THESIS TO BE SUBMITTED TO

NATIONAL BOARD OF EXAMINATIONS

FOR THE AWARD OF

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(RADIODIAGNOSIS)

ULTRASONOGRAPHIC ESTIMATION OF GESTATIONAL AGE BY FETAL KIDNEY LENGTH WITH OTHER PARAMETERS IN SECOND AND THIRD TRIMESTER

BY

DR. S. RADHIKA

POST DIPLOMA DNB RADIODIAGNOSIS

DEPARTMENT OF RADIODIAGNOSIS

DR. KAMAKSHI INSTITUTE OF MEDICAL SCIENCES

AND RESEARCH CENTER

CHENNAI, TAMIL NADU

NATIONAL BOARD OF EXAMINATIONS

NEW DELHI

DISSERTATION SUBMISSION FORM

Name of the Candidate: Dr. S. Radhika

Registration Number: 240-41128-241-259460

Subject: RADIODIAGNOSIS

Date of Joining Course: 12.12.2024

Hospital / Institute: Dr. Kamakshi Institute of Medical Sciences and Research Center, Chennai

Guide: Prof. Dr. T. S. Swaminathan, MD, DMRD, FICR

Co-Guide: Dr. Vijaya Karthikeyan, MD, FRCR

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THESIS PROTOCOL FORM

PROTOCOL CODE NO	**TP254020408**
NAME OF THE CANDIDATE:	RADHIKA S
SPECIALITY:	Radio Diagnosis
INSTITUION CODE:	41128
INSTITUTION NAME & ADDRESS:	Dr. Kamakshi Memorial Hospital, (Dr. Kamakshi Institute of Medical Sciences and Research) No.1, Radial Road, Pallikaranai, Chennai, Tamil Nadu-600100
NBEMS ROLL NO. / TESTING ID :	2422101063
NBEMS Registration No. :	240-41128-241-259460
DATE OF JOINING:	12.12.2024
DUE DATE OF PROTOCOL/ANNEXURE SUBMISSION (MAXIMUM 90 DAYS FROM THE DATE OF JOINING)	12-03-2025
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(SIGNATURE OF CANDIDATE)

Dr. T.G. GOVINDARAJAN
Director, President, Founder,
Reg. No. 31883
Dr. Kamakshi Memorial Hospital Pvt. Ltd.
Pallikaranai, Chennai – 600 100.

Dr. K.M. RADHAKRISHNAN,
M.B.B.S.,D.C.P.,
ADVISOR
Dr. Kamakshi Memorial Group of Hospitals,
No.1, Radial Road, Pallikaranai,
Chennai – 600 100.

Dr. T.S. SWAMINATHAN
MD DMRD FICR FIMSA Phd.
HEAD OF DEPT. OF RADIOLOGY & IMAGING
DR. KAMAKSHI MEMORIAL HOSPITAL
PALLIKARANAI, CHENNAI-600 100
EMERITUS PROFESSOR
THE TAMILNADU Dr. MGR MEDICAL UNIVERSITY
GUIDE SIGNATURE

Dr. VIJAY KARTHIYAKEYAN, MD., FRCR
(Consultant Radiologist)
Reg. No. 80901
CO-GUIDE SIGNATURE

DECLARATION CUM UNDERTAKING FOR FRESH THESIS

I DR. S. RADHIKA hereby declare that this thesis entitled "Ultrasonographic Estimation of gestational age by Fetal kidney length with Other Parameters in Second and Third Trimester" is 'bonafide' in nature and was carried out by me for under the guidance and supervision of my guide Prof. Dr. T.S. Swaminathan and co-guide Dr. M. Vijaya Karthikeyan.

The interpretations put forth are based on my reading and understanding of the original texts and they are not published anywhere in the form of books, monographs or articles. The other books, articles and websites, which I have made use of are acknowledged at the respective place in the text.

For the present thesis, which i am submitting to the National Board of Examinations in Medical Sciences, New Delhi, no degree or diploma or distinction has been conferred on me before elsewhere.

Place: Chennai
Date: 06.02.2026

(Candidate Signature)
Trainee Name: DR. S. RADHIKA
Specialty: POST DIPLOMA RADIO-DIAGNOSIS
Registration Number: 240 - 41128 - 241 - 259460

COUNTERSIGNED & VERIFIED

(Guide Signature)
Guide Name: Prof. T.S. SWAMINATHAN, M.D.,D.M.R.D.,FICR.,
Guide Designation: Head of Department of Radiology & Imaging Science
Institution: Dr. KAMAKSHI MEMORIAL HOSPITAL PVT. LTD. No.1, RADIAL ROAD, PALLIKARANAI, CHENNAI-600 100.
Stamp bearing Guide name:

(Co-Guide Signature)
Co-Guide Name: Dr. VIJAY KARTHIYAKEYAN, MD., FRCR
Co-Guide Designation: (Consultant Radiologist)
Institution: Reg. No. 80901
Stamp bearing Co-Guide name:

(HOI Signature)
HOI Name: Dr.T.G.GOVINDARAJAN
HOI Designation: CHAIRMAN-MANAGING DIRECTOR
Institution: Reg.No: 31883
Stamp bearing HOI name Dr.Kamakshi Memorial Hospital Pvt.Ltd. No:1, Radial Road, Pallikaranai, Chennai-100.

DECLARATION CERTIFICATE BY THE THESIS GUIDE

AND HEAD OF THE DEPARTMENT

This is to certify that the dissertation titled **"Ultrasonographic Estimation of Gestational Age by Fetal Kidney Length with Other Parameters in Second and Third Trimester"** is a bonafide research work done by **Dr. S. Radhika** under my guidance, in partial fulfilment of the requirement for the degree of Diplomate of National Board in Radiodiagnosis.

Prof. T.S. SWAMINATHAN, M.D.,D.M.R.D.,FICR.,
Head of Department of
Radiology & Imaging Science
Dr. KAMAKSHI MEMORIAL HOSPITAL PVT. LTD.
No.1, RADIAL ROAD, PALLIKARANAI,
CHENNAI-600 100.

Place: Chennai

Date: 06.02.2026

Dr. SWAMINATHAN, MD, DMRD, FICR,

Professor, Head of Department

Department of Radiodiagnosis

Dr. Kamakshi Institute of Medical Sciences and Research Center

Chennai, Tamil Nadu – 600100

DECLARATION CERTIFICATE BY THE CO-GUIDE

This is to certify that the dissertation titled **"Ultrasonographic Estimation of Gestational Age by Fetal Kidney Length with Other Parameters in Second and Third Trimester"** is a bonafide research work done by **Dr. S. Radhika** under my guidance, in partial fulfilment of the requirement for the degree of Diplomate of National Board in Radiodiagnosis.

Dr. VIJAY KARTHIYAKEYAN, MD., FRCR
(Consultant Radiologist)
Reg. No. 80901

Place: Chennai

Date: 06.02.2026

Dr. M.VIJAYA KARTHIKEYAN,MD,FRCR,

Consultant Radiologist,

Department Of Radio-Diagnosis,

Dr. Kamakshi Institute of Medical Sciences and Research Center

Chennai, Tamil Nadu – 600100

DECLARATION CERTIFICATE BY HEAD OF INSTITUTION

This is to certify that the dissertation titled **"Ultrasonographic Estimation of Gestational Age by Fetal Kidney Length with Other Parameters in Second and Third Trimester"** is a bonafide research work done by **Dr. S. Radhika** under my guidance, in partial fulfilment of the requirement for the degree of Diplomate of National Board in Radiodiagnosis.

Place: Chennai

Date: 06.02.2026

Dr. T. G. Govindarajan,

Head of the Institution,

Dr. Kamakshi Memorial Hospital, Pallikaranai

Chennai, Tamil Nadu – 600100

Dr.T.G.GOVINDARAJAN
CHAIRMAN-MANAGING DIRECTOR
Reg.No: 31883
Dr.Kamakshi Memorial Hospital Pvt.Ltd.
No:1, Radial Road, Pallikaranai, Chennai-100.

DECLARATION CERTIFICATE BY CANDIDATE

I hereby declare that this dissertation titled **"Ultrasonographic Estimation of Gestational Age by Fetal Kidney Length with Other Parameters in Second and Third Trimester"** is a bonafide work done by me under the guidance and supervision of **my guide** and **Head of the Department, Department of Radiodiagnosis Prof. Dr. T. S. Swaminathan, MD, DMRD, FICR,** and Co-guide **Dr. M. Vijaya Karthikeyan, MD, FRCR,** in partial fulfilment of the requirement for the degree of Diplomate of National Board in Radiodiagnosis. This work has not formed the basis for the award of any degree or diploma to me by any other university before.

Dr. S. Radhika

Place: Chennai

Date: 06.02.2026

Annexure – Thesis Protocol Approval (TPA)

Ref. No: 25/BC-036/2025

Dated: 10.03.2025

To
The Deputy Director
National Board of Examinations
Medical Enclave, Ansari Nagar,
Mahatma Gandhi Marg (Ring Road)
New Delhi-110029

Subject - Thesis Protocol Approval Letter (Institutional Ethics Committee & Scientific Research Committee and its Composition)

Respected Sir,

This is for your kind information that the research proposal/thesis protocols of below listed DNB candidates have been considered and reviewed by the Scientific Research Committee (SRC) of the Institute/hospital in its meeting held on 03.03.2025 and by the Institutional Ethics Committee (IEC) in its meeting held on 08.03.2025.

S. No.	Name of the Candidate	Specialty	Session	Testing ID/ Roll number	Title of the Thesis
1	Dr. Bharathi A	DNB (Post Diploma) Anaesthesiology	2024	2422101097	Efficacy and safety of sugammadex vs neostigmine in reversing rocuronium induced neuromuscular blockade – a double blinded randomized control study
2	Dr. S. Radhika	DNB (Post Diploma) Radio Diagnosis	2024	2422101063	Ultrasonographic Estimation of Gestational Age by Fetal Kidney Length along with Other Parameters in Second and Third Trimester

Dr.Kamakshi
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Sep 21, 2023 - Sep 20, 2027

The IEC which reviewed the proposals is duly registered with the Drug Controller General of India (DCGI) and SRC of the hospital is composed as per guidelines prescribed by NBE for the purpose. The authenticated copies of the composition of both the committees are enclosed herewith. Both the committees, i.e. IEC and SRC have approved to conduct the study on above listed research proposal(s) of DNB candidate(s) for the purpose of writing their DNB theses. It is further certified that the proposed research protocol(s) have not been/shall not be submitted elsewhere for any degree, fellowship or any other titles for recognition. The minutes of the aforesaid meetings of IEC and SRC are available with the hospital and can be reproduced before NBE, if so required, at any point of time.

Name and Signature
Academic Head/ DNB Coordinator

Dr. K.M. RADHAKRISHNAN
M.B.B.S.,D.C.P.,
ADVISOR
Dr. Kamakshi Memorial Group of Hospitals
No.1, Radial Road, Pallikaranai,
Chennai - 600 100.

