Biological Forum – An International Journal **15(6): 408-413(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Fetal Kidney Length as an useful Added Parameter for the Better Prediction of Gestational Age

G. Yuvabalakumaran[1*], G. Hamsini Devi [2], R.M. Sidhesh[3], R. Sathiyanarayanan[4] and Anupritha S.[5]

[1]Professor and Head, Department of Radio-diagnosis,
Vinayaka Missions Kirupananda Variyar Medical College, Salem, (Tamilnadu), India.
[2]Radiology Resident, Department of Radio-diagnosis,
Vinayaka Missions Kirupananda Variyar Medical College, Salem, (Tamilnadu), India.
[3]Associate Professor, Department of Radio-diagnosis,
Vinayaka Missions Kirupananda Variyar Medical College, Salem, (Tamilnadu), India.
[4]Assistant Professor, Department of Radio-diagnosis,
Vinayaka Missions Kirupananda Variyar Medical College, Salem, (Tamilnadu), India.
[5]Radiology Resident, Department of Radio-diagnosis,
Vinayaka Missions Kirupananda Variyar Medical College, Salem (Tamilnadu), India.

(Corresponding author: G. Yuvabalakumaran)*
(Received: 24 March 2023; Revised: 30 April 2023; Accepted: 17 May 2023; Published: 20 June 2023)
(Published by Research Trend)

ABSTRACT: The accuracy of traditional biometric parameters decreases with advancing gestational age. Hence accurate dating of pregnancies in the late second or third trimester remains a challenge. Our study was carried out to overcome this challenge, by measuring the fetal kidney length from the late second trimester and using it as a tool for the assessment of gestational age. The present study was done with the objective of determining the correlation between fetal kidney length and other biometric parameters such as BPD, HC, FL, AC derived gestational age with the gestational age derived from last menstrual period (LMP). This was prospective study carried out between February 2021 and December 2022 among 200 well dated pregnant women with no associated risk factors. Pearson correlation test was applied. A P value of less than 0.05 was considered significant. Strong positive correlation also existed between gestational age predicted by fetal kidney length and biparietal diameter in the second (0.823) and the third trimester (0.720), respectively. The strong positive correlation also found between gestational age predicted by foetal kidney length and head circumference during the second (0.807) and third trimester (0.718). The AC values and FK GA also exhibited a strong positive correlation at the second (0.797) and the third trimester (0.774). The femur length and FK GA exhibited a strong positive correlation at the second trimester (0.802) and a moderate positive correlation at the third trimester (0.491). A strong positive correlation was found to be present between FK GA and BPD (0.953), HC (0.948), AC (0.954) and FL (0.887). FKL can be used as a reliable and additional parameter for determination of gestational age.

Keywords: Fetal kidney length, biparietal diameter, head circumference, gestational age, ultrasonogram, femur length.

INTRODUCTION

Accurate estimates of gestational age with the help of better diagnostic approaches will provide more prompt medical management of a pregnant women. Ultrasound now has emerged as the more accurate method of assessing foetal gestational age (Miller *et al*., 1998). Prior to the invention of sonography, the medical practitioners had to depend on detailed histories and physical examination findings such as determining uterine fundal height for the estimation of gestational age (Peter, 1994). In particular, knowing the date of the last menstrual period was of significance. With this LMP both gestational age and the expected date of delivery can be calculated using various formulas.

The use of ultrasonography as a diagnostic technique has advanced tremendously in the last two decades, altering management and leading to better care. This is due to its non-invasive and non-ionizing nature, as well as its economic effectiveness, which leads to more acceptance. Diagnostic ultrasound's excellent safety record is undoubtedly one of the main reasons for its widespread use. Here the patient is not exposed to ionizing radiation, so the procedure is safer than X-rays and CT scans. It hasn't been linked to any negative effects on prenatal development, growth, or eyesight or hearing in children (Kieler *et al*., 1997). Similarly no negative consequences on the children's brain development or later school performance have been detected (Salaveen *et al*., 1993). In fact, many studies have proved that there are no known harmful effects when it's used as directed.

