ORIGINAL RESEARCH ARTICLE

CORRELATION BETWEEN FETAL KIDNEY LENGTH AND GESTATIONAL AGE AMONG PREGNANT WOMEN ATTENDING IMAGE DIAGNOSTIC CENTRE, PORT-HARCOURT, NIGERIA.

ABSTRACT

Background: The obstetric management of a pregnancy depends on the knowledge of an accurate gestational age particularly in unregistered case. **Aim:** The aim of the study is determine how accurately fetal kidney length (FKL) could estimate gestational age (GA) using ultrasonography. **Materials and Methods:** The study involved 200 participants with 20 to 40 weeks pregnancies, referred to the Radiology Department of Image Diagnostic Center, Rumuola Port Harcourt for obstetric ultrasound scan, within a three-month period. The left and right fetal kidney lengths were measured and data obtained were analyzed using SPSS version 23.0. Linear regression equations were deduced. **Results**: There was no statistically significant difference between the measurements of the right and left kidneys. There was a strong positive correlation between gestational age (GA) and right kidney length (RKL) ($r = .998$, $p < 0.01$) and left kidney length (LKL) ($r = .998$, $p < 0.01$). Regression formulae used for predicting GA using right and left FKL was 9.9494(RKL) + 0.3058, and 9.9404(LKL) + 0.3468, respectively. **Conclusion**: FKL proved to be a reliable predictor of gestational age of pregnancies in the second and third trimesters.

Keywords: Fetal Kidney Length. Gestational Age Estimation, Ultrasonography

INTRODUCTION

"Precise knowledge of gestational age (GA) is relevant for better antenatal care, planning, and successful management of all pregnancies. In high-risk pregnancies like preeclampsia, intrauterine growth retardation, gestational diabetes mellitus, and termination of pregnancy is planned considering the GA" [1]. "Failure in accurate estimation of GA can result in iatrogenic prematurity or postmaturity, both of which are associated with increased perinatal mortality and morbidity" [2]. Imaging plays a key role in clarifying subtle clinical signs and enabling prompt diagnosis and treatment, which are critical to the well-being of both mother and fetus [3,4].

“The application of ultrasonography has played a vital role in the estimation of GA and has become an integral part of obstetric practice” [5, 6]. “Sonographic estimations of GAs could be derived from mathematical expressions based on fetal measurements which serve as indirect indicators of gestational ages. Regression equations on the relationship between fetal biometric parameters have been developed by numerous authors and have proven early antenatal ultrasound to be an objective and accurate means of establishing GA” [2, 7 - 11]. “These biometric parameters includes gestational sac (GS), crown rump length (CRL), biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL) and fetal kidney length (FKL). However, a host of limitations with these fetal biometric parameters have been observed such as, conditions altering the skull shape thereby making BPD to be relatively unreliable after 26 weeks of gestation and other parameters such as FL has been reported to be shortened in patients with achondroplasia making it an unreliable parameter in estimating GA” [12, 13]. “Race is an important determinant of fetal development, making it impossible to apply reference ranges for fetal biometric parameters from a homogeneous population to other populations, mainly heterogeneous populations” [14].

Fetal kidney is easily identified and measured during late second and third trimesters of pregnancy and there has been a strong correlation between gestational age and FKL [6, 15, 16]. However, there is limited literature that possibly suggests the relevance of FKL in the estimation of gestational age in a Southern Nigerian population, hence this study.

MATERIALS AND METHODS

This was a retrospective, cross-sectional study. From January to March 2023, 200 consecutive pregnant women ranging between 20-40 weeks of gestation who were certain of their last menstrual period referred to the antenatal clinic of the Obstetrics and Gynaecology Department of Image Diagnostic Center Port Harcourt and satisfied the inclusion criteria were sonographically examined. As part of the study’s inclusion criteria, only healthy women with uncomplicated singleton pregnancy between 20-40 weeks of gestation and with knowledge of their last menstrual period (LMP) were selected. Excluded from the study were patients with

twin gestation, known fetal anomaly, oligo-hydramnios or polyhydramnios and patients in labour.

