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Fetal kidney length as a parameter for determination of gestational age after 20th week in healthy women with uncomplicated pregnancy

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***Abstract*---**Aim: To check the accuracy of Fetal Kidney Length (FKL) in the estimation of Gestational Age (GA). Materials and Methods: The present prospective cross sectional study was conducted in Max Super Specialty Hospital, Mohali, Punjab, India. The subjects were selected from the patients visiting the department of Radio diagnosis on in-patient or out-patient basis. The study was carried out for the duration of 12 months after taking approval from the IEC. Healthy women with uncomplicated pregnancy after 20th week of gestation were included in the study. Results: Out of 203 patients included in the study, 3 (1.3%) were in the age group of < 20 years, 76 (37.7%) were in the age group of 20-25 years, 100 (49%) were in the age group of 25-30 years and 24 (12%) were in the age group of > 30 years. In the 203 pregnant patients, age group included in the study ranged from 18 to 36 years with the mean age of 26.46 years Age of second trimester patients (100 patients) ranged from 19 to 35 with the mean of 26.26 years. The age of third trimester (103 patients) patient ranged from 18 to 36 with mean of 26.67 years. The correlation of FKL GA was best with AC & CGA (r=0.954 & 0.953) and least with FL (r=0.887). The correlation of CGA with BPD, HC & AC was almost similar (r=0.986, 0.987, 0.985) and correlation of CGA with FL was least (r=0.939). Conclusion: FKL shows a strong correlation with GA

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and with other biometric parameters like BPD, HC, AC and FL after 20 week of normal pregnancy. FKL can be used as an additional parameter for accurate determination of gestational age after 20 weeks of gestation.

***Keywords*---**FKL, GA, BPD, pregnancy.

Introduction

The first and foremost duty of an obstetrician is to date the pregnancy failing which can result in iatrogenic prematurity or post maturity of fetus leading to perinatal morbidity and mortality. The last two decades have seen a tremendous progress in application of ultrasound as a diagnostic modality to establish GA. Various sonographic biometric parameters commonly used are Crown rump Length (CRL), Biparietal diameter (BPD), Head circumference (HC), Abdominal circumference (AC) and Femur length (FL).

Conditions like oligohydramnios, multiple gestation, breech presentation, polyhydramnios and intrauterine growth restriction (IUGR) can affect the BPD, AC, FL measurements. As the pregnancy advances these parameters become increasingly unreliable in prediction of GA.[1] Therefore accurate estimation of GA in late 2nd and 3rd trimester still remains a problem. Various nontraditional sonographic parameters for estimating GA are being studied like transverse cerebellar diameter, fetal foot length, epiphyseal ossification centers, amniotic fluid volume. Fetal Kidney Length is strongly correlated to GA and is more accurate method of GA estimation than BPD, FL, HC and AC after 24th week of gestation.[2-4] In this study we sonographically measured FKL, evaluated its role in estimation of GA and compared its accuracy with other established biometric indices. Hence, the present descriptive study was undertaken by enrolling healthy women with uncomplicated singleton pregnancy after 20 weeks of pregnancy as participants. The present study was undertaken in the Department of Radio diagnosis of Max Superspecialty Hospital, Mohali where the accuracy of Fetal Kidney Length (FKL) in estimation of Gestational Age (GA) was evaluated.

Materials and Methods

The present prospective cross sectional study was conducted in Max Super Specialty Hospital, Mohali, Punjab, India. The subjects were selected from the patients visiting the department of Radio diagnosis on in-patient or out-patient basis. The study was carried out for the duration of 12 months after taking approval from the IEC. Healthy women with uncomplicated pregnancy after 20th week of gestation were included in the study.