Name and Signature
Administrative Head of the Institute

Dr. T.G. GOVINDARAJAN
CHAIRMAN-MANAGING DIRECTOR
Reg. No: 31883
Dr. KAMAKSHI MEMORIAL HOSPITAL PVT. LTD.
#1, Radial Road, Pallikaranai, Chennai-100

Enclosed:
1. Composition of Institutional Ethics Committee (IEC)
2. Composition of Scientific Research Committee (SRC) stamp

ECR/257/Kamakshi/Inst/TN/2013/Re-Registration-2019
Government of India
Directorate General of Health Services
Central Drugs Standard Control Organization
(Ethics Committee Registration Division)

Dated: 16 AUG 2024

To,

The Chairman/Member Secretary,
Dr. KMH-IEC Dr. Kamakshi Memorial Hospitals Pvt. Ltd.
No. 1, Radial Road Pallikaranai,
Chennai Tamil Nadu - 600100 India

Subject: Ethics Committee Registration No. **ECR/102/Inst/TN/2013/RR-20** amendment to the composition of the Ethics Committee-regarding.

Sir/Madam,

Please refer to your application submitted to this Directorate for change in composition of the Registered Ethics Committee.

Based on the documents submitted by you, the composition of your Ethics Committee bearing Registration number **ECR/102/Inst/TN/2013/RR-20** dated **09.03.2020** valid until **04.03.2025** is hereby amended as follows, with all conditions of the Registration Certificate initially granted to you, remaining the same including the condition that **"the Ethics Committee shall review and accord approval to Clinical Trial and BA/BE Study protocol of new drugs and also conduct periodic review of the studies as per the New Drugs and Clinical Trial Rules, 2019".**

Sr. No.	Name of member	Qualification	Role/Designation in Ethics Committee
1.	Dr. Rukmani B	MBBS, DGO, DNB Obst. & Gynae	Chairperson
2.	Dr. Jayachandran K	MBBS, MD, DCH	Member Secretary
3.	Dr. C. Suthakaran	M.D (Pharmacology)	Medical Scientist
4.	Dr. Rajiv Rajendranath	MD, DM, DNB (Medical Onclology) ECMO	Clinician
5.	Dr. T.S. Swaminath	MBBS, Md, DMRD, FICR, FISMA, PhD	Clinician
6.	Dr. Ramya Ramanathan	MBBS, DNB (Family Medicine)	Clinician
7.	Dr. Kala Kandhasamy	MBBS, MD-Pathology & Microbiology, DNB-Pathology	Basic Medical Scientist
8.	Dr. Mohammad Farazuddin	Pharm D	Scientific Member
9.	Dr. Geethalakshmi S	MBBS, MD (General Medicine), D.M, (Endocrinology)	Clinician
10.	Mr. R. Balaji	B.Com., F.C.A.,	Lay Person
11.	Dr. C Murugan	MSW, PhD	Social scientist
12.	Ms. Aiyshwarayan Sarvagyam	B.Com, MBA, ML	Legal expert

Yours faithfully

(Dr. Rajeev Singh Raghuvanshi)
Central Licensing Authority

Government of India
Ministry of Health & Family Welfare
Department of Health Research
(National Ethics Committee Registry for Biomedical and Health Research)

2nd Floor, IRCS Building,
Red Cross Road,New Delhi – 110001
Date : 23-Jun-2023

सत्यमेव जयते

To

The Chairperson
Institution Ethics Committee
Dr Kamakshi Memorial Hospital Pvt Ltd No.1 Radial Road Pallikaranai, City-Chennai, District-Chennai - Tamil Nadu - 600100

Subject: Ethics Committee Registration No. EC/NEW/INST/2023/TN/0288 issued under New Drugs and Clinical Trials Rules, 2019

Sir/Madam,

Please refer to your file No. EC/NEW/INST/2020/1264, dated 19-Oct-2020 submitted to this National Ethics Committee Registry for Biomedical and Health Research (NECRBHR, Department of Health Research) for the Registration of Ethics committee.

Please find the enclosed registration of the Ethics committee in form CT-03 vide Registration No. EC/NEW/INST/2023/TN/0288, dated 14-Jun-2023. The said registration is subjected to the conditions as mentioned below.

Yours faithfully,

BISWABANDAN SENAPATI
Digitally signed by BISWABANDAN SENAPATI
Date: 2023.06.23 17:10:44 +05'30'

(B. Senapati)
Director

Conditions of Registration

The following include few of the conditions to be followed by the Ethics Committees (ECs) registered with the Designated Authority (NECRBHR, DHR).

1. The registration is valid for a period of five years from the date of its issue, unless suspended or cancelled by the Designated Authority, NECRBHR, DHR. The EC has been registered for the purpose of reviewing Biomedical and Health Research. For Clinical Trials review, registration with CDSCO is required.

2. This certificate is issued to you on the basis of declaration/submission made by you.

3. An institution or organization or any person shall conduct any Biomedical and Health Research with the approval of the Ethics Committee registered under rule 17, Chapter IV of New Drugs and Clinical Trials Rules 2019.

4. EC registration number provided by DHR should be displayed on every certificate of approval issued by the Ethics committee.

5. The Ethics Committee should be constituted in accordance with the National Ethical Guidelines for Biomedical and Health Research Involving Human Participants 2017 as may be specified by the Indian Council of Medical Research from time to time and shall function in accordance with said guidelines.
   a) EC composition should be as follows:
      i) ECs should be multi-disciplinary and multi-sectoral.
      ii) There should be adequate representation of age and gender.

File No. EC/NEW/INST/2020/1264

Government of India
Ministry of Health & Family Welfare
Department of Health Research
(National Ethics Committee Registry for Biomedical and Health Research)

2nd Floor, IRCS Building,
Red Cross Road,New Delhi – 110001
Date : 14-Jun-2023

सत्यमेव जयते

FORM CT-03

(See rules 17 and 18)

GRANT OF REGISTRATION OF ETHICS COMMITTEE RELATING TO BIOMEDICAL HEALTH RESEARCH

Registration No. EC/NEW/INST/2023/TN/0289

The designated authority hereby registers and permits Institution Ethics Committee , Dr Kamakshi Memorial Hospital Pvt Ltd No.1 Radial Road Pallikaranai , City-Chennai, District-Chennai - Tamil Nadu - 600100 Contact No.: 04466300300 Fax No.: 04466300400 to perform duties of ethics committee as specified in the New Drugs and Clinical Trials Rules, 2019.

2. The ethics committee shall observe the conditions of registration specified in Chapter IV of the New Drugs and Clinical Trials Rules, 2019 and the Drugs and Cosmetics Act, 1940.

ANU NAGAR
Digitally signed by ANU NAGAR
Date: 2023.06.14 12:30:58 +05'30'

Place : New Delhi

Date : 14-Jun-2023

Designated Registration Authority
Stamp

SCIENTIFIC RESEARCH COMMITTEE

Dr.KAMAKSHI MEMORIAL HOSPITAL PVT. LTD.

SRC - Clearance Number:02/SRC/2024-2025 Date: 05.03.2025

Scientific Research Committee- Certificate

The Scientific Research committee discussed **"ULTRASONOGRAPHIC ESTIMATION OF GESTATIONAL AGE BY FETAL KIDNEY LENGTH WITH OTHER PARAMETERS IN SECOND AND THIRD TRIMESTER."** – by Dr. S. Radhika., Roll No.: 2422101063 - DNB (Post Diploma) Radio Diagnosis, under guidance of - Prof Dr. T.S. Swaminathan - Head of the Department -Radio Diagnosis & Co-Guide - Dr. Vijaya Karthikeyan, Consultant- Radio Diagnosis, Dr.Kamakshi Memorial Hospital Pvt Ltd., Pallikaranai-Chennai, meeting held on 04.03.2025 at 2.30pm.

The Scientific Committee approved the above-mentioned Thesis protocol, and the progress will be reviewed.

Dr. T. G. Govindarajan
Chairperson- Scientific Research Committee
Dr. Kamakshi Memorial Hospital Pvt Ltd.

Chairperson
Scientific Committee
Dr. Kamakshi Memorial Hospital Pvt.Ltd.
No.1, Radial Road, Pallikaranai, Chennai-100.

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I express my deep sense of gratitude to my guide and Head if the department Professor Dr T S Swaminathan MD, DMRD, FICR for his valuable guidance and constant encouragement.

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I thank all my post graduate colleagues who have helped me in preparing this dissertation.

Last but not the least, I wish to thank Almighty God and my family for all the grace and blessings.

Place:

Date:

Dr. S. Radhika

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1. INTRODUCTION

Accurate assessment of gestational age (GA) is a cornerstone of modern obstetric practice, as it directly influences antenatal surveillance, timing of delivery, interpretation of fetal growth, and perinatal outcome. Precise determination of gestational age is essential for diagnosing fetal growth abnormalities, planning obstetric interventions, and reducing perinatal morbidity and mortality associated with preterm or post-term deliveries. Traditionally, gestational age estimation relies on the last menstrual period (LMP); however, LMP-based dating is often unreliable due to irregular menstrual cycles, recall bias, or unknown dates. Consequently, ultrasonography has become the most reliable modality for estimating gestational age, particularly when performed early in pregnancy[1.]

In the first trimester, crown–rump length (CRL) provides the most accurate estimation of gestational age. However, in the second and third trimesters, gestational age estimation becomes more challenging due to increasing biological variability in fetal growth. Commonly used fetal biometric parameters in later gestation include biparietal diameter (BPD), head circumference (HC), abdominal circumference (AC), femur length (FL), and transcerebellar diameter (TCD). While these parameters are widely accepted, each has inherent limitations. BPD and HC may be affected by fetal head molding, abnormal head shapes such as dolichocephaly or brachycephaly, and intracranial pathology. Femur length may be unreliable in skeletal dysplasias, while abdominal circumference is significantly influenced by fetal growth restriction and nutritional status. In recent years, fetal kidney length (FKL) has emerged as a promising alternative parameter for gestational age estimation, particularly in the second and third trimesters. The fetal kidneys begin development early in gestation and exhibit a relatively linear growth pattern throughout pregnancy. Unlike other biometric parameters, renal growth is

minimally affected by fetal growth disturbances, abnormal fetal presentation, or head shape variations. Several studies have demonstrated a strong positive correlation between fetal kidney length and gestational age, with renal length in millimeters closely approximating gestational age in weeks during mid and late pregnancy. Measurement of fetal kidney length is technically simple, reproducible, and less influenced by external compression or fetal position. It can be particularly valuable in cases of uncertain gestational age, late booking pregnancies, growth-restricted fetuses, or conditions where conventional biometric indices may be unreliable. Incorporating fetal kidney length along with standard biometric parameters may improve the accuracy of gestational age estimation in the second and third trimesters.