In line with the trans-abdominal approach as described by Ghaleb et al. [6], the fetuses had been scanned in transverse plane until the kidneys were visualized just below the stomach of pregnant women. The fetal kidney was identified by approaching the renal bed with the transducer from the level where the fetal abdominal circumference is estimated [7]. The probe was rotated through 90˚ to outline the longitudinal axis of the kidney during apnea. An electronic caliper was placed at the superior pole of the fetal kidney from where a line is then drawn to the inferior pole to measure the fetal kidney length. The maximum kidney length was measured from the upper to lower pole of the kidney in a longitudinal section of the fetus in the sagittal plane. Measurements were obtained for both sides and in a sagittal plane, when full length of kidney with renal pelvis was visualized. Examinations had been performed by a sonographer using high resolution real time digital ultrasound scanner (DP-50 by Shenzhen Mindray Biomedical Electronics Co. Ltd. China, 2011) with 3.5MHz frequency convex transducer. All measurements were taken in centimeters (cm). In order to avoid intra-observer errors, the researchers ensured that two measurements were obtained for each kidney, and the mean value was recorded. The estimation of fetal gestational age was done using the Hadlock *et al* method [17].

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 23.0. Both descriptive and inferential statistics were applied. The means of both right (RKL) and left kidney length (LKL) were expressed in form of tables. Significant differences between right (RKL) and left kidney length (LKL) were done using paired samples t-test, and correlation between GA and kidney lengths were performed using Pearson's correlation. Finally, linear regression equations were obtained. Level of significance was set at 0.05.

RESULTS

The gestational age of the fetuses studied ranged from 20 to 40 weeks; thus, covering both the second and third trimesters. Majority (126) of the fetuses was in the third trimester making up about 74.3% of the study population; while about (74) fetuses were in the late second trimester corresponding to 25.7% of the study population respectively.

Mean fetal left and right kidney lengths among the (200) fetuses at the different gestational ages documented is illustrated in table 1. The mean fetal kidney length for the both kidneys (right and left) ranged from 1.89mm and 1.90mm at 20 weeks of gestation to 4.10mm and 4.10mm at 40 weeks of gestation respectively, indicating a weekly increase of 0.1mm from one successive gestational age to another. There was no statistically significant difference between the measurements of the right and left kidneys.

There was a strong positive correlation between gestational age (GA) and right kidney length (RKL) ($r = .998$, $p < 0.01$) and left kidney length (LKL) ($r = .998$, $p < 0.01$). Using linear regression analysis to deduce equations, the formula used for predicting GA using RKL was GA = 9.9494(RKL) + 0.3058, while the formula used for predicting GA using LKL was GA = 9.9404(LKL) + 0.3468 with both sharing a prediction accuracy of 99.6%.

Table 1: Descriptive statistics of gestational age, right and left kidney length of all subjects

Parameter	N	Mean	SEM	SD	Min	Max	CI (95.0%)
GA (weeks)	200	30.28	0.42	5.96	20	40	0.83
RKL (cm)	200	3.01	0.04	0.6	1.89	4.1	0.08
LKL (cm)	200	3.01	0.04	0.6	1.9	4.1	0.08

GA = Gestational age, RKL = Right kidney length, LKL = Left kidney length, CI = Confidence interval, SEM = Standard Error of Mean, SD = Standard deviation, Min = Minimum, Max = Maximum, N = Total number of subjects

Table 2: Differences between Right and Left Kidney Length

			Paired Samples Test			
Parameters	**Mean**	**SD**	**T**	**df**	**p < 0.05**	**Inference**
RKL (cm)	3.01	0.60	0.994	199	0.322	Not Significant
LKL (cm)	3.01	0.60				
N				200		

GA = Gestational age, RKL = Right kidney length, LKL = Left kidney length, df = Degree of Freedom, N = Total number of subjects

Table 3: Pearson's correlation between gestational age and kidney length

Parameters		GA	RKL	LKL
GA	Pearson Correlation	1	.998**	.998**
	Sig. (2-tailed)		0.000	0.000
RKL	Pearson Correlation	.998**	1	.999**
	Sig. (2-tailed)	0.000		0.000
	N		200	

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4. Descriptive Statistics of right and left mean kidney length (mm) for gestational age (weeks)