Inclusion Criteria

Healthy women with uncomplicated pregnancy after 20th week of gestation who were

1. Certain of their LMP

2. Had prior regular menstrual cycles

Exclusion Criteria

The following patients were excluded from the study:

1. Before 20 weeks of gestation age
2. Unknown or inaccurate date of last menstrual period
3. Irregular menstrual cycles
4. Oligohydramnios
5. Polyhydramnios
6. Diabetic mother
7. Pregnancy induced hypertension
8. Pre Eclampsia
9. Multiple gestations
10. Fetal chromosomal abnormalities
11. Fetal anomalies
12. lntra-uterine growth restriction

Sample size

The Minimum sample size (S) was calculated using the following formula.

$$S= (z)^2(p)(q)/(d)^2$$
$$= 1.96x1.96x0.02x0.98/0.05x0.05 = 39.2$$

- Where S is the sample size, z is the value for the selected alpha level, e.g. 1.96 for (0.05) i.e. at 95 % confidence level. p is the estimated proportion of an attribute that is present in the population. q is 1-p. d is the acceptable margin of error for proportion being estimated (we have taken 5%).
- Hence, minimum participants required for the study to be statistically significant is 40.
- The total number of participants included in the present study is 203.

Methodology

After explaining the procedure and the risks involved, written and informed consent was taken. PC-PNDT form i.e form F was obtained from all the patients. All relevant clinical history was obtained and the correct LMP was confirmed. EDD was calculated by Naegele's Rule [First day of LMP, Add 7 days, Subtract 3 months, Add one year] An Ultrasonography was performed with patient in supine position. Good acoustic coupling was obtained using synthetic ultrasound gel. Gestational age at the time of admission was derived from LMP which was confirmed by early USG, whenever available. Obstetric Ultrasonography was performed using GE Voluson 730 pro and Philips Epiq 7 ultrasound scanner using a 3.5 MHz convex probe. Images are recorded in the forms thermal films. In all the patients following parameters were obtained i.e Biparietal Diameter (BPD), Head Circumference (HC), abdominal circumference (AC), Femur Length (FL) and Fetal Kidney Length (FKL).

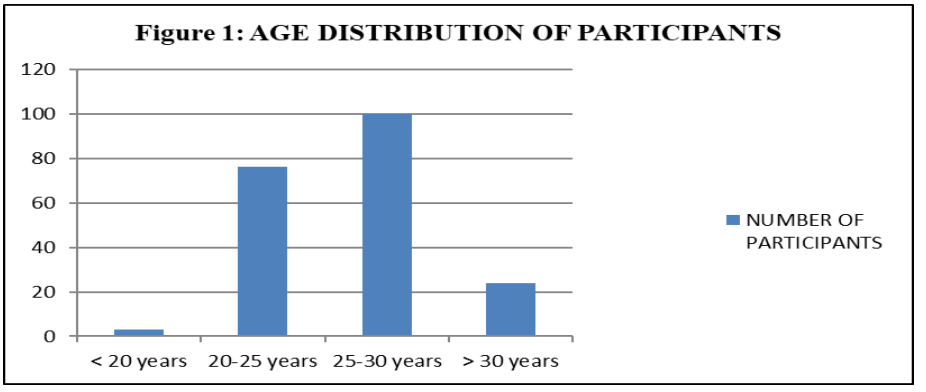
BPD and HC: Plane used for measuring BPD and HC was through the third ventricle and thalami. Cavum septum pellucidum was visible in the anterior portion of the brain and the tentorial hiatus was visible in the posterior portion of the brain. The cursor was positioned in outer edge of near calvarial wall to inner edge of far calvarial wall for BPD. For HC the cursor was positioned in outer edge of the near calvarial 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.
FL: was obtained by aligning the transducer to the long axis of the diaphysis. Measurement cursors were placed at the junction of the cartilaginous epiphysis and bone and the thin bright reflection of the cartilaginous epiphysis was not included.

Fetal kidney length was obtained in the sagittal plane, when full length of kidney was visualized. For any measurement to be included in the study, the adrenal glands were clearly identified and excluded from the measurement. Maximum length of any single fetal kidney was measured from upper pole to lower pole atleast thrice and mean of the measurements was taken.

Statistical Analysis

Statistical Methods: Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min-Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5 % level of significance. Pearson correlation has been performed to find the relationship between variables. LOESS plot using PROC LOESS from SAS has been used to plot the nomogram for relationship between fetal kidney GA with other variables.

Results



Out of 203 patient included in the study, 3 (1.3%) were in the age group of < 20 years, 76 (37.7%) were in the age group of 20-25 years, 100 (49%) were in the age group of 25-30 years and 24 (12%) were in the age group of > 30 years.