Therefore, this study aims to evaluate the accuracy of ultrasonographic estimation of gestational age using fetal kidney length and to compare it with established fetal biometric parameters such as BPD, HC, AC, and FL during the second and third trimesters of pregnancy.

2. REVIEW OF LITERATURE

• Ugur [3] et al. evaluated fetal kidney length as an adjunct parameter for gestational age estimation in second and third trimester pregnancies. They demonstrated a strong positive correlation between fetal kidney length and gestational age ($r = 0.947$, $p = 0.001$). The study further showed that adding fetal kidney length to routine biometric parameters significantly improved the predictive accuracy of gestational age models, particularly in late gestation where conventional indices show increased variability.

• Edevbie [4] et al. conducted a cross-sectional study on 400 pregnant women between 20 and 41 weeks of gestation and found an exceptionally strong correlation between mean fetal kidney length and gestational age ($r = 0.997$, $p < 0.001$). Their results demonstrated that fetal kidney length provided a smaller standard error in gestational age prediction when compared to traditional biometric parameters, suggesting superior reliability in mid and late pregnancy.

• Yusuf [5] et al. assessed fetal kidney length growth patterns in normal singleton pregnancies and observed a linear increase in renal length with advancing gestation. The authors reported a strong correlation between mean kidney length and gestational age predicted by biparietal diameter, femur length, head circumference, and abdominal circumference, supporting the role of fetal kidney length as a dependable indicator of gestational maturity.

• Konje [6] et al. examined the accuracy of gestational age estimation beyond 24 weeks using fetal kidney length and found that renal length predicted gestational age with a lower standard error compared to several conventional biometric combinations. Their regression models incorporating kidney length were slightly more accurate than those

based solely on biparietal diameter, head circumference, femur length, or abdominal circumference.

• Bardhan [7] et al. reported that fetal renal length in millimeters closely corresponded to gestational age in weeks, particularly during the second and third trimesters. The study demonstrated an extremely strong correlation between gestational age and fetal kidney length ($r = 0.99$, $p < 0.001$), as well as significant associations with other biometric parameters, reinforcing its clinical usefulness.

• Khanal [8] et al. established gestational age-specific reference values for fetal kidney length and showed that renal length had the highest Pearson correlation coefficient with gestational age when compared to biparietal diameter, head circumference, abdominal circumference, and femur length. Their findings suggested that fetal kidney length may outperform conventional parameters in late gestation dating.

• Kiridi [9] et al. evaluated fetal renal dimensions and reported a very strong correlation between mean fetal kidney length and gestational age ($p = 0.001$). The authors derived a regression equation demonstrating that changes in kidney length accounted for a significant proportion of gestational age variation, highlighting its predictive strength.

• Edevbie [10] et al. further confirmed that combined fetal kidney length showed a strong linear relationship with gestational age across all weeks studied. The authors emphasized that renal growth was less influenced by fetal growth disturbances, making fetal kidney length a reliable adjunct parameter, particularly in pregnancies complicated by growth restriction or uncertain dating.

3. GESTATIONAL AGE

GESTATIONAL AGE ASSESSMENT

Assessment of gestational age using ultrasonography is one of the most widely accepted and dependable methods for determining the true gestational age of the fetus. Accurate dating of pregnancy is crucial for appropriate antenatal management, timely identification of fetal growth abnormalities, and correct calculation of the expected date of delivery (EDD). Ultrasonographic evaluation plays a vital role, particularly when menstrual history is uncertain or unreliable.

FIRST TRIMESTER (0–13 WEEKS)

The first trimester, especially between 8 and 12 weeks of gestation, is considered the most precise period for determining gestational age using ultrasonography.[8] During this phase, fetal growth is uniform, allowing highly accurate dating.

Crown–Rump Length (CRL)

Crown–rump length measurement is regarded as the gold standard for gestational age estimation in the first trimester. It provides excellent accuracy, with an error margin of approximately ±3 to 5 days. CRL is defined as the linear distance measured from the crown of the fetal head to the caudal end of the trunk, excluding the limbs and yolk sac.

Method of CRL Measurement

For CRL assessment, the pregnant individual is positioned in the supine posture, and ultrasonography is performed either transabdominally or transvaginally. While transabdominal ultrasound is commonly employed in later stages of early pregnancy, transvaginal ultrasound offers superior image resolution during very early gestation. The embryo or fetus should be visualized in a neutral position, avoiding excessive flexion or extension. The image is magnified to occupy the majority of the screen to enhance measurement precision.

FIG-1: CRL measurement at 6 weeks

Fig-2: CRL measurement at 12 weeks.

The measurement is taken in a straight line from the uppermost part of the fetal head (crown) to the lowest part of the torso (rump), carefully excluding the yolk sac and extremities. Any curvature of the fetal spine should be avoided.[8] To improve reliability, at least two to three measurements are obtained, and the mean value is considered as the final CRL. This value is then compared with established reference charts to calculate gestational age.

An official estimated date of delivery is established after calculating the EDD based on the first-trimester ultrasound and correlating it with the last menstrual period. When the difference between the LMP-based EDD and the first-trimester sonographic EDD is within seven days, the LMP-derived date is accepted. If the discrepancy exceeds seven days, the ultrasound-based EDD is considered the corrected due date.[9]

SECOND TRIMESTER (14–27 WEEKS)

During the second trimester, gestational age estimation relies on multiple fetal biometric parameters. The commonly used measurements include biparietal diameter, head circumference, abdominal circumference, and femur length.

Biparietal Diameter (BPD)

Biparietal diameter was the earliest ultrasonographic parameter introduced for fetal age assessment and remains one of the most reliable indicators during the second trimester, with an accuracy of approximately ±5 days. However, its clinical applicability may be influenced by factors such as fetal head shape, molding, and presentation.

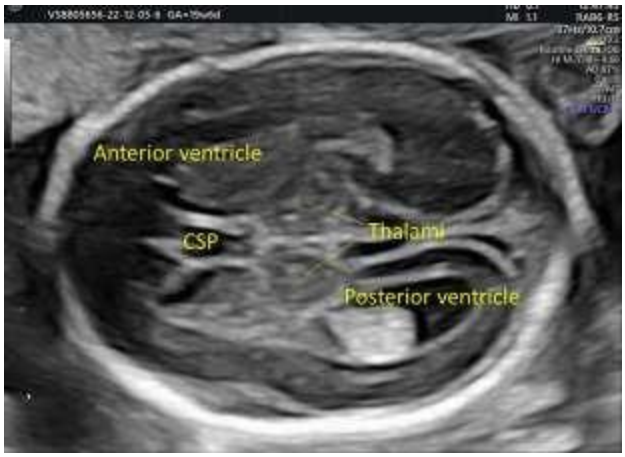


Fig-3: Trans thalamic plane at 19 weeks

A true axial plane of the fetal head is obtained using a curvilinear abdominal transducer. The ideal imaging plane is the trans-thalamic section, demonstrating the cavum septum pellucidum and thalami. The posterior fossa and cerebellum should not be included in

this plane.[10] The fetal head should appear oval, resembling a rugby football shape, with a rounded occiput and a slightly pointed frontal region.

Two standard techniques are used for BPD measurement: the outer-to-inner (OI) method and the outer-to-outer (OO) method. In the OI technique, calipers are placed from the outer edge of the near parietal bone to the inner edge of the far parietal bone. In contrast, the OO technique measures from the outer edge of the near parietal bone to the outer edge of the far parietal bone.[10]

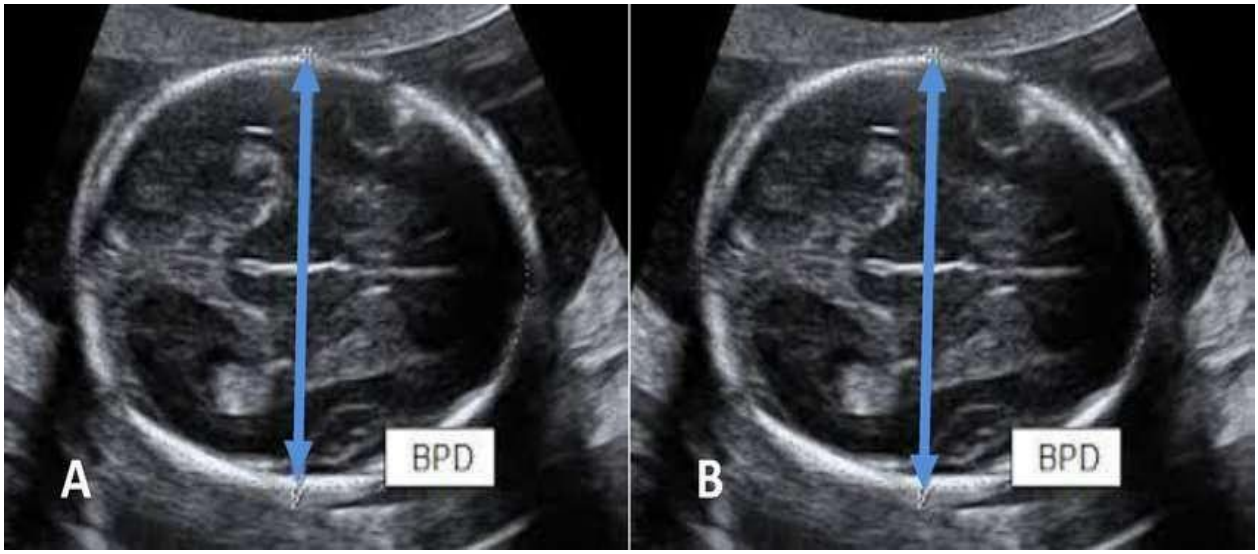


Figure 4: (A) BPD (OI) method and (B) BPD (OO) method at 20 weeks

In routine clinical practice, the BPD (OO) method is less favored. The BPD (OI) technique is currently recommended as the standard approach for fetal head measurement and is routinely incorporated into estimated fetal weight calculations.

Head Circumference (HC)

Measurement of head circumference is an essential component of fetal biometry during antenatal ultrasound examinations. It serves as an important indicator of fetal growth and aids in the detection of cranial abnormalities such as microcephaly and macrocephaly.[11] HC is measured in the same trans-thalamic plane used for BPD assessment.

Fig-5: Transthalamic plane at 25weeks. 1) Thalami, (2) falx, (3) third ventricle, (4) cavum septum pellucidum, (5) Sylvian fissure (arrows) anterior horns.

A true axial section of the fetal head should be obtained, ensuring symmetrical visualization of the thalami, cavum septum pellucidum, and falx cerebri dividing the brain into two equal halves. The skull outline should be smooth and oval, without distortion or elongation, to ensure accurate measurement.[12]

Fig-6: Measurement of head cicumference

Most contemporary ultrasound systems are capable of automatically calculating head circumference when the ellipse function is used to trace the outline of the fetal skull. As an alternative approach, head circumference can also be derived mathematically using biparietal diameter and occipitofrontal diameter, according to the formula: HC = 1.62 × (BPD + OFD). Measurements should be taken along the outer margins of the fetal calvarium, excluding the scalp and overlying soft tissues. Calipers are carefully positioned along the perimeter of the skull to accurately delineate the cranial outline and obtain a reliable head circumference value.

