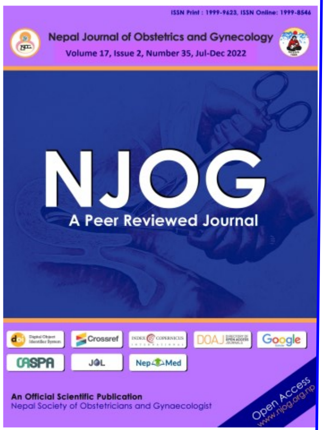

Ultrasound measurement of fetal kidney length in the second and third trimester of pregnancy and its correlation with gestational age

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ABSTRACT

Aims: To measure the fetal kidney length in the second and third trimesters of pregnancy and correlate it with the gestational age and other routine fetal parameters.

Methods: This prospective cross-sectional study includes 250 pregnant women presented in the Nobel Medical College for ultrasound examination from the period of July 2021 to June 2022. Gestational age was estimated based on the last menstrual date and ultrasonogram. Routine fetal parameters and mean fetal kidney length were measured. The correlation between gestational age, fetal kidney length, and routine fetal parameters was studied.

Results: The mean gestational age according to ultrasound and last menstrual period were 35.5 ± 3.4 weeks and 35.2 ± 3.2weeks respectively**.** The mean fetal kidney length was 36.8 ± 4.02mm. There was a very strong positive correlation between gestational age and fetal kidney length (r=0.921, p =0.001). Compared to the routine fetal parameters, adding fetal kidney length improved the effectiveness in predicting gestational age. (R^2=0.918 vs. R^2=0.936)

Conclusion: Fetal kidney length can be added to the other standard parameters to improve the prediction of gestational age.

Keywords: fetal ultrasonography, gestational age, kidney length

INTRODUCTION

Accurate estimation of gestational age (GA) is crucial for selecting the most appropriate mode of delivery and the GA also influences the choice of management and the result. Different parameters are used for the estimation of GA in various stages of pregnancy. The last menstrual period (LMP) and mean sac diameter is more reliable in the first trimester.[1] As the pregnancy progresses biparietal diameter (BPD), femur length (FL), abdominal circumference (AC), and head circumference (HC) is used.[2] Studies have shown a wide range of standard deviation of these indices, particularly in the late second and third trimesters.[3,4] Medical conditions like intrauterine growth restriction also affect these indices.[5]

The availability of high-resolution real-time ultrasound allows the fetal organs to be easily visualized. Numerous studies have demonstrated a relationship between GA and kidney size.[6,7] Although single parameter cannot measure the GA, it is essential to look for an accurate way. The fetal kidney length (FKL) increases the possibility of determining the GA using a single parameter. Thus, this study aims to measure the FKL in the second and third trimesters of pregnancy and correlate it with GA and other routine fetal parameters.

METHODS

This prospective cross-sectional study was conducted at the Department of Radiology, Nobel Medical College from the period of July 2021 to June 2022. The Institutional review committee approved this study (IRC No.46112021). Informed consent was taken before the examination. Non-probability consecutive convenience sampling method was used for patient selection and 250 patients were included in this study. Singleton viable pregnancy of 24- 39+6 weeks of gestation presented in the Radiology department for an antenatal scan with complete visualization of at least one kidney during ultrasound examination was included in this study. Patients who were uncertain about their LMP, anomalous fetus, oligo- or poly-hydramnios, suspected intrauterine growth restriction and fetal hydroureteronephrosis were excluded from the study. Ultrasound was performed with a high-resolution scanner using B mode real-time with a curved transducer of 3-5MHZ frequency. The fetus was examined in the transverse plane till the kidneys were visualized beneath the stomach. Then the probe was rotated to 90 degrees to visualize the kidney in its longitudinal axis. The kidneys were measured from the outer edge of the upper pole to the outer edge of the lower pole in the sagittal or coronal plane in the longitudinal axis as described by Bertagnoli et al.[8] All the measurements were taken by a single radiologist. The length of both kidneys was measured and the mean was taken. Where the measurement of the kidney was not successful due to the position of the fetus, they were also excluded from the study. BPD, HC, FL, and AC were also measured in a standard technique as described by Salomon et al.[9] All the data was collected in a predesigned proforma. Data analysis was performed using the statistical package for social science (SPSS) version 25. Pearson correlation was used to determine the relationship between the mean FKL and other routine parameters. Beta coefficients were calculated using linear regression analysis. R2 was calculated to show the effectiveness of a model. Statistical significance was considered to be achieved at P-values < 0.05.

RESULTS

The mean age of the patient was 24.45 ± 3.5 years. Among the cases 56.4%(n=129) were multiparous and 48.4%(n=121) were primi. The mean gestation age according to LMP and Ultrasound was 35.5 ± 3.4 weeks and 35.2 ± 3.2weeks respectively. The mean fetal biometry including BPD, HC, AC, FL, and MKL [Table-1].