Table 1: Age/trimester distribution of participants

TRIMESTER	N	MEAN AGE (Years)	SD	MEDIAN	MINIMUM	MAXIMUM
2	100	26.26	3.184	26	19	35
3	103	26.27	3.757	27	18	36
TOTAL	203	26.46	3.479	26	19	36

In the 203 pregnant patients, age group included in the study ranged from 18 to 36 years with the mean age of 26.46 years Age of second trimester patients (100 patients) ranged from 19 to 35 with the mean of 26.26 years. The age of third trimester (103 patients) patient ranged from 18 to 36 with mean of 26.67 years.

Table 2: Mean fetal kidney length according to fetal kidney GA

GA	NUMBER	FETAL KIDNEY LENGTH (mm)		
		MEAN	SD	95% CI
21 WEEKS	22	21.59	0.47	21.4 to 21.7
22 WEEKS	18	22.00	0.00	22 to 22
23 WEEKS	24	23.39	0.50	23.2 to 23.6
24 WEEKS	9	25.00	0.00	25 to 25
25 WEEKS	4	26.00	0.00	26 to 26
26 WEEKS	14	27.71	0.47	27.4 to 28
27 WEEKS	5	29.00	0.00	29 to 29
28 WEEKS	5	29.40	0.20	29.3 to 29.6
29 WEEKS	11	30.55	0.52	30.2 to 30.9
30 WEEKS	5	32.00	0.00	32to 32
31 WEEKS	5	33.00	0.00	33 to 33
32 WEEKS	10	34.00	0.80	33.2to 34.8
33 WEEKS	9	35.00	0.4	34.6 to 35.4
34 WEEKS	12	35.42	0.20	35.2 to 35.6
35 WEEKS	7	36.00	0.00	36 to 36
36 WEEKS	20	37.50	0.51	37.3 to 37.7
37 WEEKS	5	38.60	0.42	38.3 to 38.8
38 WEEKS	7	39.71	0.49	39.3 to 40.2
39 WEEKS	9	41.22	0.44	40.9 to 41.6
40 WEEKS	2	43.00	0.00	43 to 43

Table 3: Predicted gestational age for FKL OF 21-43 mm.

FETAL KIDNEY LENGTH (mm)	NUMBER	FETAL KIDNEY GA (weeks)		
		MEAN	SD	95% CI
21	26	21.29	0.12	21.2 to 21.4
22	18	22.00	0.08	22 to 22
23	17	22.57	0.06	22.6 to 22.6
24	11	23.30	0.04	23.3 to 23.3
25	12	24.29	0.05	24.3 to 24.3

26	4	25.14	0.00	25.1 to 25.1
27	8	25.57	0.03	25.6 to 25.6
28	14	26.30	0.05	26.2 to 26.3
29	5	27.29	0.00	27.3 to 27.3
30	5	29.00	0.02	29 to 29
31	6	29.14	0.44	28.7 to 29.5
32	5	30.00	0.00	30 to 30
33	4	31.00	0.06	31 to 31
34	10	31.57	0.20	31.4 to 31.8
35	9	33.00	0.08	33 to 33
36	7	34.71	0.51	34.2 to 35.2
37	12	35.57	0.42	35.2 to 36.0
38	12	36.30	0. 04	36.3 to 36.3
39	2	38.14	0.06	38.1 to 38.2
40	5	38.43	0.12	38.3 to 38.5
41	7	39.00	0.08	38.9 to 39.0
42	2	39.43	0.00	39.4 to 39.4
43	2	39.71	0.00	39.7 to 39.7

Table 4: Correlation coefficient of FKL GA with CGA, BPD, HC, AC and FL IN both trimesters

PAIR	PEARSON CORRELATION	P VALUE
FKL GA vs CGA	0.953	<0.001**
FKL GA vs BPD	0.949	<0.001**
FKL GA vs HC	0.948	<0.001**
FKL GA vs AC	0.954	<0.001**
FKL GA vs FL	0.887	<0.001**

The above table shows the association between fetal measurements and FKL GA. All the correlations were statistically significant. The correlation of FKL GA was best with AC & CGA (r=0.954 & 0.953) and least with FL (r=0.887).