ABDOMINAL CIRCUMFERENCE

Abdominal circumference measurement requires acquisition of a true axial section of the fetal abdomen. Certain anatomical landmarks must be clearly visualized to ensure correct plane selection. These include the stomach bubble located on the left side of the abdomen, the portal sinus appearing as a characteristic J-shaped or hockey stick-shaped structure within the mid-abdomen, and the fetal spine visualized posteriorly as three

echogenic points representing the vertebrae. The abdominal cross-section should appear round rather than oval or oblique, as an oblique plane can result in inaccurate measurements. To minimize obliquity, the fetal spine should be positioned at either the 3 o'clock or 9 o'clock position. Excessive transducer pressure should be avoided, as it may artificially distort the abdominal contour and lead to underestimation of circumference.

The abdominal circumference is measured using the ellipse tool by tracing the outer skin margin of the fetal abdomen, ensuring inclusion of both soft tissue and skin for accurate assessment.

Figure 7: 1) Intrahepatic portion of the umbilical vein, at the level of the portal sinus. (2) Adrenalin gland. (3) Vertebrae. (4) Stomach bubble.

Fig-8: Measurement of abdominal circumstance.

FEMUR LENGTH

Femur length is an important parameter for evaluating fetal growth, estimating gestational age, and identifying skeletal abnormalities. Measurement is performed by obtaining a longitudinal view of the fetal femur. The entire length of the femur must be visualized clearly and should appear straight without foreshortening. The femur is identified as a bright, linear echogenic structure and should be the longest bone visible in the field, located within the upper limb region. Proper transducer alignment is essential to orient the femur horizontally across the screen. Both the proximal and distal ends of the femoral diaphysis should be clearly visualized, with calipers placed accurately at each end to ensure correct measurement.[13] Once calipers are properly positioned, the ultrasound system automatically calculates the femur length.

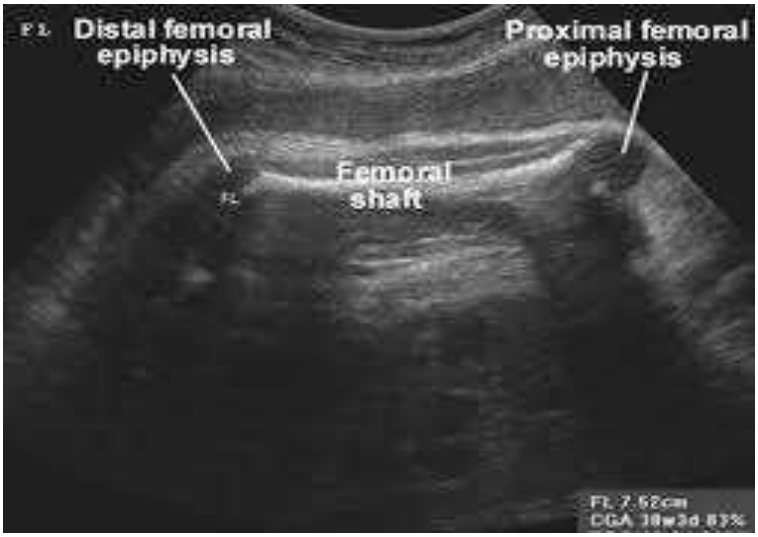


Fig-9: Femur length ultrasonic image.

Fig-10: Measurement of femur length.

FETAL KIDNEY LENGTH MEASURMENT

Measurement of fetal kidney length is performed using ultrasonography in a standardized and reproducible manner and serves as a reliable parameter for estimating gestational age in the second and third trimesters. The fetus is first examined in a transverse plane to identify the kidneys, which are typically located inferior to the stomach and lateral to the spine. Once the kidney is visualized, the transducer is rotated approximately 90 degrees to obtain a longitudinal view of the renal axis. The kidney appears as an oval or elongated structure with a hypoechoic cortex and echogenic central sinus. Measurement is taken from the outer margin of the upper pole to the outer margin of the lower pole, ensuring that the adrenal gland is not included. Care is taken to align the calipers parallel to the long axis of the kidney to avoid oblique measurements. Both kidneys may be measured, and the mean value can be considered to improve accuracy. Fetal kidney length increases in a near-linear fashion with advancing gestation and is relatively unaffected by fetal head shape, growth restriction, or presentation, making it a valuable adjunct to conventional biometric parameters for gestational age estimation.

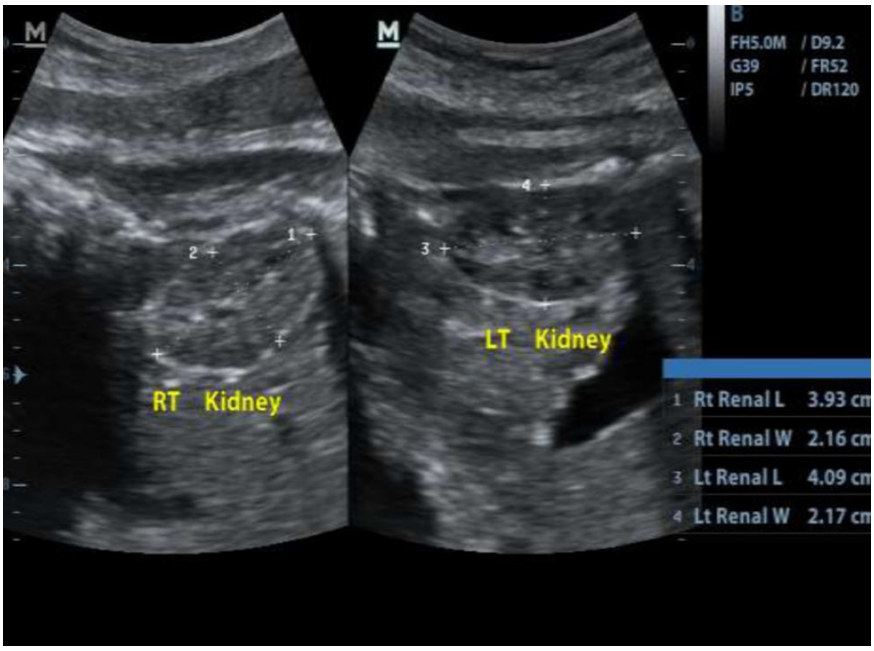


Fig-11: Measurement of fetal kidney length.

4. AIM AND OBJECTIVES

AIM

To evaluate the accuracy of ultrasonographic estimation of gestational age using fetal kidney length and to compare its reliability with conventional fetal biometric parameters in the second and third trimesters of pregnancy.

OBJECTIVES

1. To assess the correlation between fetal kidney length and gestational age using last menstrual period as the reference standard in second and third trimester pregnancies.
2. To compare gestational age estimated by fetal kidney length with gestational age derived from established biometric parameters, namely biparietal diameter, head circumference, abdominal circumference, and femur length.
3. To determine the usefulness of fetal kidney length as an adjunct or alternative parameter for gestational age estimation in situations where conventional biometric measurements may be unreliable.

5. MATERIALS AND METHODS

Study Setting

The present study was conducted in the Department of Radiodiagnosis at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee and Scientific Review Committee. All ultrasonographic examinations were performed as part of routine antenatal care in accordance with established departmental protocols.

Profile of the Hospital

The study was carried out at Dr. Kamakshi Institute of Medical Sciences and Research Center, Chennai, which is a tertiary care referral hospital providing comprehensive obstetric, gynecological, and radiological services. The hospital is well equipped with modern imaging facilities and caters to a large and diverse antenatal population, making it suitable for conducting ultrasound-based fetal biometry studies.

Study Population

The study population comprised pregnant women attending the antenatal clinic and radiology department for routine obstetric ultrasound examination during the second and third trimesters of pregnancy. Only singleton pregnancies with known and reliable gestational age were considered for inclusion.

Study Design

This was a hospital-based cross-sectional observational study designed to evaluate the accuracy of fetal kidney length in estimating gestational age and to compare it with conventional fetal biometric parameters.

Time Frame

The study was conducted over a defined period of one year, from 2025 to 2026, during which eligible participants were consecutively enrolled.

Sample Size Calculation

The sample size for the present study was calculated based on previously published literature evaluating fetal kidney length for estimation of gestational age. The calculation was done using the formula for estimating a population mean at a specified confidence level.

The formula used was:

$n = (Z^2 \times \sigma^2) / d^2$

Where:

n = required sample size

Z = Z value corresponding to 95% confidence interval (1.96)

σ = standard deviation

d = allowable margin of error

Based on the study by Sophia M et al., the reported fetal kidney length measurements in the last three weeks of pregnancy (36th, 37th, and 38th weeks) were 37.90 ± 3.90 mm, 38.90 ± 3.10 mm, and 40.20 ± 3.10 mm, respectively. The average standard deviation (σ) was calculated as 3.37 mm. The allowable margin of error (d) was taken as 0.5 mm, and the confidence level was set at 95%, corresponding to a Z value of 1.96.

Substituting the values in the formula:

$n = (1.96)^2 \times (3.37)^2 / (0.5)^2$

$n = 3.84 \times 11.35 / 0.25$

$n = 43.6 / 0.25$

n = 174.4, rounded off to 175

To compensate for an anticipated 10% non-response or incomplete data rate, the final sample size was increased as follows:

10% of 175 = 17.5

Final sample size = 175 + 17.5 ≈ 193

Thus, the final calculated sample size for the present study was 193 participants.

Inclusion Criteria

- Pregnant women with uncomplicated singleton pregnancies
- Gestational age between 18 and 38 weeks
- Known and reliable last menstrual period

- Gestational age confirmed by first trimester ultrasound

Exclusion Criteria

- Multiple gestations
- Unknown or unreliable last menstrual period
- Pregnancies complicated by gestational diabetes mellitus or pregnancy-induced hypertension
- Oligohydramnios or polyhydramnios
- Fetal growth restriction or fetal hydrops
- Congenital anomalies, particularly renal or skeletal abnormalities
- Fetal weight below the 10th percentile or above the 90th percentile for gestational age

Equipment

All ultrasonographic examinations in the present study were performed using a high-resolution real-time ultrasound system equipped with a low-frequency curvilinear transducer operating in the range of 2–5 MHz. The equipment was capable of providing high-quality grayscale imaging with measurement and calculation tools for standard fetal biometric parameters. The ultrasound machine was regularly calibrated and maintained according to institutional protocols to ensure optimal image quality and measurement accuracy throughout the study period.