N	GA (weeks)	Mean RKL (cm)	Mean LKL (cm)	N	GA (weeks)	Mean RKL (cm)	Mean LKL (cm)
10	20	1.98 ± 0.06	1.98 ± 0.06	6	31	3.10 ± 0.02	3.10 ± 0.01
8	21	2.06 ± 0.04	2.06 ± 0.03	12	32	3.16 ± 0.06	3.16 ± 0.06
8	22	2.16 ± 0.05	2.16 ± 0.05	6	33	3.30 ± 0.03	3.29 ± 0.03
7	23	2.28 ± 0.03	2.28 ± 0.03	14	34	3.40 ± 0.02	3.41 ± 0.06
10	24	2.40 ± 0.02	2.39 ± 0.02	14	35	3.49 ± 0.04	3.49 ± 0.03
10	25	2.49 ± 0.03	2.49 ± 0.04	14	36	3.59 ± 0.02	3.59 ± 0.02
13	26	2.60 ± 0.03	2.60 ± 0.03	8	37	3.69 ± 0.01	3.69 ± 0.01
6	27	2.72 ± 0.05	2.72 ± 0.05	12	38	3.79 ± 0.03	3.78 ± 0.03
8	28	2.79 ± 0.02	2.79 ± 0.01	4	39	3.89 ± 0.01	3.88 ± 0.02
10	29	2.88 ± 0.02	2.88 ± 0.02	10	40	3.96 ± 0.09	3.95 ± 0.08
10	30	2.99 ± 0.02	2.98 ± 0.02				

GA = Gestational age, RKL = Right kidney length, LKL = Left kidney length, N = Total number of subjects

Table 5: Comparison of Pearson correlation coefficients of relationship between GA and FKL in the present study with related literature

Author(s)	Year	Study population	Pearson's coefficient (r)
Kumar et al [19]	2013	India	0.985
Enefia *et al* [20]	2023	Nigeria	0.86
Akintomide & Efanga [27]	2022	Nigeria	0.982
Singh et al. [24]	2021	India	0.875
Eldafrawy et al. [28]	2022	Egypt	Right FKL (0.978) Left FKL (0.937)
Present study	2023	Nigeria	Right FKL (0.998) Left FKL (0.998)

GA = Gestational Age, FKL = Fetal Kidney Length

Figure 1: Relationship between mean Right Kidney Length and Gestational Age

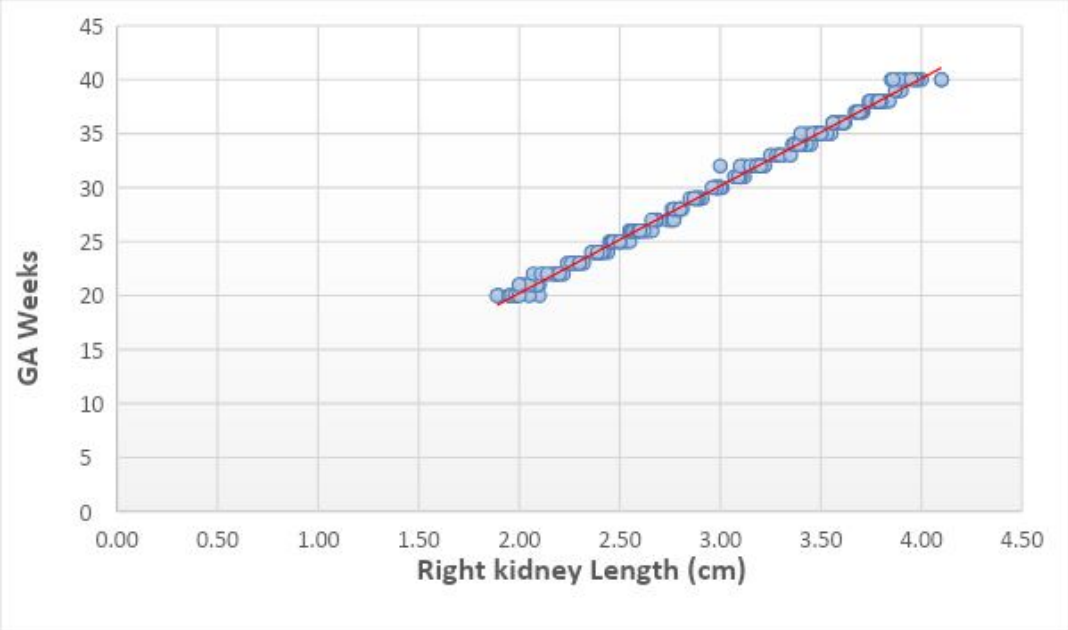
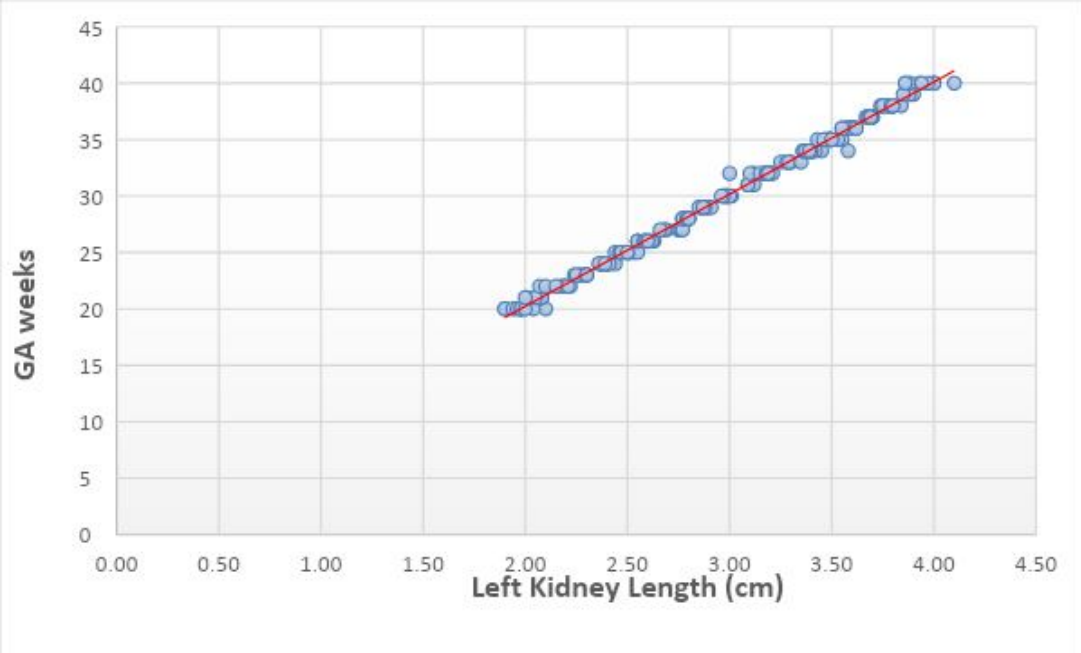