Table 5: Correlation coefficient of CGA WITH BPD, HC, AC, FL AND FKL GA in both trimesters

PAIR	PEARSON CORRELATION	P VALUE
CGA vs BPD	0.986	<0.001**
CGA vs HC	0.987	<0.001**
CGA vs AC	0.985	<0.001**
CGA vs FL	0.939	<0.001**
CGA vs FKL GA	0.953	<0.001**

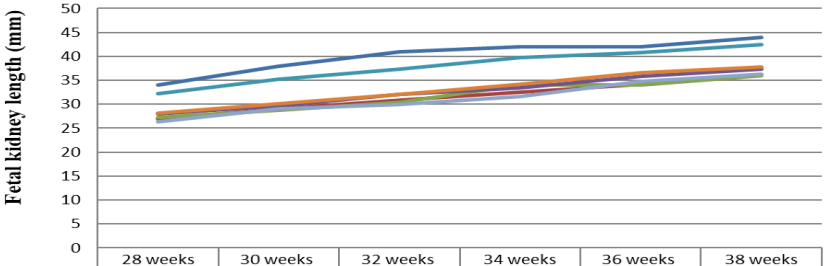
The above table shows the association between fetal measurements and CGA. All the correlations were statistically significant. The correlation of CGA with BPD, HC & AC was almost similar (r=0.986, 0.987, 0.985) and correlation of CGA with FL was least (r=0.939).

Discussion

Accurate gestational dating is of paramount importance and the cornerstone for management of pregnancies. With the advent of high resolution real time ultrasound, the ability to image various organs in utero has dramatically improved, which has heralded the utilization of various biometric parameters for accurate estimation of fetal gestational age. The conventional biometric indices are highly accurate in first trimester having error margin ranging within a week. However with increasing Gestational Age, particularly in late second and entire third trimester the accuracy of biometric indices decreases significantly having an error range of +/- 3.8 weeks. This inaccuracy lead to search of another alternative parameter that is accurate, easy to measure and has low variability associated with growth alterations. Several studies have delineated a linear relationship between FKL and Gestational age after 20th week of gestation. Some studies have advocated the use of FKL as an independent biometric parameter for accurate estimation of GA in third trimester.

This prospective observational cross sectional study involving 203 healthy women with uncomplicated singleton pregnancy of more than 20 weeks demonstrates a linear relationship between the fetal kidney length (mm) and the gestational age (weeks) during the late second (20 wks to 28 wks) and third (29 wks to term) trimester. Present study determined a strong statistically significant correlation between the FKL and GA as well as between FKL and other traditional biometric parameters like BPD, HC, AC and FL. The mean fetal kidney length (mm) for a specific GA that was derived in the present study was in concordance with four independent studies i.e. Kansaria and Parulekar[5], Muthaian et al.[6], Indu kaul[7] and Bertagnoli et al.[8] which showed almost similar mean FKL (mm) for specific GA as our study, and confirmed the rule of thumb that is “renal length in millimeters approximates the Gestational Age in weeks.” The study of Cohen et al, reported, in their sonographic study of 397 obstetric patients, the mean fetal kidney length of 27mm at 22 weeks and of 42 mm at 39 weeks of gestation.[4] These findings for fetal kidney length are greater and confidence intervals are wider than our study and previously reported studies.

Figure 2: COMPARISON OF MEAN FKL WITH GA AMONG DIFFERENT STUDIES



	28 weeks	30 weeks	32 weeks	34 weeks	36 weeks	38 weeks
Cohen et al	34	38	41	42	42	44
Kansaria et al	26,9	29	30,8	32,5	34,2	36,2
Bertagnoli et al	27,2	28,8	30,4	34	34	36
Indu kaul et al	28	29,67	32	33,44	35,76	37,4
Ahmadi et al	32,27	35,23	37,41	39,7	40,81	42,45
Muthaiain et al	28,12	30,17	32	34,22	36,56	37,86
Present study	26,3	29	30	31,57	34,71	36,3

The results of Cohen et al.[4] and Ahmadi et al.[9] demonstrated higher FKL for GA as compared to present study as well as the four studies mentioned above. This difference could likely be attributed to the demographic variation of the study population. The study of Ahmadi et al[9] also reported greater FKL for specific GA as compared to present study. The major factor responsible for this difference could be the demographic variation of the study population. Other reasons that could explain these differences are:

- The number of operators (multiple v/s two skilled operators /one skilled operator)
- Quality of ultrasound machine (older v/s newer).