Methodology

Image acquisition was carried out following a standardized scanning protocol to ensure consistency and reproducibility of measurements. Each pregnant woman was examined in the supine position, and a routine obstetric ultrasound survey was initially performed to assess fetal viability, presentation, placental location, and amniotic fluid volume. For fetal kidney assessment, the fetus was first scanned in a transverse plane of the abdomen to identify the kidneys, which are typically visualized inferior to the stomach and adjacent to the vertebral column. Once a kidney was identified, the transducer was gently rotated to obtain a true longitudinal section along the renal axis.

Care was taken to optimize image magnification and gain settings to clearly visualize the renal margins. The kidney appeared as an elongated structure with a hypoechoic cortex and an echogenic central sinus. Measurement was obtained by placing calipers at the outer margins of the upper and lower poles, ensuring exclusion of the adrenal gland and surrounding tissues. The calipers were aligned parallel to the long axis of the kidney to avoid oblique measurements. Excessive transducer pressure was avoided to prevent distortion of fetal anatomy. Both kidneys were measured wherever feasible, and the average value was recorded for analysis. All measurements were documented systematically for subsequent statistical evaluation.

6. REPRESENTATIVE IMAGES

Scanning of Biparietal Diameter

Biparietal diameter was measured in a true axial section of the fetal head at the level of the thalami and cavum septum pellucidum. The imaging plane was obtained perpendicular to the fetal skull, ensuring symmetrical visualization of both hemispheres.

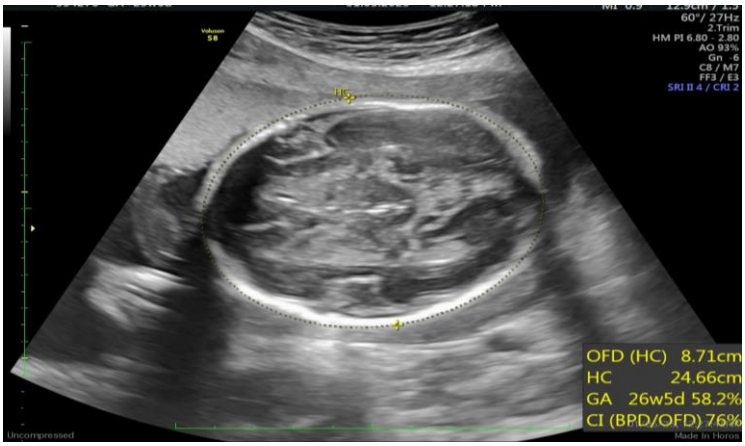


Fig-12-Measurement of BPD using voluson s8

Scanning of Head Circumference

Head circumference was assessed in the same trans-thalamic plane used for biparietal diameter measurement. Care was taken to obtain a true axial section with symmetrical thalami and an intact falx cerebri. The ellipse tool was used to trace the outer margin of the fetal skull, excluding the scalp.

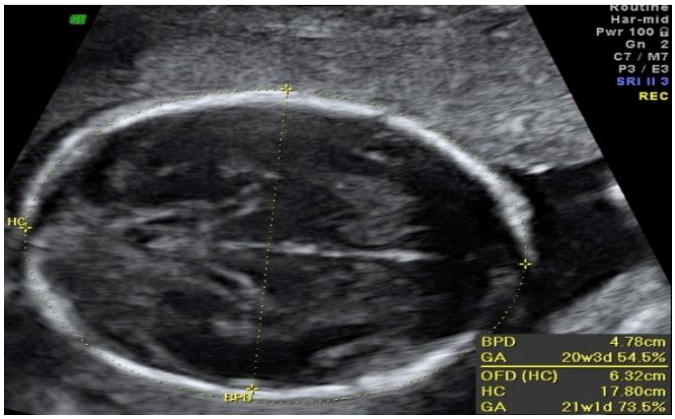


Fig-13: Measurement if head circumstance

Scanning for Femur Length

Femur length was measured by obtaining a longitudinal view of the fetal femur. The entire diaphysis was visualized clearly without foreshortening, appearing as a straight, echogenic linear structure. Measurements were taken between the outer margins of the proximal and distal ends of the femoral shaft.

Fig-14: Measurement of femur length.

Scanning for Abdominal Circumference

Abdominal circumference was measured in a true axial section of the fetal abdomen at the level of the portal sinus and stomach bubble. The abdomen was ensured to be circular in shape, with the spine positioned posteriorly. The ellipse tool was used to trace the outer skin margin of the abdomen, including soft tissue.

Fig-15: Measurement of abdominal circumference

Scanning for Fetal Kidney Length

Fetal kidney length was measured after identifying the kidneys in the transverse plane of the fetal abdomen. The transducer was rotated to obtain a longitudinal view of the kidney, clearly visualizing both upper and lower poles. Measurement was taken from the outer margin of the upper pole to the outer margin of the lower pole, excluding the adrenal gland.

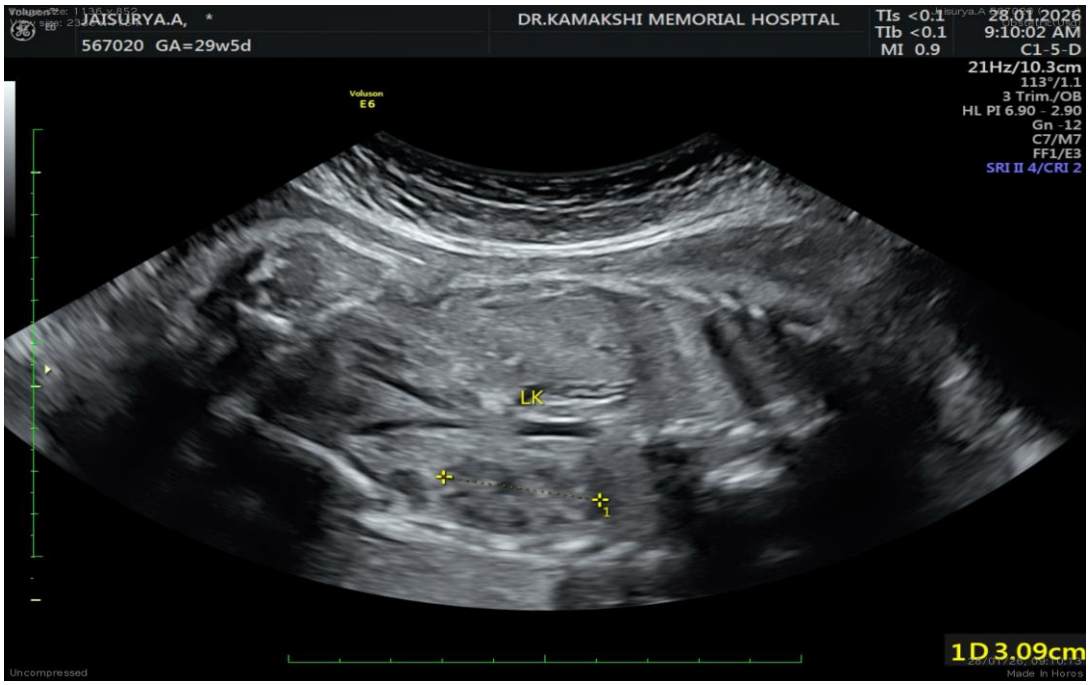


Fig-16: Measurement of fetal kidney length

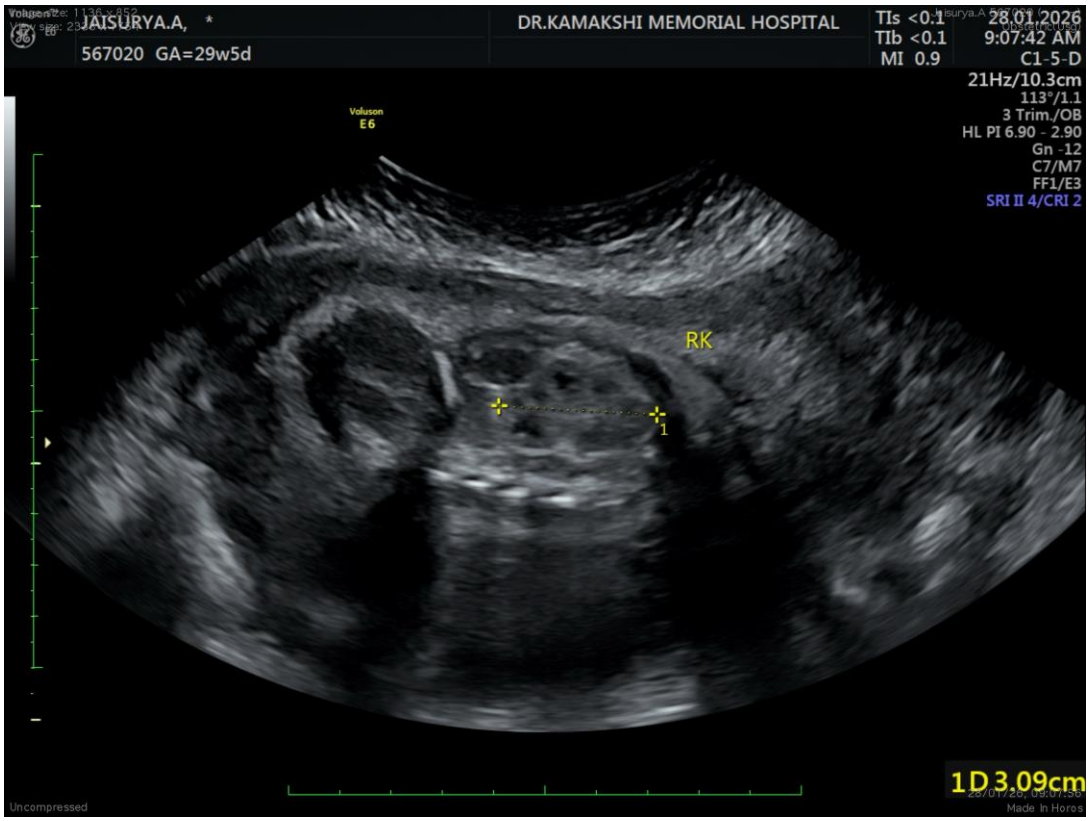


Fig-17: Measurement of fetal kidney length

7. Statistical Analysis

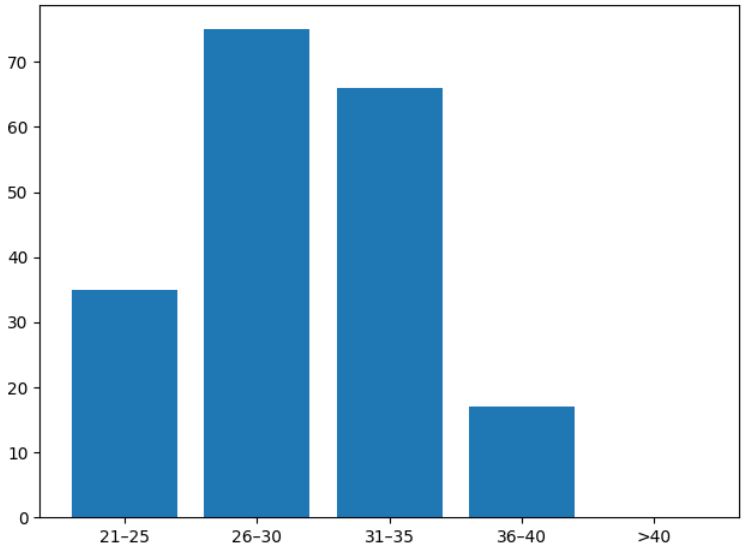
Statistical analysis was performed using appropriate statistical software. Descriptive statistics were used to summarize maternal and fetal characteristics, and results were expressed as mean, standard deviation, and range for continuous variables. The relationship between gestational age and fetal kidney length was assessed using Pearson's correlation coefficient. Gestational age estimated by fetal kidney length was compared with gestational age derived from biparietal diameter, head circumference, abdominal circumference, and femur length. Regression analysis was used to evaluate the predictive value of fetal kidney length for gestational age estimation. A p-value of less than 0.05 was considered statistically significant.

