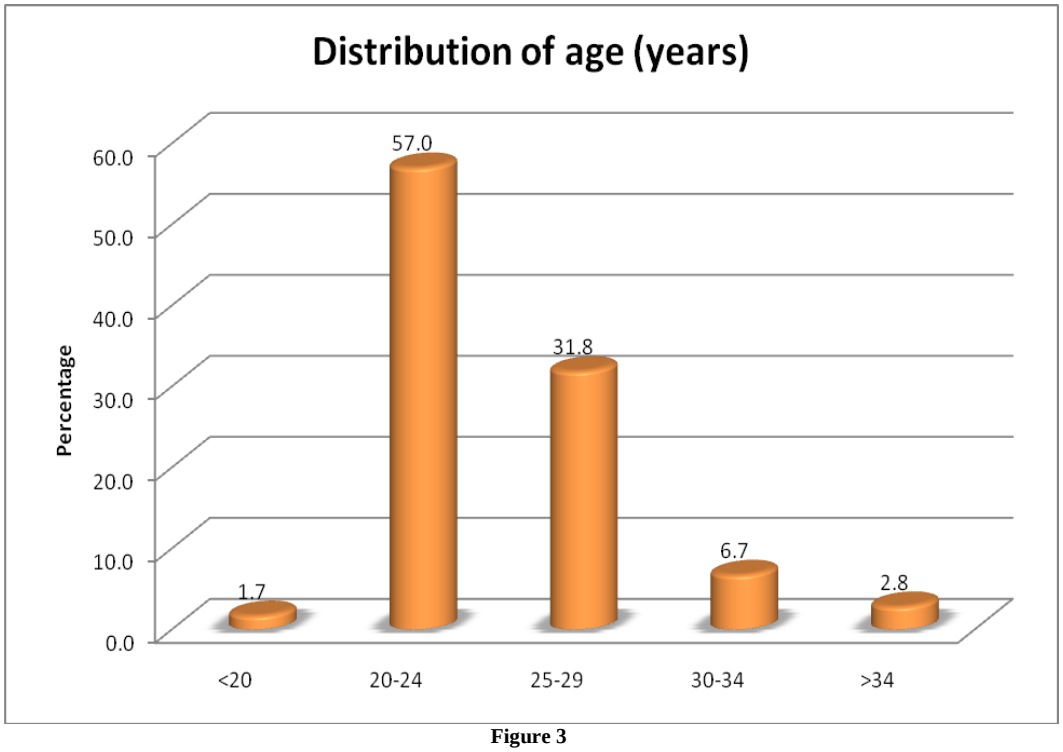

Figure 3

The trimester distributions of the 179 pregnant women who are included in the study are:

Table 2: Distribution according to trimester

Trimester	Frequency
2nd	92
3rd	87
Total	179

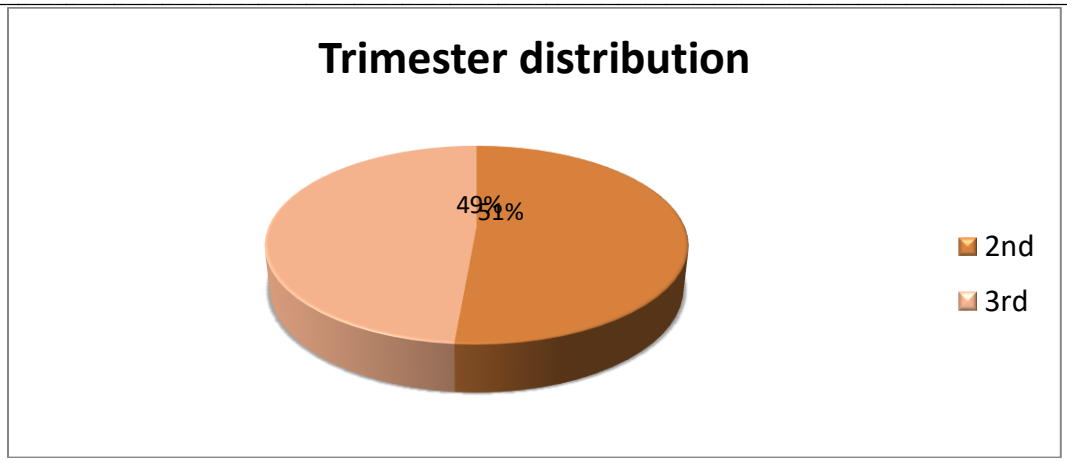

Figure 4

Table 3: Correlation between fetal kidney gestation age and BPD

	Mean ± SD	Mean difference	95 % CI for difference	t-value	p-value
FK GA	26.20 ± 5.92	1.41	-3.86 - 1.04	1.14	0.257
BPD	27.6 ± 15.6				

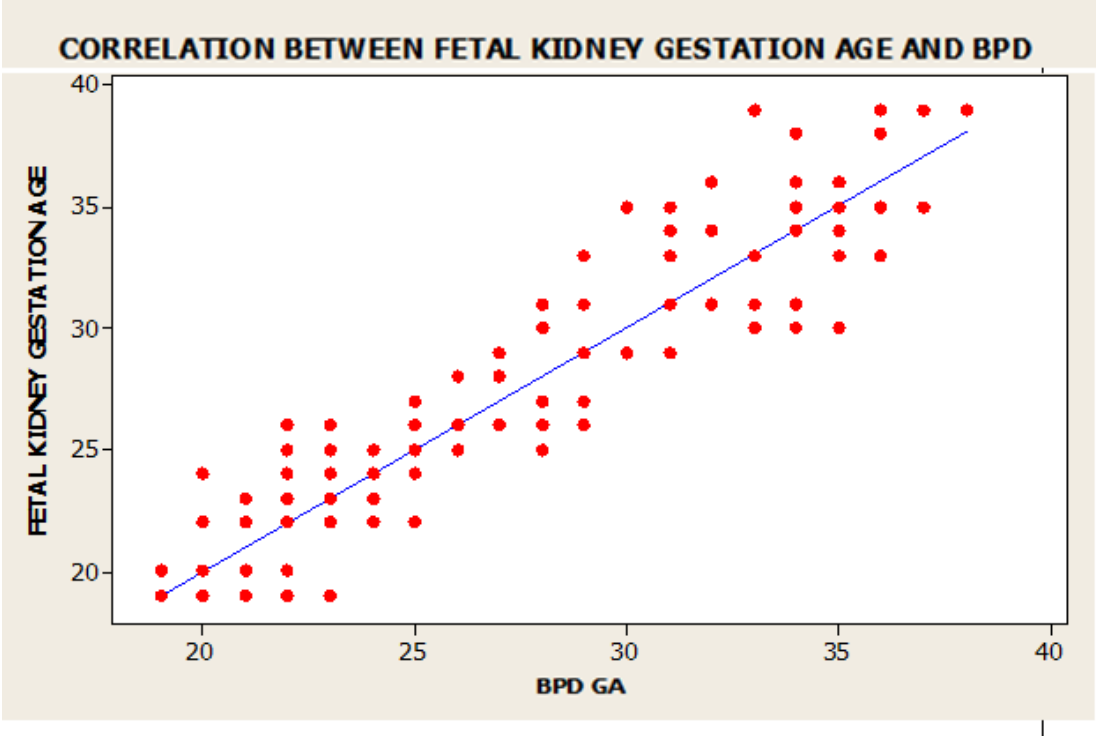

Figure 5

Table 4: Correlation between fetal kidney gestation age and FL

	Mean ± SD	Mean difference	95 % CI for difference	t-value	p-value
FK GA	26.20 ± 5.92	0.033	-1.22 - 1.16	0.06	0.96
FL	26.23 ± 5.54				