Ultrasound gives images of soft tissues with better definition. A Doppler ultrasound study, is a technique that evaluates blood flow in the umbilical cord, foetus or placenta; is a part of obstetric sonogram.

More accurate methods for dating pregnancies have emerged with the debut of diagnostic ultrasonography. In the first trimester, measurements of the gestational sac's diameter and volume, as well as the crown rump length, are taken. The measurement of the crown rump length has been shown to reliably predict gestational age to within ± 4.7 days. In second- or third-trimester a combination of multiple biometric parameters such as biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), and femur length (FL) are used to determine the gestational age, rather than a single parameter. When the estimation of gestational age is done, based only on a third-trimester ultrasound, it is difficult to confirm an accurate expected date of delivery (Noumburg *et al*., 2000).

In Third Trimester Dating multiple parameters are correlated with estimated age and fetal maturity. For example, Ossification centers of femoral epiphyseal are often noted at 32 weeks. And ossification centers of Proximal tibia are visualized at 35 weeks. The ossification centers of proximal humeral will appear in the late trimester and have been correlated with fetal lung maturity (Mahony *et al*., 1985).

The accuracy of traditional biometric parameters decreases with advance in gestation age, it is because of the biological variability of fetal size in comparison with gestational age. As a result, accurate dating of pregnancies in the late second or third trimester remains a challenge, particularly for women who seek maternity care late and are unsure of the date of their LMP (Richard *et al*., 1984).

Several recent studies have shown that there is a significant association between fetal kidney length and gestational age, specifically in the third trimester. It is easy to identify and measure fetal kidney lengths from the late second trimester and is used as a tool for the assessment of gestational age. In this proposed study the accuracy of fetal kidney length (FKL) in the determination of FGA after 20th week of gestation will be estimated with the aim to create baseline reference values of fetal kidney length (Nyborg *et al*., 2002; Leanty *et al*., 1982).

The present study was done with the objective of determining the correlation between fetal kidney length and gestational age, by comparing the mean fetal kidney length and other biometric parameters such as BPD, HC, FL, AC derived gestational age with the gestational age derived from last menstrual period (LMP) in healthy women with uncomplicated pregnancy between the 20th week of pregnancy and term. And to create a nomogram for estimating gestational age of the fetus after 20th week of gestation till term using mean fetal kidney length. Similar studies were not carried out in the study setting before.

MATERIAL AND METHODS

The present study was prospective study carried out between February 2021 and December 2022 among 200 well dated pregnant women with no associated risk factors, with more than 20th week of gestation referred to the Radio-Diagnosis Department for Obstetric ultrasound examination. The study was conducted in the Department of Radiodiagnosis at Vinayaka Missions Kirupananda Variyar Medical College and Hospital, Salem. Women with gestation of less than 20 weeks, pregnant women with oligohydramnios and polyhydramnios, women with multiple gestation, patients with risk factors of pregnancy like preeclampsia, eclampsia, diabetes and chronic renal disease, Patients in whom LMP was not known, foetus with anomalies, suspected intrauterine growth retardation, foetus with renal pathology and ill-defined kidney and adrenal margins were excluded from the study. Ethical clearance for the study was obtained from the institutional ethics committee.

After obtaining written informed consent and signature in the F form, ultrasound examination was carried using GE LOGIQ F8 Expert to measure mean kidney length along with other routine biometries such as femur length, head circumference, biparietal diameter and abdominal circumference. Measurements was taken in the sagittal plane, so as to visualize the entire kidney length along with renal pelvis. Maximum length of anyone single fetal kidney was measured using gray scale real time ultrasonographic scanner with 3.75 MHz transducer from upper pole to lower pole at least thrice and mean of the measurements was taken. Using this mean fetal kidney length, normogram for the estimation of gestational age was derived. Gestational age was calculated from mean fetal kidney length and from other multiple biometric parameters. These values were then compared with actual gestational age derived from LMP.