Table-1: Mean value of routine parameters including the mean FKL

	Minimum	Maximum	Mean±SD
BPD	34.26	99.50	85.35±8.42
HC	225.35	390.00	300.45±32.45
AC	229.00	376.00	305.23±32.37
FL	30.24	79.00	66.92±7.46
FKL	28.05	45.30	36.80±4.02

BPD-biparietal diameter, HC-Head Circumference, AC-Abdominal circumference, FL-Femur length, FKL-Fetal kidney length, SD-Standard Deviation

There was a very strong positive correlation between the gestational age with mean FKL (r= 0.921) and routine fetal parameters (for GA, BPD, HC, AC, and FL r = 0.902, 0.936, 0.909, 0.944 respectively). [Table-2]

Table-2: Pearson correlation coefficients for the relation between GA with routine fetal biometric parameters and mean FKL

	FKL	GA	BPD	HC	AC	FL
GA	.921**	1	.902**	.936**	.909**	.944**
BPD	.820**	.902**	1	.934**	.876**	.894**
HC	.881**	.936**	.934**	1	.899**	.945**
AC	.857**	.909**	.876**	.899**	1	.906**
FL	.897**	.944**	.894**	.945**	.906**	1
FKL	1	.921**	.820**	.881**	.857**	.897**

BPD-biparietal diameter, HC-Head Circumference, AC–Abdominal circumference, FL-Femur length, FKL-Fetal kidney length

There was a strong relationship between gestational age and mean FKL (R^2=0.849) (Figure 1). The regression model for routine fetal parameters to predict GA [Table-3] and the regression model for mean FKL combined with routine parameters [Table-4].

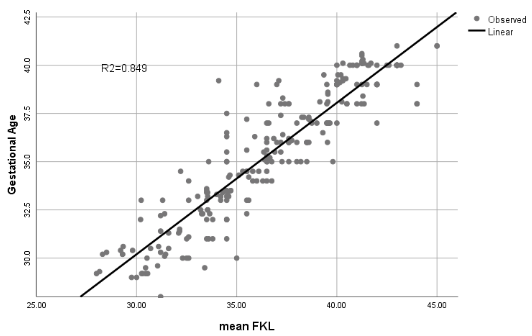

Figure-1: Correlation between GA and mean FKL

Table-3: Regression model for routine fetal biometric parameters (R^2=0.918)

Model 1	Unstandardized Coefficients		Standardized Coefficients	*P*-value
	B	SE	Beta	
Constant	-1.953	0.770		0.012
BPD	0.142	0.061	0.122	0.002
HC	0.248	0.076	0.232	0.001
AC	0.224	0.052	0.200	0.001
FL	0.462	0.065	0.434	0.001

BPD-biparietal diameter, HC-Head Circumference, AC–Abdominal circumference, FL-Femur length

Table-4: Regression model for routine fetal biometric parameters and fetal kidney length (R^2=0.936)

Model 2	Unstandardized Coefficients		Standardized Coefficients	*P*-value
	B	SE	Beta	
Constant	-1.079	0.691		0.120
BPD	0.189	0.055	0.162	0.001
HC	0.134	0.069	0.126	0.053
AC	0.147	0.047	0.131	0.002
FL	0.296	0.061	0.278	0.001
FKL	0.270	0.033	0.316	0.001

BPD-biparietal diameter, HC-Head Circumference, AC-Abdominal circumference, FL-Femur length, FKL-Fetal kidney length

DISCUSSION

Ultrasound is well known safe, and non-invasive useful tool in the assessment of GA. Prenatal ultrasonography is a vital component of antenatal care for monitoring fetal growth. Accurate estimation of the GA is crucial in obstetrical management, especially in high-risk cases like intrauterine growth restriction, preeclampsia, chronic hypertension, and Rh alloimmunization.

Due to the availability of high-resolution real-time imaging ultrasound machines, more studies are being done to find additional biometric elements that can accurately estimate GA. Trans-cerebellar diameter, fetal kidney length, hard palate width, sacral length, and the length of the foot are a few examples of such parameters. Sherer et al used hard palate width for estimation of the GA in 602 pregnant women between 15 to 41 weeks of gestation and found that hard palate indices correlated well with GA, BPD, FL, and AC.[10] Ozat et al used sacral length in the estimation of GA and found a significant correlation between sacral length and GA.[11] But the assessment of these parameters requires advanced ultrasound skills and may not be visualized well despite the best effort. So, a more easy and more reliable method to assess GA is required. Sonographic measurements of the size of a normal FKL with gestational age were originally first published by Seoys et al.[12] Throughout pregnancy, fetal kidney growth is steady, increasing by around 1.7 mm every two weeks, and is unaffected by growth abnormalities. Similarly, the study by Bertagnoli et al proved that fetal kidney measurements can be used as an additional parameter in the routine antenatal ultrasound scan.[8]