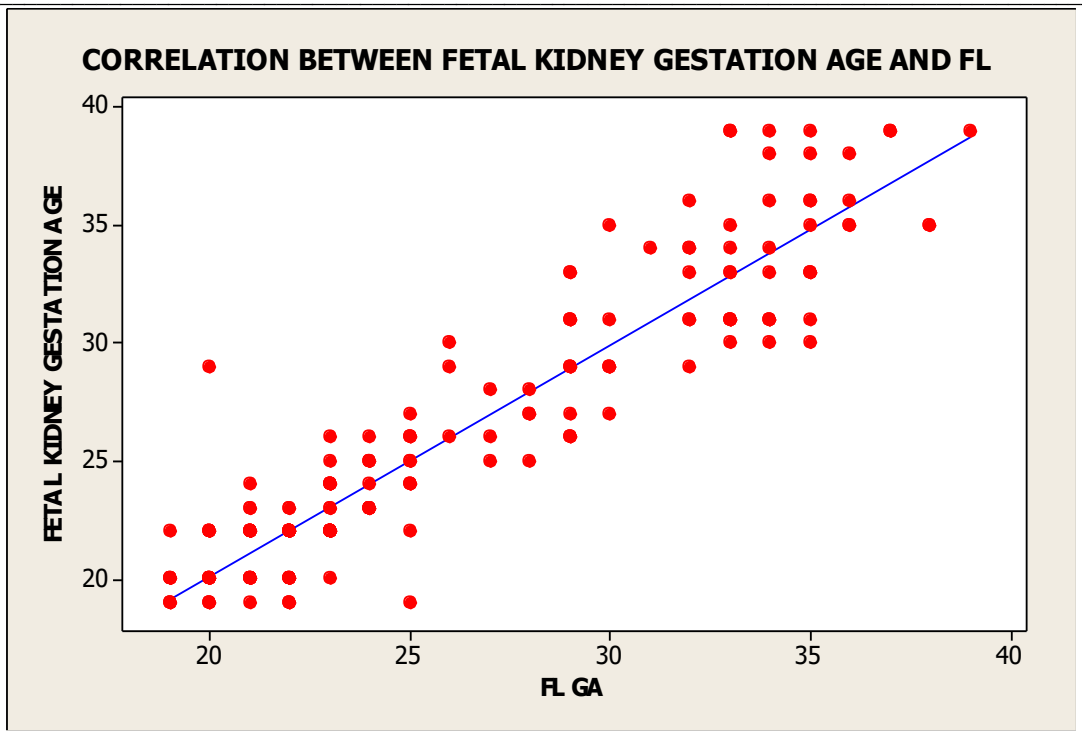

Figure 6

Table 5: Correlation between fetal kidney gestation age and HC

	Mean ± SD	Mean difference	95 % CI for difference	t-value	p-value
FK GA	26.20 ± 5.92	0.10	-1.32 - 1.11	0.16	0.87
HC	26.30 ± 5.74				