Examination Method. All of the patient's PCPNDT forms, especially form F, are obtained. The accurate LMP was determined after collecting the relevant clinical history. With the patient lying in supine position, an ultrasonography was conducted. Using synthetic ultrasonic gel, good acoustic coupling was achieved. GE LOGIQ F8 Expert ultrasound scanner with 3.5 MHz convex probe was used for obstetric ultrasonography. The digital camera was used to capture images on the thermal films. The following parameters were collected in all of the patients. BPD, HC, AC, FL, TCD, fetal heart rate, estimated fetal weight, AFI, and placental position were the ones to pay attention to.

The third ventricle and thalami were employed as measurement planes for BPD and HC. The tentorial hiatus must be evident in the posterior portion of the brain and the cavum septi pellucidi must be seen in the anterior portion. For BPD, the cursors are placed from the outer margin of the near calvarial wall to the inner edge of the far calvarial wall. The cursors for HC are placed at the exterior margin of the near calvarial wall and the outer edge of the far calvarial wall, respectively. The umbilical vein was perpendicular to the fetal spine, and the stomach bubble was visible.

The FL was determined by aligning the transducer with the long axis of the diaphysis. The narrow bright

reflection of the cartilaginous epiphysis should not be included when measuring cursors at the intersection of the cartilaginous epiphysis and bone. When the whole length of the kidney with the renal pelvis is observed in the sagittal plane, the fetal kidney length is obtained. At least three times the maximum length of a single fetal kidney is measured from higher pole to lower pole, and the average of the measurements is taken.

Statistical analysis: The data collected were entered into Microsoft excel 360 and master chart was created. The master chart was then loaded into SPSS version 26 for analysis. The data consisted of both quantitative variables and qualitative variables. The quantitative variables were expressed using mean and standard deviation. The qualitative variables were expressed using frequency and percentages. To find out the correlation between two quantitative variables, Pearson correlation test was applied. A P value of less than 0.05 was considered to be statistically significant.

RESULTS AND DISCUSSION

49% were in the age group 26 to 30 years followed by 37.6% in the age group 20 to 25 years. 51% were in their third trimester and 49% were in second (Table 1).

The gestational age predicted using foetal kidney length were found to have strong correlation with the actual gestational age estimated clinically at the second trimester (0.809), third trimester (0.758), respectively. Similar strong positive correlation also existed between gestational age predicted by fetal kidney length and biparietal diameter in the second (0.823) and the third trimester (0.720), respectively.

The strong positive correlation also found between gestational age predicted by foetal kidney length and head circumference during the second (0.807) and third trimester (0.718). The AC values and FK GA also exhibited a strong positive correlation at the second (0.797) and the third trimester (0.774). The femur length and FK GA exhibited a strong positive correlation at the second trimester (0.802) and a moderate positive correlation at the third trimester (0.491). When both the trimesters combined too, a strong positive correlation was found to be present between FK GA and BPD (0.953), HC (0.948), AC (0.954) and FL (0.887).

The foundation for managing pregnancies, accurate gestational dates is of the utmost significance. Regardless of GA, pregnancy dating techniques should be easy and uncomplicated.

Table 1: Baseline characteristics among the study population.

Variable		Frequency (n=203)	Percentage (%)
Age group (in years)	<20	3	1.3
	20-25	76	37.6
	26-30	100	49
	>30	24	12
Trimester	Second	100	49
	Third	103	51

Table 2: Correlation co-efficient of FK GA with CGA, BPD, HC, AC and FL in second trimester.

Pair	Pearson correlation	P value
FK GA VS CGA	0.809	0.001
FK GA VS BPD	0.823	0.001
FK GA VS HC	0.807	0.001
FK GA VS AC	0.797	0.001
FK GA VS FL	0.802	0.001

Table 3: Correlation co-efficient of FK GA with CGA, BPD, HC, AC and FL in third trimester.

Pair	Pearson correlation	P value
FK GA VS CGA	0.758	0.001
FK GA VS BPD	0.720	0.001
FK GA VS HC	0.718	0.001
FK GA VS AC	0.774	0.001
FK GA VS FL	0.491	0.001

Table 4: Correlation co-efficient of FK GA with CGA, BPD, HC, AC and FL in second and third trimester.