There is no doubt that the study population's size has a significant impact on statistical validity. Four hundred fetuses were evaluated in study conducted by Edevbie JP et al, but in many other publications, the number is less than 100.[13,14] In this study, 250 fetuses were evaluated which is similar to the study by Agnieszka et al.[15]

The range of mean FKL in this present study was 28.05mm at 28 weeks of gestation to a maximum of 45.3mm at 41 weeks of gestation with a mean of 36.80mm and a standard deviation of 4.02mm. This study showed that at a specific period of gestation, the mean FKL in mm is nearly equal to the GA in weeks i.e., 28.05 mm in 28 weeks of gestation. This study also showed that the length of the fetal kidney increases along with GA. These findings are similar to the study by Lawson et al where FKL at 30 weeks was 32mm and 42-43 mm at term.[16] Similarly, the FKL measurement in another study by Bertagneli et al also corresponds to the gestational age.[8] Thus, our study in addition to these two studies follows the dictum that the renal length in millimeters roughly corresponds to GA in weeks. In another study by Cohen et al in 397 fetuses the measurements of FKL have a greater and wider confidence interval value of 27mm at 20 weeks and 42 mm at 39 weeks of gestation.[17] This could be because of different ultrasound equipment being used or different operator efficiency.

In this study, a very strong positive correlation was found between GA and FKL ($r= 0.921$, $p=0.001$). The result of our study is similar to the study by Akram et al ($r= 0.939$, $p=<0.05$) who concluded that FKL is the most reliable parameter for assessing GA compared to other biometric indices, especially when other parameters like BPD, AC, HC, and FL are unreliable for measuring GA in the second and third trimesters of pregnancy.[18] In another study by Edevbie et al, a strong positive correlation was found between mean FKL and gestational age($r = 0.997$, $P = 0.0001$) which was similar to our study.[13] Similarly, the previous studies by Shivalingaiah et al (2014), Kaul et al (2011), and Ugur et al (2016) also showed a strong Pearson's connection between the mean FKL and GA similar to this study.[14,19,20] The study by Bardhan et al also concurred with the findings of the present study and concluded that there is a highly significant association between GA and mean FKL, with a Pearson's correlation coefficient of 0.99 and significance with a P value less than 0.001.[21] The regression model for fetal routine biometric parameters alone in the prediction of GA is $R^2=0.918$. Similarly, the regression model for fetal biometric parameters in combination with mean FKL is $R^2=0.936$. The study by Ugur et al also found that the regression model of routine fetal parameters predicted the GA R^2=0.968. But when mean FKL is combined with the routine fetal parameters the prediction enhances i.e. R^2=0.987.[19] These values are comparable to our study. The study by Chatterjee et al was also similar to our study; agreed with the current study and concluded that kidney length can be employed as a single parameter in determining GA, particularly in later trimesters where biometric indices may not be very trustworthy. (R^2=0.989).[22] Konje and Abrams measure the mean FKL between 24 and 38weeks of pregnancy and they found that mean FKL had a better predictive value for accurate dating of GA compared to other fetal biometric measures including BPD, AC, HC, and FL.[23] It was demonstrated by Kansaria et al. in another study done in India that using FKL improved dating labor.[24]

The limitation of this study is that the mean FKL per week of GA was not calculated Normogram of the kidney length as per GA was not obtained due to the small sample size. In the future, a multicenter prospective cross-sectional study with a large sample size may be required to obtain a standard normogram for FKL in our population.

In this study, we found that there is a linear relationship between the gestational age and the mean FKL as the mean FKL increases as the pregnancy advances. The single parameter for the estimation of GA is unreliable and is inaccurate after 30 weeks of gestation. The current study, therefore, supports previously published other studies on FKL that mean FKL can be employed as a crucial sonographic parameter for precise prediction of fetal gestation age in combining with the other routine parameter, especially in the third trimester of pregnancy where the standard plane of routine parameters is difficult to obtain due to the breech presentation and head engagement.

CONCLUSION

Fetal kidney length accurately estimates the gestational age, especially in the second and third trimesters. In cases where the last menstrual date is unknown or the patient presents in the advanced stage of pregnancy with an uncertain LMP, mean FKL can be used as a tool for estimating GA and it improves the prediction of GA in combination with the other routine parameters.