Figure 2: Relationship between mean Left Kidney Length and Gestational Age



DISCUSSIONS

"Accurate and easily reproducible ultrasound fetal biometric parameters for GA dating are clinically essential for ideal pregnancy management. This is essential for determining the timing of multiple pregnancy tests, assessing adequate growth, and timing of delivery for optimal obstetric outcomes" [18]. "Several studies have been done earlier to assess the variability in gestational age determination from fetal kidney length" [6, 15, 16]. They found that there is a linear relationship between the fetal kidney length (FKL) and the gestational age (GA). This study was done to find out any difference in a specific pregnant female Nigerian population that attended the antenatal clinic of the Obstetrics and Gynaecology Department of Image Diagnostic Center Port Harcourt. It will be beneficial to patients who forgot their date of LMP, and do not have dating scan done in first trimester and coming for antenatal check-up late.

Both Ghaleb *et al*. [6] and Mustapha *et al*. [16] reported from their studies that "there was no significant difference between the right and left kidney lengths which is in agreement with this current study". "In comparison with a study done by Kumar *et al*. [19] using an Indian population, the mean FKL in this present study as observed from 20th to 24th week of gestation

was much higher but became lesser as from the 26th to 40th week of gestation. This could be best explained that there are racial and geographical differences that could be attributed to the gestational changes that occur during fetal development". A recent study by Enefia *et al* [20] revealed that "the right FKL (3.74 ± 0.81 cm) was slightly longer than the left FKL (3.66 ± 0.88 cm) while similar studies by Khalaf & Hassein [21] and Zamir et al. [22] countered that the left FKL was slightly higher than the right FKL. In this current study, the mean right and left FKL measurements were relatively the same as observed".

There was a positive strong correlation between gestational age (GA) and right kidney length (RKL) (r = .998, p = 0.000) and left kidney length (LKL) (r = .998, p = 0.000) in this current study. In concordance with related studies, Ghaleb et al. [6] also reported a strong correlation between GA and RKL (r = 0.932, p = 0.000) and LKL (r = 0.784, p = 0.000), while Ugur et al. [23], there was a very strong positive correlation between GA and FKL (r = 0.947, p = 0.001). In a study done by Singh et al. [24], a linear relationship was established in the second and third trimesters between GA and FKL with a correlation coefficient of 0.875.