Pair	Pearson correlation	P value
FK GA VS CGA	0.953	0.001
FK GA VS BPD	0.949	0.001
FK GA VS HC	0.948	0.001
FK GA VS AC	0.954	0.001
FK GA VS FL	0.887	0.001

For the best obstetric care of pregnancies, accurate and easily repeatable sonographic foetal biometric data for gestational dates are crucial. This is particularly true when deciding the best time to do various prenatal tests, gauge the baby's growth, and schedule the birth.

The gestational age and FKL appear to be correlated in this prospective research of 200 healthy pregnant women. A linear association between the foetal kidney development measured in mm and the gestational age in weeks was discovered between the second (12^{th} to 28^{th} week) and third (29^{th} week to term) trimesters.

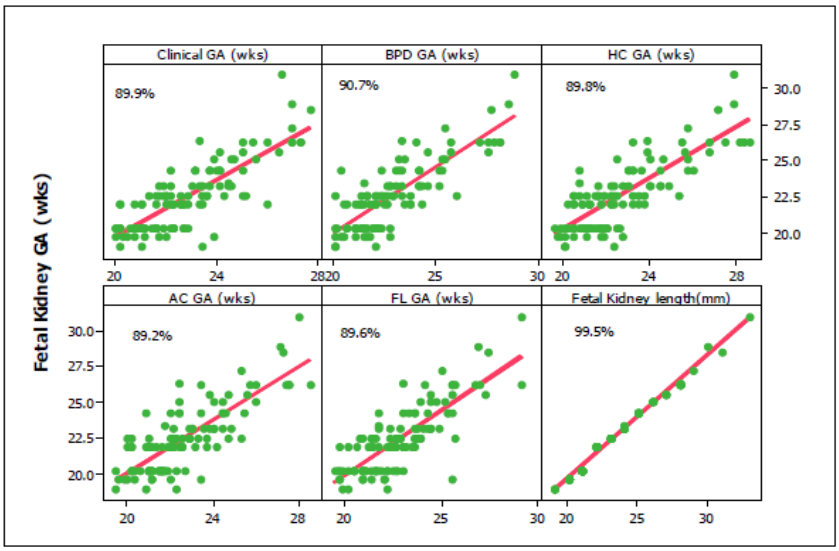

Fig. 1. Second trimester correlation of FK GA with other biometric parameters and clinical gestation age.

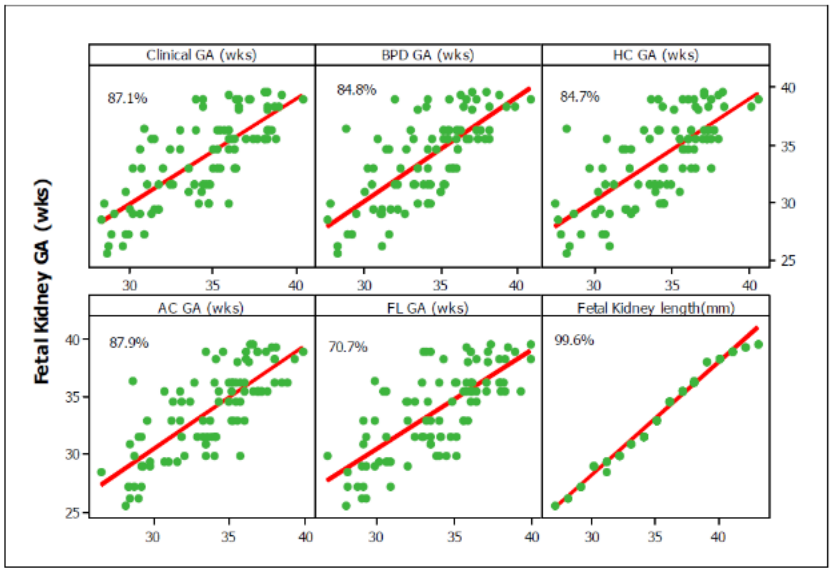

Fig. 2. Third trimester correlation of FK GA with other biometric parameters and clinical gestation age.