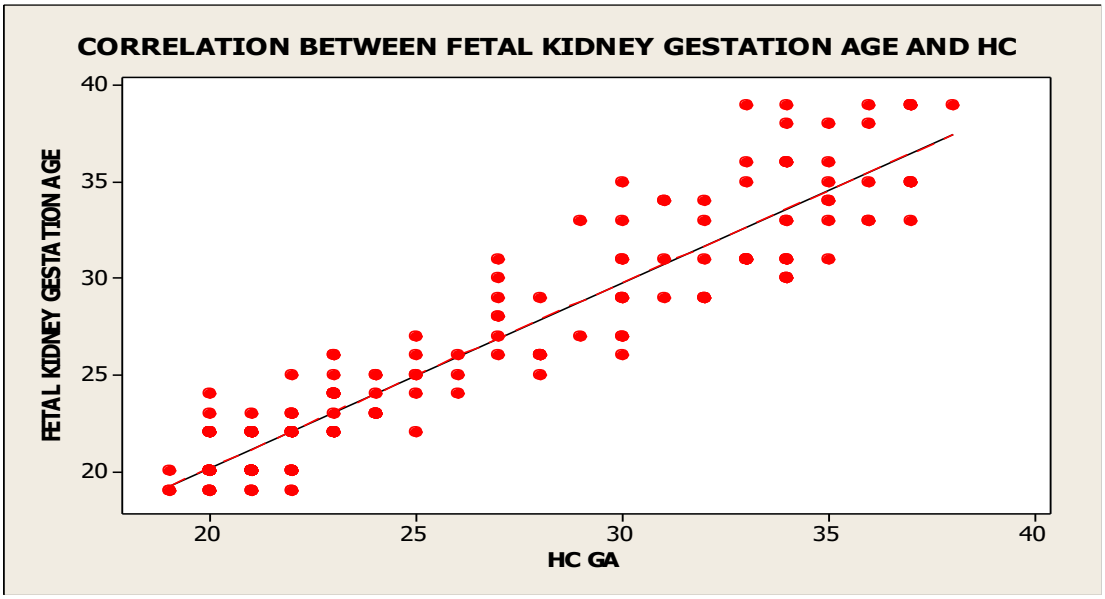

Figure 7

Table 6: Correlation between fetal kidney gestation age and AC

	Mean ± SD	Mean difference	95 % CI for difference	t-value	p-value
FK GA	26.20 ± 5.92	0.033	-1.15 - 1.22	0.06	0.96
AC	26.17 ± 5.49				