Linear regression analyses aimed at deducing formulae for predicting gestational age using both right and left FKL were done in this present study. In comparison with a related study done by Ghaleb et al. [6], predicting GA using RKL (in millimetres) was (0.81 * RKL) + 7.08 while that of LKL (in millimetres) was (0.68 * LKL) + 11.86. This present study showed that there was a prediction accuracy of 99.6% when predicting gestational age from fetal kidney length for both sides. Ugur et al. [23] deduced regression model for fetal renal length to estimate to gestational age and was shown to have an accuracy of 89.6% and concluded that fetal kidney length was a strong predictor for gestational age estimation. Furthermore, a related study by Ghaleb et al. [6] revealed a prediction accuracy with an R-squared value of 0.951 (at p = 0.000), which was in close concordance with this present study. In line with similar studies done by Konje et al. [25] and Kaul et al. [26], they showed from their results that fetal kidney length was the most reliable predictor of gestational age in comparison with other fetal biometric parameters.

CONCLUSION

In conclusion, fetal kidney length by ultrasound is a reliable method for gestational age estimation during pregnancy. With a constant increase, FKL has shown a strong correlation with

GA in third trimester pregnancy. Consequently, it is essential for health care providers to incorporate fetal kidney length by ultrasound in their routine practice for accurate and timely gestational age estimation.

Ethical Approval:

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

Consent:

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

REFERENCES

1. Shivalingaiah, N., Sowmya, K., Ananya, R., Kanmani, T.R. and Marimuthu, P. (2014) Fetal Kidney Length as a Parameter for Determination of Gestational Age in Pregnancy. *International Journal of Reproduction, Contraception, Obstetrics and Gynecology*, 3, 424-427
2. Egley CC, Seeds JW, Cefalo RC. (1986). Femur length versus biparietal diameter for estimating gestational age in the third trimester. *Am J Perinatol*. 3:77–9.
3. Woodfield CA, Lazarus E, Chen KC, Mayo-Smith WW. (2010). Abdominal Pain in Pregnancy: Diagnoses and Imaging Unique to Pregnancy—Review. *Am. J. Roentgenol*. 194: WS14–WS30
4. Masselli G, Brunelli R, Monti R, Guida M, Laghi F, Casciani E, Polettini E, Gualdi G. (2014). Imaging for acute pelvic pain in pregnancy. *Insights Imaging*. 5: 165–181.
5. Kalish RB, Chervenak FA. (2002). Ultrasound assessment of gestational age. *Optimal Obstetric*. 1:1–6
6. Ghaleb, M.M., Shokri, A.I.A.F., El Sayed El Sokkary, M.S. and El Shourbagy, M.M.A. (2021) Role of Ultrasonographic Measurement of Fetal Kidney Length in Determination

of Gestational Age during Third Trimester of Pregnancy. *Open Journal of Obstetrics and Gynecology*, 11, 221-232.