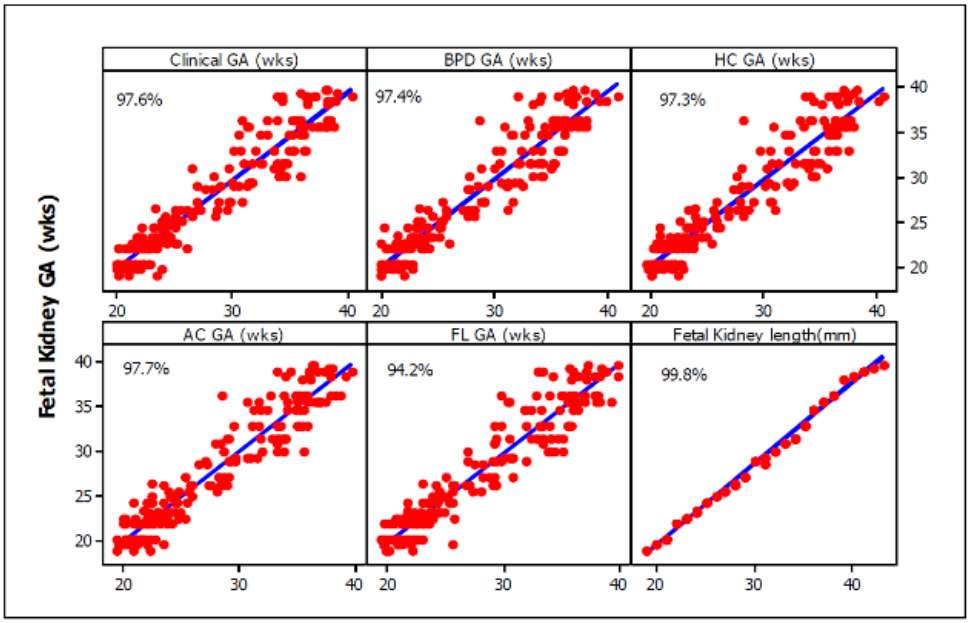

Fig. 3. Second and third trimester correlation of FK GA with other biometric parameters and clinical gestation age.

Table 5: Mean fetal kidney length according to fetal kidney gestational age.

Gestational age	N	Fetal Kidney Length (cm)		
		Mean	SD	95%CI
19 weeks	3	19.00	0.00	19 to 19
20 weeks	34	20.76	0.43	20.6 to 20.9
21 weeks	22	21.59	0.47	21.4 to 21.7
22 weeks	18	22.00	0.00	22 to 22
23 weeks	28	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	32 to 32
31 weeks	4	33.00	0.00	33 to 33
32 weeks	10	34.00	0.00	34 to 34
33 weeks	9	35.00	0.00	35 to 35
34 weeks	12	35.42	0.20	35.2 to 35.6
35 weeks	7	36.00	0.00	36 to 36
36 weeks	24	37.50	0.51	37.3 to 37.7
37 weeks	5	38.60	0.42	38 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

It is statistically significant that gestational age correlates with the size of the developing kidney in the foetus. The heterogeneity in gestational age estimation from FKL in the second and third trimesters has been the subject of several investigations. This linear association has been established in the current study in the second and third trimesters, and it is strongly correlated with clinical gestational age. Although the correlation coefficient is a little lower than the other parameters in the current study, the FK GA correlates well with gestational age, with correlation coefficients of 0.80 and 0.75 in the second and third trimesters, respectively. FK GA correlates with gestation age overall in the combined second and third trimester with a strong correlation value of 0.95, along with other parameters (BPD, HC, AC) as the precise parameters for gestational age assessment. Although growth differences impact kidney size as they do for all embryonic organs, they seem to primarily effect the anterior-posterior and transverse diameters. In small for gestational age foetuses, the length of the kidney is mostly unaltered.

Table 6: Predicted gestational age for FKL of 19 to 43 mm.