In present study, FKL GA correlates well with gestational age having correlation coefficient of 0.80 and 0.75 in the second and third trimester respectively. The correlation coefficient of FKL GA is slightly less than the other parameters; however in the combined second and third trimester, FKL GA correlates with gestation age with high correlation coefficient of 0.95 along with other parameters (BPD, HC, AC) as the accurate parameters for assessing the gestational age. All the contemporary studies have shown a statistically significant positive correlation between the FKL and GA after the age of 20th week in uncomplicated pregnancy in healthy women.

The study conducted by Peter M et al[10], Muthaian E & Selvaraj K[6] and Kaul I et al[7] demonstrated results similar to the present study with FKL GA and Gestational age correlation coefficient of 0.947, 0.947, 0.957 and 0.962 respectively. Kiran L and Aneesh et al (2019) found a linear increase in the standard deviation of the FKL with progressing gestational age. However, no such linear correlation between the standard deviation of FKL and increasing gestational age was recorded by the present study or by any other study mentioned above.[11] The study of Cohen et al[4] showed a wider range of Confidence interval of FKL for GA, however no specific linear relationship between the progressing Gestational Age and FKL SD was noted.

The correlation coefficient of FKL in late second trimester (after 20th week) was best with BPD (r=0.823) and least with AC (r=0.797). The correlation coefficient of FKL in third trimester was best with AC (r=0.774) and least with FL (r=0.491). The correlation coefficient of FKL in combined second and third trimester was best with AC (r=0.954) and least with FL (r=0.887). The FKL showed the strongest positive correlation with AC in the present study as well as in the independent study conducted by Yusuf et al.[12,] In the study conducted by Peter M et al, FL demonstrated the strongest positive correlation with FKL.[10] In the study of Abonyi EO et al, both FKLs correlated weakly albeit positively with other biometric parameters whose efficacy decreases as gestation increased towards term. This weak correlation between FKL and other biometric indices could possibly be attributed to demographic variance.[13]

Present study found AC, which was marginally better than other biometric indices, to be the most accurate index for Gestational Age estimation after 20th weeks of uncomplicated pregnancy in healthy women while FL was determined to be relatively most inaccurate. The findings of the present study were in

concordance with that of Peter M et al.[10] who found AC (SE of 6.943 days) to be the most accurate index for fetal age estimation after 20 weeks of uncomplicated pregnancy in healthy women. Peter M et al found HC (SE of 12.098 days) to be the most inaccurate index.[10] Konje KC et al.[14] and Kansaria et al.[5] found FKL (SE of 10.29 days and 9.17 days respectively) to be the most accurate index while AC was the most inaccurate index (SE of 14.54 days and 11.14 days respectively). The above mentioned observations of Konje KC et al.[14] and Kansaria et al.[5] were of conflicting nature when compared to the results of the present study & the study of Peter M et al.[10] The reason for this discordance of findings could be attributed to the inter-operator variability of AC measurements among the studies.

Even though FKL was not determined to be the most accurate biometric index after 20th week, the present study found FKL to be similar accuracy biometric index as compared to BPD, HC, AC and FL, It was noted that more accurate GA estimation can be obtained by using FKL as an additional parameter along with the already established biometric indices (BPD, HC, AC, FL). As our 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. However, they are not suitable for judging the appropriateness of the growth of kidneys across time. A number of observer errors and technical errors could have occurred in obtaining the fetal kidney length measurements; the major source of errors may be due to uncertainty of end points and skewed off-axis images of the kidneys. The fetal adrenal gland is relatively large, and, it is difficult to separate it from the kidney due to the lack of perirenal fat and having a similar echo pattern, which may result in apparent false increase in the length of the kidney because of the addition of fetal kidney and adrenal gland together.