7. Akram, M. S., Yousaf, M., Farooqi, U., Arif, N., Riaz, A., Khalid, M., & Glani, S. M. Y. F. (2019). Estimation of gestational age from fetal kidney length in the second and third trimester of pregnancy by ultrasonography. *Saudi J Med Pharm Sci*, *5*(3), 222-229.
8. Gaharwar, A., & Tiwari, V. (2019). Correlation between crown rump length of fetus and gestational age in first trimester of pregnancy in North Indian population.
9. Zakaria, A. M., Mohamed, A. H., & Eldarder, A. K. M. (2019). Comparison between transcerebellar diameter, biparietal diameter and femur length for gestational age measurement accuracy in third trimester of pregnancy. *The Egyptian Journal of Hospital Medicine*, *74*(1), 17-22.
10. Soliman, M. A., Hassanin, M. S. E. D., & Abdel-Aziz, B. R. (2022). Evaluation of yolk sac diameter, gestational sac diameter and embryonic heart rate as prognostic factors of first trimestric outcome. *Al-Azhar International Medical Journal*, *3*(9), 58-63.
11. Saleh, S. M., Abdellah, A. H., Hassan, A. G. E., & Almaz, D. M. G. (2023). Value of intrauterine fetal length measurement in assessment of fetal age. *SVU-International Journal of Medical Sciences*, *6*(1), 122-129.
12. El-Refaie, T., Samy, M., Khattab, R., & Taha, Y. (2022). Accuracy of Fetal Transcerebellar Diameter in Evaluation of Fetal Gestational Age in Egyptian Pregnant Women. *Evidence Based Women's Health Journal*. *12*(1), 86-96.
13. Masod, L. E., Metawie, M., Reyad, I. A., & Younis, M. H. (2023). Transcerebellar Diameter for Determination of Gestational Age In Comparison to Conventional Fetal Biometry in the Second Half of Pregnancy. *Medicine Updates*. *13*(13), 30-40
14. Parikh LI, Nolan J, Tefera E & Driggers R. (2014). Fetal biometry: does patient ethnicity matter? *J Matern Fetal Neonatal Med*. 27(5):500–504.
15. Yusuf N, Moslem F, Haque J.A. (2007). Fetal Kidney Length: can be a new parameter for determination of gestational age in 3rd trimester. *TAJ Journal of Teachers Association*. 20(2): 147-150.
16. Mustafa, MO., Ali, QM., Haleeb, M., Badawey, K., Abdelmotalab, MAA. (2022). Ultrasonography of fetal kidney length as the approach for estimation of gestational age in Sudanese. *Anatomy Journal of Africa*. 11(2): 2167-2174

17. Hadlock FP, Harrist RB, Sharman RS, Deter RL, Park SK. (1985). Estimation of fetal weight with the use of head, body, and femur measurements--a prospective study. *Am J Obstet Gynecol*. 151:333–337.
18. Mahony B, Callen P, Filly R. The distal femoral epiphyseal ossification center in the assessment of third-trimester menstrual age: sonographic identification and measurement. Radiology 1985;155(1):201–204.
19. Kumar K, Lalwani R, Babu R, Aneja S, Malik A. (2013). Ultrasonographic estimation of fetal gestational age by fetal kidney length. *Journal of the Anatomical Society of India*. 62: 33–36
20. Enefia KK, Peter CO, Datonye CB, *et al*. (2023). Ultrasound Measurement of Foetal Kidney Length during Healthy Pregnancy: Relationship with Gestational Age. *Ethiop J Health Sci*. 33(1):97.
21. Khalaf, A. S., & Hassein, M. R. (2022). Ultrasonic Evaluation of Fetal Kidney Length in Second and Third Trimester Correlated with Gestational Age in Salaldeen General Hospital. *Journal of Pharmaceutical Negative Results*. 982-986.
22. Zamir, A., Azam, S., Ali, A., Afsar, R., Khalid, A., & Dar, W. M. (2022). Correlation of Sonographic Gestational Age with Fetal Kidney Length in Normal Pregnancy: Sonographic Gestational Age with Fetal Kidney Length in Normal Pregnancy. *Pakistan BioMedical Journal*. 55-59.
23. Ugur, M. G., Mustafa, A., Ozcan, H. C., Tepe, N. B., Kurt, H., Akcil, E., & Gunduz, R. (2016). Fetal kidney length as a useful adjunct parameter for better determination of gestational age. *Saudi Medical Journal*, *37*(5), 533.
24. Singh A, Singh G, Gupta K. Estimation of Gestational Age by Using Fetal Kidney Length and Transcerebellar Diameter in Comparison with Other Biometric Indices. Donald School J Ultrasound Obstet Gynecol 2021;15(1):4–9.
25. Konje JC, Abrams KR, Bell SC, Taylor DJ. (2002). Determination of gestational age after the 24th week of gestation from fetal kidney length measurements. *Ultrasound Obstetrics and Gynaecology*. 19: 592-597
26. Kaul, I., Menia, V., Anand, AK., Gupta, R. (2012). Role of fetal kidney length in estimation of gestational age. *JK Science*. April-June: 65 – 69.

27. Akintomide AO, Efanga SA. (2022). Fetal kidney length: A likely sole index for gestational age determination in late pregnancy and certain abnormalities. Niger J Med. 31:138 – 43.
28. Eldafrawy NEM, Hussein NAM, Elbadry AMT, Agllan NIM. (2022). Ultrasonographic Assessment of Third Trimester Fetal Kidney Length as a Measure of Gestational age in Growth Restricted Fetuses. *Journal of Advances in Medicine and Medical Research*. 34(5): 75-89.