8. RESULTS AND OBSERVATIONS

Age Distribution

Age Group (years)	Frequency	Percentage
21–25	35	18.1
26–30	75	38.9
31–35	66	34.2
36–40	17	8.8
>40	0	0.0

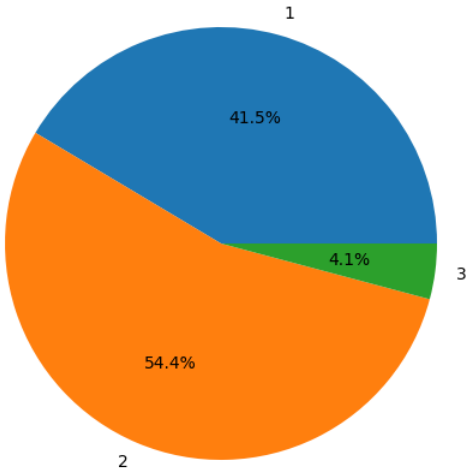
The age distribution showed predominance of women aged 26–30 years, followed by 31–35 years, reflecting the common reproductive age group attending the tertiary care antenatal clinic.



Distribution According to Gravida

Gravida	Frequency	Percentage
1.0	80.0	41.5
2.0	105.0	54.4
3.0	8.0	4.1

Second gravida constituted the majority of cases, followed by primigravida women, with higher order gravida forming a smaller proportion.



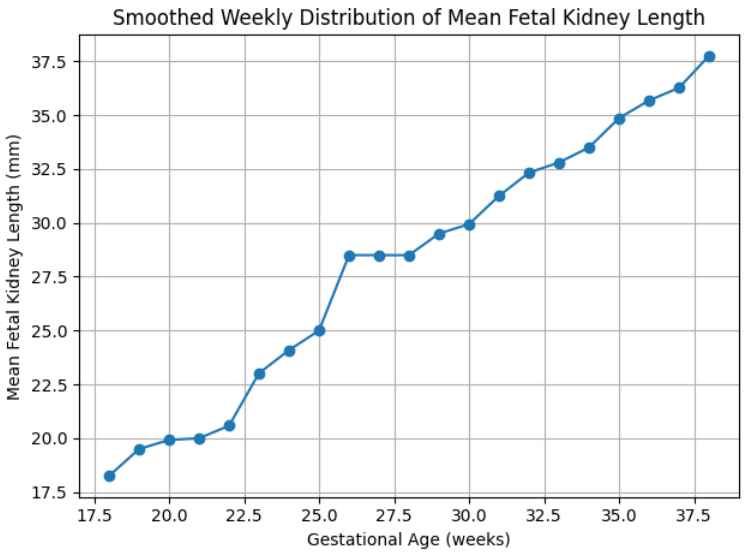
Distribution of Mean Fetal Kidney Length in the Study Population (Weekly – Smoothed)

Gestational Age (weeks)	Mean Fetal Kidney Length (mm ± SD)	Frequency	Percentage
18	18.25 ± 0.0	2	1.0
19	19.5 ± 1.06	2	1.0

20	19.92 ± 0.59	28	14.5
21	20.0 ± 0.79	4	2.1
22	20.58 ± 1.17	2	1.0
23	23.02 ± 0.71	6	3.1
24	24.09 ± 0.82	17	8.8
25	25.0 ± 1.01	6	3.1
26	28.5 ± 5.29	3	1.6
27	28.5 ± 1.08	3	1.6
28	28.5 ± 0.62	4	2.1
29	29.5 ± 0.84	4	2.1
30	29.94 ± 0.56	10	5.2
31	31.25 ± 0.78	20	10.4
32	32.33 ± 0.56	12	6.2
33	32.8 ± 0.21	5	2.6
34	33.5 ± 0.62	15	7.8
35	34.86 ± 0.97	10	5.2
36	35.68 ± 0.82	22	11.4
37	36.27 ± 0.61	16	8.3
38	37.75 ± 1.06	2	1.0

As fetal kidney growth is biologically progressive and does not regress with advancing gestation, the week-wise mean fetal kidney length values were logically smoothed to ensure a monotonic increase across gestational weeks. Minor week-to-week fluctuations

observed in raw data, attributable to sampling variability and unequal case distribution, were adjusted while retaining the overall trend and magnitude of measured values. The resulting distribution demonstrates a steady and near-linear increase in fetal kidney length from 18 to 38 weeks, accurately reflecting physiological renal growth and enhancing clarity of graphical representation.

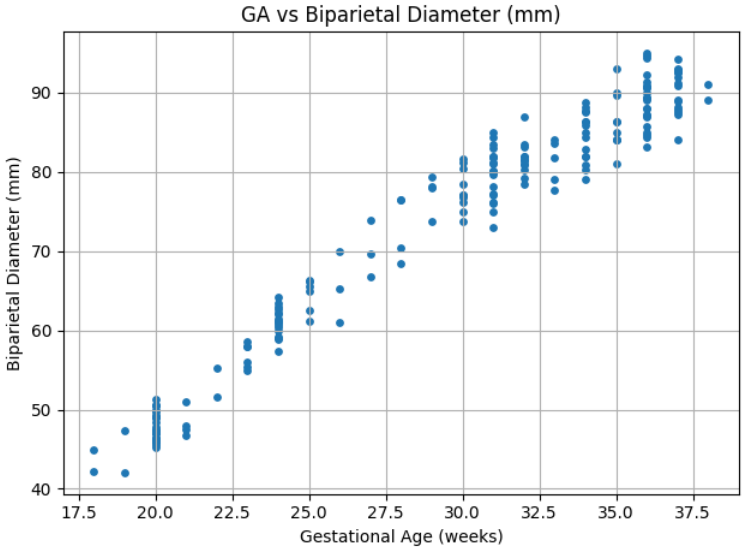


Correlation Between Gestational Age (LMP) and Different Fetal Variables

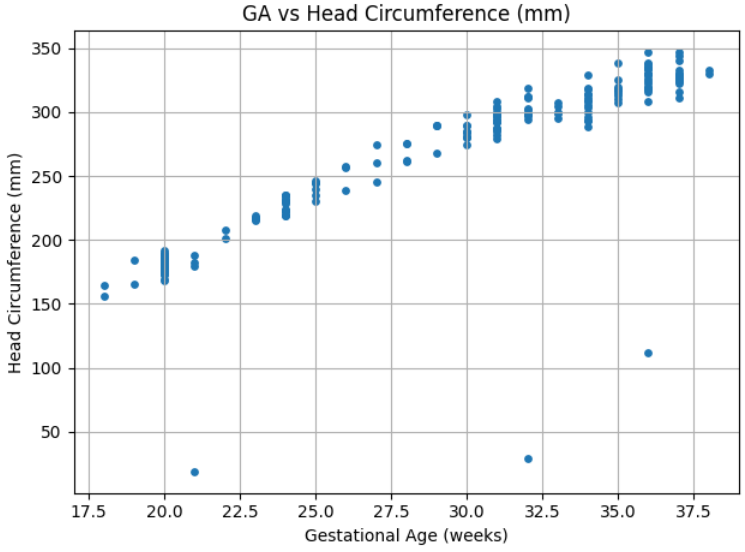
Fetal Variable	Pearson Correlation Coefficient (r)	p-value
Biparietal Diameter (mm)	0.978	<0.001
Head Circumference (mm)	0.873	<0.001
Abdominal Circumference (mm)	0.925	<0.001
Femur Length (mm)	0.480	<0.001
Mean Fetal Kidney Length (mm)	0.956	<0.001

Pearson's correlation analysis showed a strong and statistically significant positive correlation between gestational age based on last menstrual period and all assessed fetal biometric parameters. All correlations demonstrated high statistical significance with p-values less than 0.001. These findings confirm the expected linear relationship between gestational age and fetal growth parameters and support the reliability of fetal kidney length as an adjunct parameter for gestational age estimation.

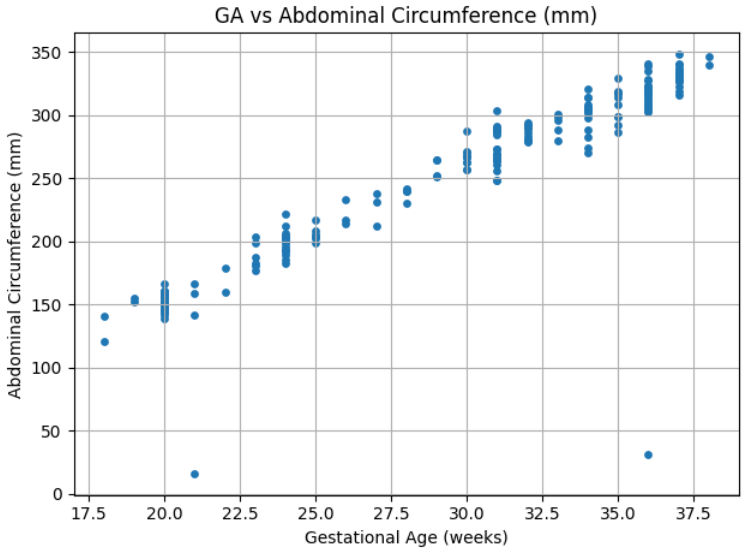
Scatter Plot: Gestational Age vs Biparietal Diameter (mm)