Although the probability & possibility of these errors was kept in mind while conducting the study, these errors might have unknowingly creeped inside the study, in the absence of the awareness of the researchers. The rectification methods for these possible errors were not included in this study. Notwithstanding the above possible technical and observer errors, the measurements taken in the present study were reasonably accurate. The results of present study and previously published studies on FKL shows that additional small improvements in accurate gestational dating can be achieved by incorporating the results of FKL in combination with other fetal biometric parameters i.e. Biparietal Diameter (BPD), Head Circumference (HC), Abdominal Circumference (AC), and Femur Length (FL).

Conclusion

FKL shows a strong correlation with GA and with other biometric parameters like BPD, HC, AC and FL after 20 week of normal pregnancy. Nomogram of the FKL shows a linear relationship between the fetal kidney length and the gestational age. FKL can be used as an additional parameter for accurate determination of gestational age after 20 weeks of gestation.

References

1. Abonyi EO, Eze CU, Agwuna KK, Onwuzu WS. Sonographic estimation of gestational age from 20 to 40 weeks by fetal kidney lengths' measurements among pregnant women in Portharcourt, Nigeria. BMC Med Imaging. 2019 Aug 22;19(1):72.
2. Ahmadi F, Taqi Dizaj AV, Akhbari F, Hohreh Irani S, Holamreza Khalili G. Fetal kidney measurement in 26–39 weeks gestation in normal fetuses of Iranian pregnant women. J Pregnancy Child Health 2015;2:139.
3. Benson CB, Doubilet PM. Sonographic prediction of gestational age: accuracy of second-and third-trimester fetal measurements. AJR. Am J roentgenology. 1991;157(6):1275-7.
4. Bertagnoli L, Lalatta F, Gallicchio R, et al. Quantitative characterization of the growth of the fetal kidney. J Clin Ultrasound 1983;11(7):349–356.
5. Cohen HL, Cooper J, Eisenberg P, Mandel FS, Gross BR, Goldman MA, Barzel E, Rawlinson KF. Normal length of fetal kidneys: sonographic study in 397 obstetric patients. AJR. Am J Roentgenology. 1991;157(3):545-8.
6. Kansaria JJ, Parulekar SV. Nomogram for fetal kidney length. BHJ. 2009;51(2):155-62.
7. Kaul I, Menia V, Anand AK, Gupta R. Role of Fetal Kidney Length in Estimation of Gestational Age. JK SCIENCE. 2012; 14(2):65-69.
8. Kiran L, Aneesh MM, Aravind Thulaseedharan. Fetal kidney length in estimation of gestation age by sonography. International Journal of Contemporary Medicine Surgery and Radiology. 2019;4(3):C79-C81
9. Konje JC, Okaro CI, Bell SC, de Chazal R, Taylor DJ. A cross-sectional study of changes in fetal renal size with gestation in appropriate- and small-for-gestational-age fetuses. Ultrasound Obstet Gynecol 1997;10(1):22–26
10. MacGregor SN, Sabbagha RE. Assessment of gestational age by ultrasound. Glob libr women's med. 2008.
11. Muthaian E, Selvaraj K. Accuracy of the Fetal Kidney Length Measurement by Ultrasonography in the Determination of the Gestational Age in Pregnancy. Natl J Clin Anat 2019;8:18–21.
12. Peter M, Nayak AK, Giri PP, Jain MK. Fetal kidney length as a parameter for determination of gestational age from 20th week to term in healthy women with uncomplicated pregnancy. Int J Res Med Sci 2017;5:1869–1873.
13. Santi, L. K. S., Sudewi, A. A. R., Duarsa, D. P., & Lesmana, C. B. J. (2021). The effect of pregnancy massage on level of depression, anxiety and stress in pregnant women. *International Journal of Health & Medical Sciences*, *4*(2), 220-225. https://doi.org/10.31295/ijhms.v4n2.1692
14. Suryasa, I. W., Rodríguez-Gámez, M., & Koldoris, T. (2021). Health and treatment of diabetes mellitus. *International Journal of Health Sciences*, *5*(1), i-v. https://doi.org/10.53730/ijhs.v5n1.2864
15. Susan Stranding. Gray's anatomy the anatomical basis of clinical practice, 39th edition, Elsevier Churchill livingstone, Edinburgh. 2005.
16. Yusuf N, Moslem FN, Haque JA, et al. Fetal kidney length: can be a new parameter for determination of GA in 3rd trimester. TAJ 2007;20(2):147–150