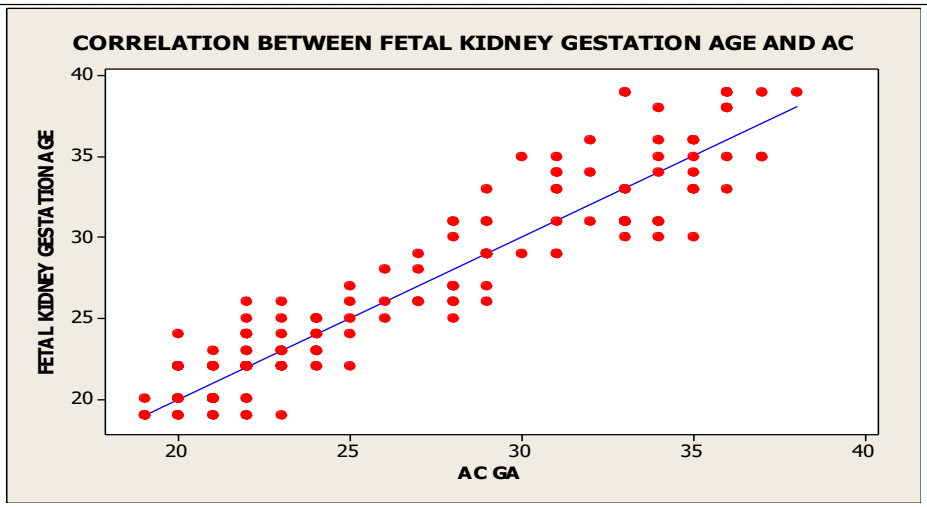

Figure 8

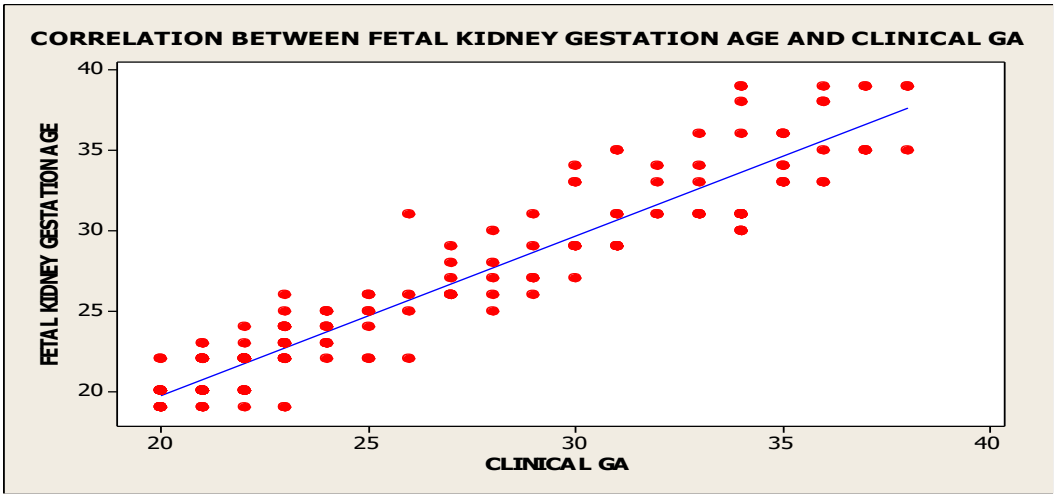

Figure 9

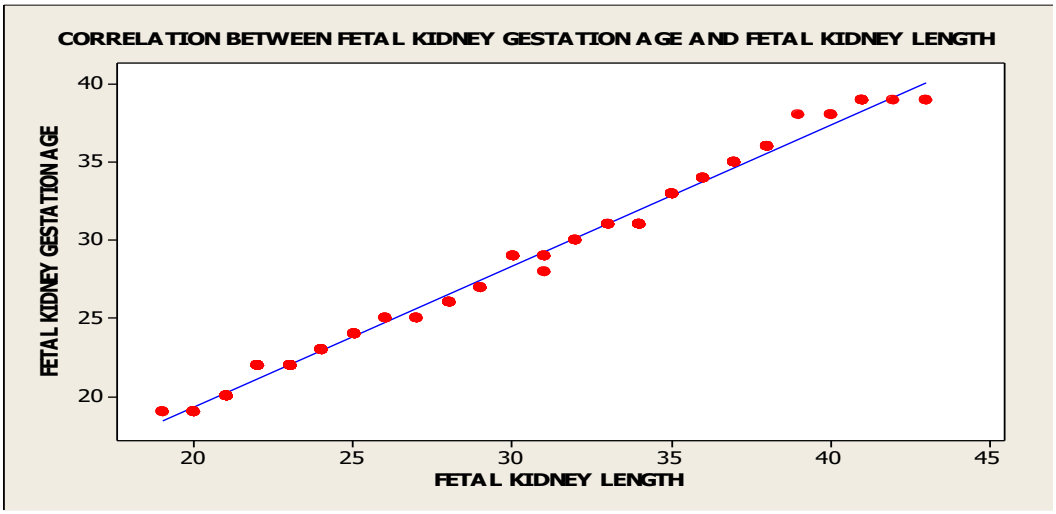

Figure 10

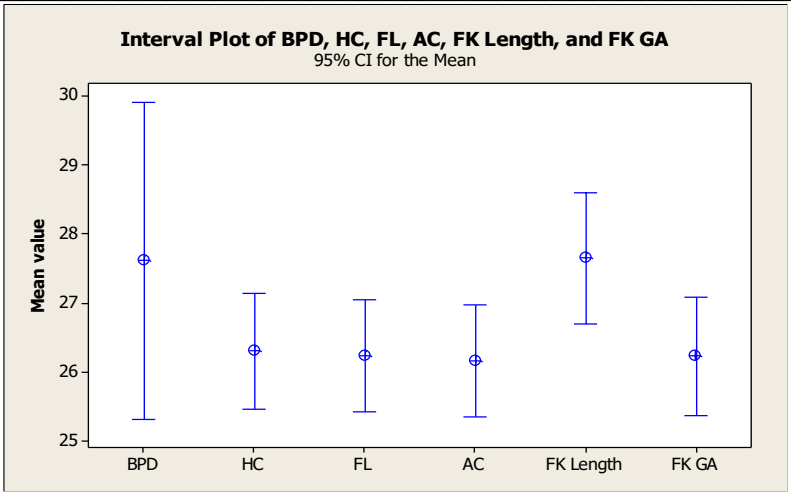

Figure 11

Table 7: Mean fetal kidney length according to Fetal kidney Gestational age

Gestational age (weeks)	Number	Fetal Kidney length (mm)		
		Mean	SD	95 % CI
19	11	19.73	0.47	19.41 - 20.04
20	25	21.00	0.00	21.0 - 21.0
22	34	22.50	0.51	22.32 - 22.67
23	11	24.00	0.00	24.0 - 24.0
24	10	25.00	0.00	25.0 - 25.0
25	8	26.50	0.53	26.05 - 26.95
26	10	28.00	0.00	28.0 - 28.0
27	5	29.00	0.00	29.0 - 29.0
28	2	31.00	0.00	31.0 - 31.0
29	9	30.44	0.53	30.04 - 30.85
30	4	32.00	0.00	32.0 - 32.0
31	14	33.71	0.47	33.44 - 33.98
33	9	35.00	0.00	35.0 - 35.0
34	5	36.00	0.00	36.0 - 36.0
35	7	37.00	0.00	37.0 - 37.0
36	5	38.00	0.00	38.0 - 38.0
38	3	39.67	0.58	38.24 - 41.10
39	7	41.71	0.95	40.83 - 42.59

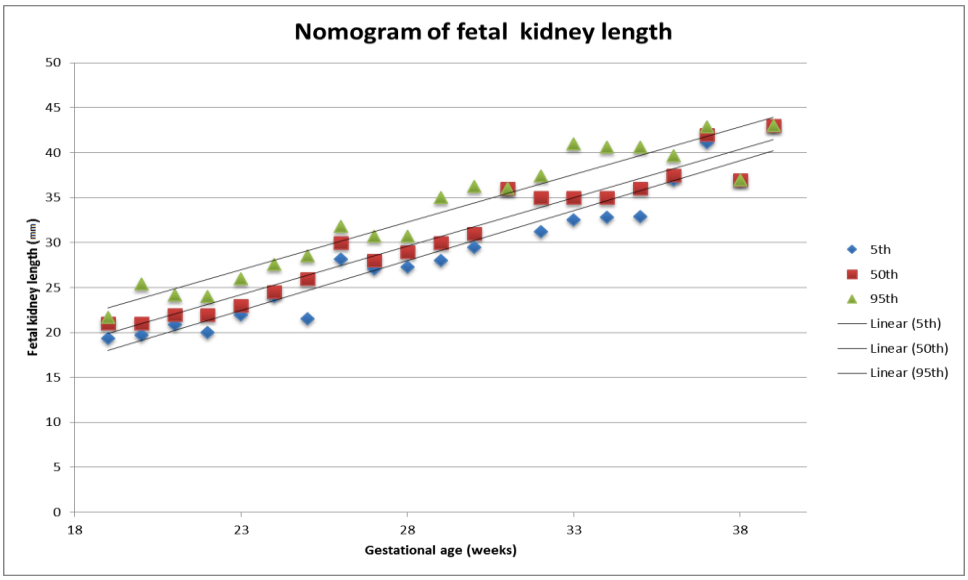

Figure 12

Table 8: Nomogram for present study

FK GA (weeks)	5th percentile	50th percentile	95th percentile
19	19.35	21	21.65
20	19.7	21	25.4
21	20.85	22	24.15
22	20	22	24
23	22	23	26
24	24	24.5	27.55
25	21.5	26	28.5
26	28.2	30	31.8
27	27.1	28	30.7
28	27.3	29	30.7
29	28	30	35
30	29.5	31	36.25
31	36	36	36
32	31.2	35	37.4
33	32.5	35	41
34	32.8	35	40.6
35	32.9	36	40.65
36	37	37.5	39.7
37	41.1	42	42.9
38	37	37	37
39	43	43	43

Statistical analysis

Gestational age obtained using fetal kidney was compared with gestational age obtained from individual parameters such as biparietal diameter, head circumference, abdominal circumference and femoral length using Student's 't' test and correlation among these parameters was assessed by using the Pearson's correlation coefficient. A two-tailed p-value less than 0.05 were considered as significant. Data was analyzed by using software SPSS.