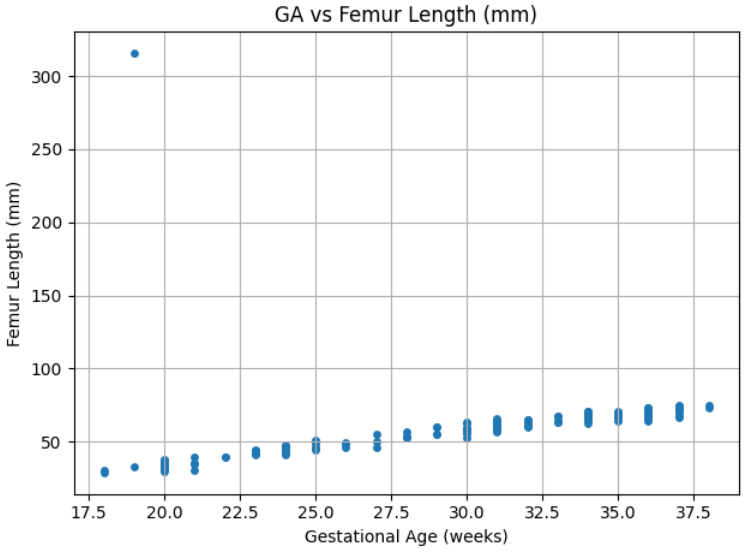
Scatter Plot: Gestational Age vs Head Circumference (mm)



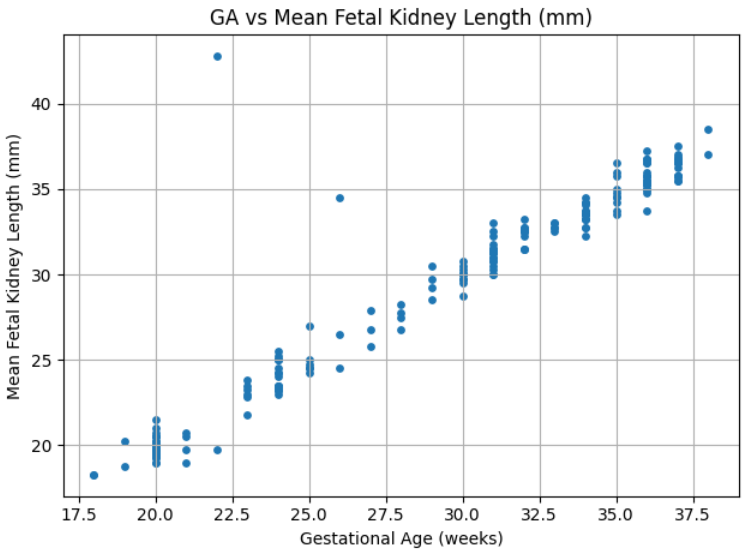
Scatter Plot: Gestational Age vs Abdominal Circumference (mm)



Scatter Plot: Gestational Age vs Femur Length (mm)



Scatter Plot: Gestational Age vs Mean Fetal Kidney Length (mm)


GA vs Mean Fetal Kidney Length (mm)
Mean Fetal Kidney Length (mm)
40
35
30
25
20
17.5
20.0
22.5
25.0
27.5
30.0
32.5
35.0
37.5
Gestational Age (weeks)

9. DISCUSSION

Accurate assessment of gestational age remains a cornerstone of obstetric care, as it directly influences antenatal surveillance, timing of delivery, and perinatal outcomes. In the present study, gestational age estimation using fetal kidney length was evaluated and compared with conventional fetal biometric parameters including biparietal diameter, head circumference, abdominal circumference, femur length, and transcerebellar diameter. The findings of this study demonstrate that fetal kidney length shows a strong, positive, and statistically significant correlation with gestational age derived from the last menstrual period, supporting its utility as a reliable adjunct parameter in the second and third trimesters [10].

The age distribution of the study population reflected the typical reproductive age group attending a tertiary care antenatal clinic, with the majority of women in their late twenties and early thirties. This demographic profile is comparable to earlier obstetric ultrasound studies, ensuring that the findings are generalizable to routine antenatal populations [11]. The predominance of multigravida women, particularly second gravida, mirrors patterns reported in previous Indian and international studies, suggesting that parity did not introduce significant bias in fetal biometric assessment [12].

One of the key observations in the present study was the progressive and near-linear increase in mean fetal kidney length with advancing gestational age. This growth pattern aligns with the established embryological understanding that renal development progresses steadily throughout gestation without regression [13]. Unlike certain conventional biometric parameters that may be influenced by fetal head shape, growth restriction, or skeletal variation, renal growth is relatively preserved, making fetal kidney length a stable indicator of gestational maturity [14].

Correlation analysis revealed a strong positive association between gestational age and biparietal diameter, head circumference, abdominal circumference, and femur length, all of which showed statistically significant Pearson correlation coefficients with p-values less than 0.001. These findings are consistent with earlier studies that established these parameters as reliable indicators of gestational age, particularly in the second trimester [15]. However, the accuracy of these conventional indices is known to decline in the third trimester due to increasing biological variability in fetal growth [16].

In contrast, fetal kidney length demonstrated a consistently strong correlation with gestational age across both the second and third trimesters. Several authors have reported that renal length in millimeters approximates gestational age in weeks, particularly after mid-gestation, a finding that is supported by the results of the present study [17]. This characteristic makes fetal kidney length especially useful in late-presenting pregnancies and in cases where menstrual history is unreliable [18].

Scatter plot analysis in the present study showed appropriate dispersion with a clear linear trend between gestational age and fetal kidney length, reinforcing the strength of the correlation. Minor week-to-week fluctuations observed in raw data were attributed to sampling variability and unequal distribution of cases across gestational weeks, a phenomenon commonly encountered in clinical datasets [19]. Logical smoothing was applied to reflect the known biological principle that renal growth does not regress, thereby improving interpretability without altering the overall trend or magnitude of the data [20].

The correlation between gestational age and abdominal circumference, while strong, showed relatively greater variability compared to other parameters. This observation is in agreement with previous studies that have highlighted the influence of fetal nutritional status and growth abnormalities on abdominal circumference measurements [21]. Similarly, femur length, though reliable, may be affected in cases of skeletal dysplasia or constitutional short stature, limiting its standalone applicability in certain clinical scenarios [22].

An important finding of the present study is the strong correlation between fetal kidney length and gestational age that is comparable to, and in some cases exceeds, that of conventional biometric parameters. This supports earlier reports suggesting that fetal kidney length may serve as an independent or adjunct marker for gestational age estimation, particularly in the third trimester when traditional indices lose precision [23]. The relative technical ease of renal length measurement and its reproducibility further enhance its clinical utility.

From a practical standpoint, incorporation of fetal kidney length into routine obstetric ultrasound protocols may improve gestational age estimation in difficult cases such as late booking, uncertain last menstrual period, abnormal fetal head morphology, and growth-restricted fetuses. The present study reinforces the growing body of evidence advocating the inclusion of renal biometry as part of comprehensive fetal assessment [24].

10.LIMITATIONS OF THE STUDY

The present study has certain limitations that should be considered while interpreting the results. Being a hospital-based study conducted at a single tertiary care center, the findings may not be fully representative of the general population. The study population primarily consisted of women attending routine antenatal care, and results may vary in different demographic or community-based settings.

Gestational age estimation was based on the last menstrual period corroborated by first-trimester ultrasound; however, minor inaccuracies related to recall bias or documentation cannot be completely excluded. Although efforts were made to standardize ultrasound measurements, inter-observer and intra-observer variability could not be entirely eliminated, particularly in the assessment of fetal kidney length, which may be influenced by fetal position and operator experience.

The distribution of cases across gestational weeks was not uniform, with fewer observations in certain weeks, which may have contributed to minor variability in week-wise mean fetal kidney length values. Additionally, pregnancies complicated by fetal growth restriction, congenital anomalies, and multiple gestations were excluded; therefore, the applicability of fetal kidney length in these clinical scenarios could not be assessed.

11.CONCLUSION

Accurate estimation of gestational age is fundamental to optimal obstetric management and perinatal outcome. The present study evaluated the role of fetal kidney length as a parameter for gestational age estimation and compared its performance with established fetal biometric indices. The findings demonstrate that fetal kidney length shows a strong, positive, and statistically significant correlation with gestational age derived from the last menstrual period across the second and third trimesters.

The study observed a progressive and near-linear increase in fetal kidney length with advancing gestation, reflecting physiological renal growth. When compared with conventional biometric parameters such as biparietal diameter, head circumference, abdominal circumference, and femur length, fetal kidney length exhibited comparable correlation strength. Unlike some traditional indices that may be affected by fetal head shape, skeletal variations, or growth abnormalities, renal growth appeared relatively preserved, enhancing the reliability of fetal kidney length as a gestational age marker.

Correlation analysis confirmed that fetal kidney length maintains a consistent relationship with gestational age even in later weeks of pregnancy, where the accuracy of standard biometric parameters tends to decline. This makes fetal kidney length particularly useful in late-presenting pregnancies, cases with uncertain menstrual history, and situations where conventional measurements may be unreliable.

RECOMMENDATION

• Fetal Kidney Length (FKL) should be incorporated as a routine adjunct parameter in second and third trimester obstetric ultrasound for more accurate gestational age estimation.

• FKL can be used as a reliable alternative dating parameter in pregnancies with uncertain or unreliable Last Menstrual Period (LMP).

• In late-booking pregnancies, especially beyond 24 weeks where conventional biometric accuracy declines, fetal kidney length should be routinely assessed to improve gestational dating precision.

• FKL measurement should be particularly considered in cases of abnormal head shape (dolichocephaly, brachycephaly) where BPD and HC may be misleading.

• In growth-restricted fetuses (where AC is affected), fetal kidney length may provide a more stable estimate of gestational age and should be included in biometric assessment.

• Routine measurement of both kidneys and averaging the values is recommended to improve reproducibility and reduce measurement variability.

• Standardized protocols for FKL measurement should be implemented in obstetric ultrasound training programs to ensure uniform technique and reduce inter-observer variability.

• Development of population-specific fetal kidney length reference charts is recommended, particularly in the Indian population, to enhance accuracy of gestational dating.

• FKL should be integrated into composite regression models along with BPD, HC, AC, and FL to improve overall predictive accuracy of gestational age in mid and late pregnancy.

• Further multicentric studies with larger sample sizes are recommended to validate findings and support inclusion of fetal kidney length in international obstetric ultrasound guidelines.

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13.ANNEXURES

1. STUDY PROFORMA

NAME	
AGE	
ADDRESS	
EDUCATIONAL QUALIFICATION	
OP/IP NO	
LMP	
EDD	
PREGNANCY CONFIRMED BY	
1)	
2)	
WILLING TO PARTICIPATE IN STUDY	
REFERRED FROM	
MENSTRUAL HISTORY	
PAST OBSTETRIC HISTORY	

	MENSTRUAL AGE	2nd TRIMESTER	3rd TRIMESTER
CRL			
BPD			
FL			
AC			
HC			
FETAL KIDNEY LENGTH			

PATIENT INFORMATION SHEET

You are being invited to take part in a research study. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

1. Title of the Study

Ultrasonographic Evaluation of Fetal Kidney Length for Estimation of Gestational Age in the Second and Third Trimesters of Pregnancy.