Fetal Kidney Length (cm)	Number	Fetal Kidney Gestational age in weeks		
		Mean	SD	95%CI
19	3	19.00	0.00	19 to 19
20	8	19.71	0.00	19.7 to 19.7
21	26	20.29	0.00	20.3 to 20.3
22	18	22.00	0.00	22 to 22
23	17	22.57	0.00	22.6 to 22.6
24	11	23.50	0.04	23.3 to 23.3
25	9	24.29	0.00	24.3 to 24.3
26	4	25.14	0.00	25.1 to 25.1
27	4	25.57	0.00	25.6 to 25.6
28	10	26.30	0.05	26.3 to 26.3
29	5	27.29	0.00	27.3 to 27.3
30	5	29.00	0.00	29 to 29
31	6	29.14	0.44	28.7 to 29.6
32	5	30.00	0.00	30 to 30
33	4	31.00	0.00	31 to 31
34	10	31.57	0.00	31.6 to 31.6
35	9	33.00	0.00	33 to 33
36	7	34.71	0.00	34.7 to 34.7
37	12	35.57	0.00	35.6 to 35.6
38	12	36.30	0.40	36.3 to 36.3
39	2	38.14	0.00	38.1 to 38.1
40	5	38.43	0.00	38.4 to 38.4
41	7	39.00	0.00	39 to 39
42	2	39.43	0.00	39.4 to 39.4
43	2	39.71	0.00	39.7 to 39.7

The correct assessment of gestational age and early identification of a variety of kidney disorders may both be made possible by knowledge of these parameters.

Additionally, FKL has been calculated to forecast mean gestational age in various ethnic groups. The patient's ethnic background is not unrelated to the length of the foetal kidney. In order to forecast gestational age for a certain ethnic community, normogram for FKL may be created for various nations and races. All of the patients in our research were of Indian descent, and the normogram for estimating gestational age from FKL was acquired.

The measurements of the length of the foetal kidney at various gestational ages were greater than those found in studies by Konje *et al*. (2002); Jeanty *et al*. (1984). The current study also demonstrated that kidney length in mm and gestational age in weeks are about equivalent. These disparities might be explained by various following factors:

(a) The number of operators (many vs. two/one/skilled operators).

(b) Cross-sectional vs. longitudinal study design, rounded vs. precise gestational age estimation.

(c) Ultrasound machine quality (older vs. newer).

(d) Racial distinctions.

Our foetal kidney charts were created using cross-sectional data. For comparing renal size at a known gestational age with reference data, they are appropriate. They are not useful for determining if kidney development over time has been adequate. While measuring the length of the foetal kidneys, both technical and observer mistakes may occur. The ambiguity of the end points and skewed, off-axis pictures of the kidneys may be the main sources of error. Due to the lack of perirenal fat and a similar echo pattern, and since the foetal adrenal gland is rather big, it can be challenging to distinguish it from the kidney, even in near-term newborns. Due to the measurement of the embryonic kidney and adrenals, there may appear to be an increase in the kidney's length. These possible errors were not evaluated in this study. Despite the aforementioned potential technical and observer mistakes, the measurements collected for this investigation were quite precise.

The current study thus supports the suggestion that foetal kidney length can be employed as a crucial sonographic criterion for precise prediction of foetal gestational age. Incorporating the results of the FKL with a combination of other foetal biometric parameters, such as biparietal diameter head circumference, abdominal circumference and femur length, can result in minor additional improvements in the accuracy of gestational dating, according to the results of the current study and other studies on the subject that have been published in the past. But it's still up for debate whether set of biometric measures is the most effective.

CONCLUSIONS

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

FUTURE SCOPE

The utilisation of FK GA would aid in predicting gestational age more accurately during the second and third trimesters where at present there were only very limited tools available.

Conflict of interest. None.

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How to cite this article: G. Yuvabalakumaran, G. Hamsini Devi, R.M. Sidhesh, R. Sathiyanarayanan and Anupritha S. (2023). Fetal Kidney Length as an useful Added Parameter for the Better Prediction of Gestational Age. *Biological Forum – An International Journal*, *15*(6): 408-413.