Table 9: Correlation co-efficient of FK GA with Clinical GA, BPD, HC, AC, FL

Pair	Pearson's correlation co-efficient (r)	p-value
Clinical GA	0.948	<0.0001
BPD	0.296	<0.0001
HC	0.94	<0.0001
FL	0.931	<0.0001
AC	0.944	<0.0001
FK length	0.996	<0.0001

The above mentioned table denotes the association between the fetal measurement and FK GA. The correlation was best for FK GA vs FK (0.996) and least for FK GA vs BPD (0.296). All the correlations were statistically significant.

Table 10: Correlation co-efficient of Clinical GA with BPD, HC, AC, FL, FK GA

Pair	Pearson's correlation co-efficient (r)	p-value
BPD	0.318	<0.0001
HC	0.983	<0.0001
FL	0.968	<0.0001
AC	0.980	<0.0001
FK length	0.953	<0.0001
FK GA	0.948	<0.0001

The above mentioned table denotes the association between the Clinical GA and FK GA. The correlation was best for clinical GA vs. HC (0.983) and least for FK GA vs. BPD (0.318). All the correlations were statistically significant.

Table 11: Mean fetal kidney length according to fetal kidney Gestational age

Gestational age (weeks)	Number	Fetal Kidney length (mm)		
		Mean	SD	95 % CI
19	11	19.73	0.47	19.41 - 20.04
20	25	21.00	0.00	21.0 - 21.0
22	34	22.50	0.51	22.32 - 22.67
23	11	24.00	0.00	24.0 - 24.0
24	10	25.00	0.00	25.0 - 25.0
25	8	26.50	0.53	26.05 - 26.95
26	10	28.00	0.00	28.0 - 28.0
27	5	29.00	0.00	29.0 - 29.0
28	2	31.00	0.00	31.0 - 31.0
29	9	30.44	0.53	30.04 - 30.85
30	4	32.00	0.00	32.0 - 32.0

31	14	33.71	0.47	33.44 - 33.98
33	9	35.00	0.00	35.0 - 35.0
34	5	36.00	0.00	36.0 - 36.0
35	7	37.00	0.00	37.0 - 37.0
36	5	38.00	0.00	38.0 - 38.0
38	3	39.67	0.58	38.24 - 41.10
39	7	41.71	0.95	40.83 - 42.59

Table 12: Predicted Mean Fetal kidney length according to Fetal kidney Gestational age

Fetal Kidney length (mm)	Number	Fetal Kidney Gestational age in weeks		
		Mean	SD	95 % CI
19	3	19.00	0.00	19.0 - 19.0
20	8	19.00	0.00	19.0 - 19.0
21	25	20.00	0.00	20.0 - 20.0
22	17	22.00	0.00	22.0 - 22.0
23	17	22.00	0.00	22.0 - 22.0
24	11	23.00	0.00	23.0 - 23.0
25	10	24.00	0.00	24.0 - 24.0
26	4	25.00	0.00	25.0 - 25.0
27	4	25.00	0.00	25.0 - 25.0
28	10	26.00	0.00	26.0 - 26.0
29	5	27.00	0.00	27.0 - 27.0
30	5	29.00	0.00	29.0 - 29.0
31	6	28.67	0.52	28.12 - 29.03
32	4	30.00	0.00	30.0 - 30.0
33	4	31.00	0.00	31.0 - 31.0
34	10	31.00	0.00	31.0 - 31.0
35	9	33.00	0.00	33.0 - 33.0
36	5	34.00	0.00	34.0 - 34.0
37	7	35.00	0.00	35.0 - 35.0
38	5	36.00	0.00	36.0 - 36.0
39	1	38.00	0.00	38.0 - 38.0
40	2	38.00	0.00	38.0 - 38.0
41	4	39.00	0.00	39.0 - 39.0
42	1	39.00	0.00	39.0 - 39.0
43	2	39.00	0.00	39.0 - 39.0

The Regression equation is,
Fetal kidney gestation age = 1.35 + (0.9 x Fetal kidney length)
The R value is 0.996, which represents the strong correlation and, therefore, indicates a high degree of correlation. The R^2 value indicates how much of the dependent variable, fetal kidney length, can be explained by the independent variable, fetal kidney gestation age (weeks). In this case, 99.2% can be explained, which is very large.
Overall, the model applied is significantly good enough in predicting the outcome variable.