REFERENCES

1. Butt K, Lim K. Determination of gestational age by ultrasound. J Obstet Gynaecol Can. 2014;36(2):171-81.
2. Self A, Daher L, Schlussel M, Roberts N, Ioannou C, Papageorghiou AT. Second and third trimester estimation of gestational age using ultrasound or maternal symphysis-fundal height measurements: A systematic review. BJOG. 2022;129(9):1447-58.
3. Falatah HA, Awad IA, Abbas HY, Khafaji MA, Alsafi KGH, Jastaniah SD. Accuracy of Ultrasound to Determine Gestational Age in Third Trimester. Open Medical Imaging J. 2014;04(03):7.
4. Benson CB, Doubilet PM. Sonographic prediction of gestational age: accuracy of second- and third-trimester fetal measurements. AJR Am J Roentgenol. 1991;157(6):1275-7.
5. Dacaj R, Izetbegovic S, Stojkanovic G, Gjocaj C. Hepato - Cephalic Index as a Predictor of Intrauterine Growth Restriction. Acta Inform Med. 2016;24(1):12-5.

6. 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 Medical Imaging. 2019;19(1):72.
7. Nouh M, El Sharawy M, El Said H, El Sayed Aglaan D. Accuracy of gestational age estimation using fetal kidney length in normal singleton pregnancies. Tanta Med. J. 2021;49(4):252-6.
8. Bertagnoli L, Lalatta F, Gallicchio R, Fantuzzi M, Rusca M, Zorzoli A, et al. Quantitative characterization of the growth of the fetal kidney. J Clin Ultrasound. 1983;11(7):349-56.
9. Salomon LJ, Alfirevic Z, Da Silva Costa F, Deter RL, Figueras F, Ghi T, et al. ISUOG Practice Guidelines: ultrasound assessment of fetal biometry and growth. Ultrasound Obstet Gynecol. 2019;53(6):715-23.
10. Sherer DM, Abramowicz JS, Plessinger MA, Woods JR, Jr. Fetal sacral length in the ultrasonographic assessment of gestational age. Am J Obstet Gynecol. 1993;168(2):626-33.
11. Ozat M, Kanat-Pektas M, Gungor T, Gurlek B, Caglar M. The significance of fetal sacral length in the ultrasonographic assessment of gestational age. Arch Gynecol Obstet. 2011;283(5):999-1004.
12. Seo Y-S, Choi C-H, Choi S-J, Choi S-J, Kim Y-A, Yang S-H, et al. Normal size of fetal kidneys: sonographic measurements. Korean J Obstet Gynecol. 2003;46(3):537-41.
13. Edevbie JP, Akhigbe AO. Ultrasound measurement of fetal kidney length in normal pregnancy and correlation with gestational age. Niger J Clin Pract. 2018;21(8):960-6.
14. Shivalingaiah N, K S, R A, TR K, P M. Fetal kidney length as a parameter for determination of gestational age in pregnancy. Int. j. reprod. contracept. obstet. gynecol. 2017;3(2):4.
15. Zalinska A, Sylwestrzak O, Papis A, Oszukowski P, Pieta-Dolinska A. Fetal kidney measurement — additional biometric parameter for accurate gestational age assessment. Ginekologia Polska. 2022;0(0).
16. Lawson TL, Foley WD, Berland LL, Clark KE. Ultrasonic evaluation of fetal kidneys. Radiology. 1981;138(1):153-6.
17. Cohen HL, Cooper J, Eisenberg P, Mandel FS, Gross BR, Goldman MA, et al. Normal length of fetal kidneys: sonographic study in 397 obstetric patients. AJR Am J Roentgenol. 1991;157(3):545-8.
18. Akram MS, Yousaf M, Farooqi U, Arif N, Riaz A, Khalid M, et al. Estimation of gestational age from fetal kidney length in the second and third trimester of pregnancy by ultrasonography. Saudi J Med Pharm Sci. 2019;5(3):222-9.
19. Ugur MG, Mustafa A, Ozcan HC, Tepe NB, Kurt H, Akcil E, et al. Fetal kidney length as a useful adjunct parameter for better determination of gestational age. Saudi Med J. 2016;37(5):533-7.
20. Kaul I, Menia V, Anand AK, Gupta R. Role of Fetal Kidney Length in Estimation of Gestational Age. JK science. 2012;14(2).
21. Bardhan J, Ghosh SK, Sarkar KN, Sarkar M. Fetal kidney length as a

parameter for gestational age determination and its comparative evaluation with other fetal biometric indices. IAIM. 2016;3(8):36-44

22. Chatterjee S, Yadav K, Prakash P, Shekhawat K. Foetal kidney length as a parameter for determination of gestational age in pregnancy by ultrasonography. Int. j. reprod. contracept. obstet. gynecol. 2016;5(6):1949-53.
23. Konje JC, Abrams KR, Bell SC, Taylor DJ. Determination of gestational age after the 24th week of gestation from fetal kidney length measurements. Ultrasound Obstet Gynecol. 2002;19(6):592-7.
24. Kansaria J, Parulekar S. Nomogram for foetal kidney length. Bombay Hosp J. 2009; 51(2):155-62.