Discussion

Estimating accurate gestational age is of paramount importance and the cornerstone for management of pregnancies. Method to estimate the date in pregnancies should be simple and straightforward, irrespective of GA. Accurate and easily reproducible sonographic fetal biometric parameters for gestational dating are clinically important for the optimal obstetric management of pregnancies. This is especially true in determining timing of a variety of gestational tests, assessing adequacy of growth of fetus and timing of delivery for the optimal obstetric outcome[7].
In my prospective study of 179 healthy women with uncomplicated pregnancy suggestive of correlation between the gestational age and FKL. A linear relationship was found between the fetal kidney growth measured in mm and the gestational age in weeks during 2nd to 3rd trimester. The relationship of fetal kidney growth and gestational age is statistically significant. Many studies have been conducted to assess the variability in gestational age determination from FKL in second and third trimester and result showed significant correlation. In my study, this linear relationship has been established between 2nd to 3rd trimester and correlating well with clinical gestational age. In my study, FK GA correlates well with clinical gestational age with correlation coefficient of 0.95 from the 2nd to 3rd trimester, even though the correlation coefficient is slightly less than the other parameters. Overall in combined second and third trimesters, FK GA correlates with clinical gestational age with high correlation coefficient of 0.95 along with other parameters (BPD, HC and AC) as the accurate parameters for assessing the gestational age[8].
Although all the fetal organs, are affected by growth variation, the kidney size also appear to predominantly affect only antero-posterior and transverse diameters, but the length of kidney remains largely unchanged in small for gestational age fetus. Knowledge of these measurements may allow earlier diagnosis of variety of renal abnormalities as well as accurate estimation of gestational age.
FKL measurement has also been used to predict mean gestational age in different ethnic groups. Fetal kidney length is not independent of ethnic origin of patient. Nomogram for FKL can be developed for different countries and races to predict gestational age for a particular ethnic population. In my study, all the patients were of Indian origin and the nomogram for predicting gestational age from FKL was obtained. The values for the fetal kidney length at different gestational age was higher than the study of those reported by Cohen et al[41] and Jeanty et al[59,60]. My study also showed that kidney length in mm is approximately the same as the gestational age in weeks[9].
In my study, charts of fetal kidney were derived from cross sectional data. They are appropriate for comparing renal size at a known gestational age with reference data. They are not suitable for judging the appropriateness of growth of kidneys across time.

My study hence only validates the recommendation that the fetal kidney length can be used as an important sonographic parameter for accurate prediction of fetal gestational age.

The results of my study and previously published studies on FKL shows that additional small improvements in accurate gestational dating can be achieved by incorporating the other fetal biometric parameters (Bi-parietal diameter, head circumference, femur length, abdominal circumference) with the fetal kidney length. Nevertheless, the best combination of biometric measurement remains to be determined[10].

Conclusion

With the advent of high resolution and higher machines with advanced Fourier transformation in technology, the ability of ultrasound for higher and in depth study of abdominal organs along with fetal descriptors of intrauterine anatomy has been improved.

The obstetric scan has also advanced from 2D to 3D and 4D technology leading us to describe new parameters like fetal kidney length, trans-cerebellar diameter, bipolar diameter of kidney, which helps to estimate gestational age apart from the common parameters like BPD, HC, AC, FL.

My study shows that FKL positively correlated with BPD, HC, AC and FL. Nomogram of the FKL shows that there is a linear relationship between the fetal kidney length and the gestational age. FKL can be used as a reliable parameter for determination of gestational age.

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