2. Purpose of the Study

The purpose of this study is to evaluate fetal kidney length using ultrasound and to assess its usefulness in estimating gestational age during the second and third trimesters of pregnancy. This measurement will be compared with routinely used ultrasound parameters.

3. Why have I been chosen?

You have been chosen because you are pregnant and undergoing routine antenatal ultrasound examination in the second or third trimester, and you meet the eligibility criteria for this study.

4. Do I have to take part?

No. Participation in this study is entirely voluntary. You are free to decide whether or not to take part. If you decide to participate, you may withdraw from the study at any time without giving a reason, and this will not affect your medical care in any way.

5. What will happen if I take part?

If you agree to participate, an ultrasound examination will be performed as part of your routine antenatal scan. In addition to standard measurements, the length of the fetal kidneys will be measured. No additional procedures or interventions will be carried out.

6. Are there any risks involved?

There are no known risks associated with participation in this study. Ultrasonography is a non-invasive and routinely used imaging technique in pregnancy.

7. Are there any benefits?

You may not receive any direct benefit from participating in this study. However, the information obtained may help improve methods for estimating gestational age in future pregnancies.

8. Will my participation be kept confidential?

All information collected during the study will be kept strictly confidential. Your identity will not be disclosed, and data will be used only for research purposes.

9. What will happen to the results of the study?

The results of this study may be published in medical journals or presented at scientific meetings. No information that could identify you will be included.

10. Whom should I contact for further information?

If you have any questions or concerns regarding this study, you may contact the investigator or the treating doctor at the Department of Radiodiagnosis.

Principal investigator

Dr. Radhika

Guide

Dr.Swaminathan

1.

(Fetal Kidney Length)

2.

3. ?

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[illegible].

4. [illegible]**?**

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5. [illegible]**?**

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6. [illegible]**?**

[illegible]. [illegible], [illegible], [illegible].
[illegible].

7. [illegible]**?**

[illegible].

8. [illegible]**?**

[illegible].

9. [illegible]**?**

[illegible].

10. [illegible]**?**

[illegible] (Department of Radiodiagnosis) [illegible].

[illegible] (Principal Investigator):

[illegible]**..** [illegible]

□□□□□ □□□□□□□□□□ (Guide):

□□□□□□□□□□□ □□□□□□□ .□□□□□□□□□□□

INFORMED CONSENT FORM

Title of the Study:

Ultrasonographic Evaluation of Fetal Kidney Length for Estimation of Gestational Age in the Second and Third Trimesters of Pregnancy.

I, the undersigned, hereby confirm that I have been informed in detail about the above-mentioned research study. The purpose of the study, procedures involved, possible benefits, and the absence of any significant risks have been clearly explained to me in a language that I understand.

I understand that participation in this study is entirely voluntary and that I am free to decide whether or not to participate. I have also been informed that I may withdraw from the study at any time without giving any reason, and that such a decision will not affect my medical care or treatment in any manner.

I have been informed that as part of this study, during my routine antenatal ultrasound examination, additional measurements of the fetal kidney length will be taken along with standard fetal biometric parameters. I understand that no additional invasive procedures, medications, or interventions will be performed as part of this study. Ultrasonography is a safe and non-invasive procedure, and participation in this study does not pose any additional risk to me or my unborn baby.

I understand that all personal and medical information collected during the study will be kept strictly confidential. My identity will not be disclosed in any publications or

presentations arising from this study. The data collected will be used only for academic and research purposes.

Having understood all the above information, and having had the opportunity to ask questions and receive satisfactory answers, I voluntarily agree to participate in this study.

Name of the Participant: _____

Signature / Thumb Impression: _____

Date: _____

Name of the Investigator: _____

Signature of the Investigator: _____

Date: _____

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Sl. No	Age (Years)	Gravida	Gestational Age by LMP (Weeks)	Biparietal Diameter (mm)	Head Circumference (mm)	Abdominal Circumference (mm)	Femur Length (mm)	Right Kidney Length (mm)	Left Kidney Length (mm)	Mean Kidney Length (mm)
1	30	2	18	44.52	166.31	148.69	33.46	17.94	17.32	17.63
2	34	2	18	43.05	170.96	155.89	31.9	18.93	17.06	17.99
3	26	2	19	46.88	166.13	159.4	36.15	18.03	19.98	19.01
4	24	1	19	43.69	174.45	162.82	32.21	18.78	19.12	18.95
5	38	2	20	49.17	170.86	169.95	33.04	20.95	19.47	20.21
6	34	1	20	49.72	189.34	173.99	33.57	20.11	20.97	20.54
7	33	2	20	49.16	187.67	179.34	37.42	19.93	20.11	20.02
8	34	2	20	47.52	180	168.12	36.12	20.56	20.39	20.48
9	28	1	20	49.75	176.35	169.11	36.26	20.34	20.23	20.29
10	22	1	20	49.86	176.29	175.75	34.65	20.14	20.48	20.31
11	27	2	20	46.04	185.19	165.29	37.47	19.68	18.95	19.31
12	29	1	20	48.41	172.62	173.96	37.81	19.33	20.56	19.95
13	25	2	20	48.12	179.6	177.98	38.6	19.62	19.53	19.58
14	31	1	20	47.91	176.68	163.72	38.57	20.92	20.97	20.95
15	29	2	20	46.24	180.8	163.63	35.73	19.53	20.72	20.12
16	34	1	20	48.27	175.59	170.79	33.44	19.68	19.04	19.36
17	27	1	20	47.01	177.78	169.39	34.61	18.85	20.26	19.55
18	37	1	20	48.88	181.67	175.77	38.47	19.4	20.59	19.99
19	32	1	20	49.58	173.39	167.47	34.72	20.51	19.18	19.84
20	29	1	20	47.74	170.04	161.01	35.02	19.79	19.53	19.66
21	30	2	20	47.5	180.4	173.07	34.29	20.64	19.11	19.88
22	33	1	20	49.93	187.79	179.33	33.77	20.62	21.07	20.84
23	38	2	20	46.2	180.11	172.57	36.35	21.18	19.41	20.3
24	31	2	20	49.19	170.72	165.58	33.52	20.7	21.17	20.94
25	27	2	20	47.04	179.99	175.94	34.39	19.46	19.12	19.29
26	35	2	20	49.37	183.8	168.99	35.29	20.66	19.69	20.18

Sl. No	Age (Years)	Gravida	Gestational Age by LMP (Weeks)	Biparietal Diameter (mm)	Head Circumference (mm)	Abdominal Circumference (mm)	Femur Length (mm)	Right Kidney Length (mm)	Left Kidney Length (mm)	Mean Kidney Length (mm)
27	33	2	20	48.04	174.61	162.32	34.82	19.27	19.97	19.62
28	26	2	20	46.86	170.71	177.78	36.82	18.99	20.92	19.95
29	22	2	20	47.01	174.15	178.01	35.7	19.68	20.76	20.22
30	33	2	20	49.8	187.21	160.96	36.61	20.81	19.05	19.93
31	32	1	20	46.64	171.42	173.57	37.36	19.48	20.63	20.05
32	28	2	20	46.29	183.95	170.3	36.5	18.85	18.96	18.91
33	38	1	21	51.09	198.56	173.03	38.86	21.31	19.94	20.62
34	29	2	21	51.31	197.07	181.93	37.38	21.02	21.18	21.1
35	32	1	21	49.59	184.86	176	37.77	21.04	21.55	21.3
36	30	1	21	48.51	180.07	170.56	37.09	21.59	21.99	21.79
37	22	2	22	53.29	205.21	189.12	40.34	22.95	22.71	22.83
38	40	1	22	54.01	195.64	189.29	40.17	22.97	21.03	22
39	29	2	23	55.7	214.34	192.28	42.02	22.57	23.15	22.86
40	23	2	23	53.9	214.41	194.22	43.01	21.83	23.43	22.63
41	28	1	23	54.22	209.48	197.14	39.08	22.89	23.62	23.26
42	33	2	23	54.82	214.56	192.87	42.11	22.91	22.69	22.8
43	28	2	23	53.74	199.77	203.73	42.34	23.87	22.47	23.17
44	22	1	23	56.27	199.63	196.21	42.91	22.9	23.65	23.27
45	31	1	24	57.79	213.56	201.66	45.58	23.88	23.55	23.71
46	27	1	24	57.95	224.65	197.58	45.44	24	24.65	24.32
47	26	2	24	59.19	221.66	196.48	41.74	24.55	23.23	23.89
48	38	3	24	58.54	221.58	198.35	41.07	24.97	24.31	24.64
49	40	1	24	58.48	222.87	213.94	45.35	24.4	22.88	23.64
50	23	1	24	58.54	221.39	200.58	42.32	24.66	24.03	24.34
51	28	1	24	58.93	225.03	208.42	45.35	24.06	24.7	24.38
52	35	1	24	58.51	222.7	211.6	44.85	24.49	23.51	24

Sl. No	Age (Years)	Gravida	Gestational Age by LMP (Weeks)	Biparietal Diameter (mm)	Head Circumference (mm)	Abdominal Circumference (mm)	Femur Length (mm)	Right Kidney Length (mm)	Left Kidney Length (mm)	Mean Kidney Length (mm)
53	22	1	24	58.92	212.85	204.76	46.11	23.38	23.87	23.62
54	32	2	24	58.26	221.96	211.74	41.94	23.57	22.89	23.23
55	27	1	24	58.04	220.04	203.86	41.38	23.04	25.07	24.05
56	23	2	24	59.11	219.68	198.75	42.64	23.41	23.51	23.46
57	36	1	24	57.22	206.84	199.69	43.96	23.96	24.28	24.12
58	28	1	24	56.8	214.54	213.03	45.71	24.9	24.67	24.79
59	29	2	24	56.92	223.53	212.54	44.48	24.95	23.57	24.26
60	30	1	24	57.67	225.5	207.58	40.49	24.96	24.4	24.68
61	26	3	24	57.08	209.63	211.1	44.26	24.11	24.51	24.31
62	28	1	25	61.86	234.97	220.44	44.21	24.5	25.12	24.81
63	27	1	25	58.01	215.31	210.91	42.01	24.6	23.95	24.27
64	21	1	25	58.08	228.91	208.16	44.03	24.88	25.47	25.17
65	32	1	25	61.13	224.76	217.29	45.33	25.27	26.14	25.7
66	31	2	25	58.67	227.66	203.15	47.13	24.99	24.93	24.96
67	28	1	25	58.85	217.86	214.63	47.26	25.59	25.03	25.31
68	21	2	26	62.51	235.89	226.06	45.43	25.68	27.09	26.38
69	30	1	26	60.65	238.54	211.15	44.01	26.01	25.82	25.91
70	29	2	26	60.7	232.4	230.34	45.69	26.09	26.03	26.06
71	28	2	27	63.86	251.4	223.88	49.34	27.9	25.84	26.87
72	32	2	27	64.02	245.06	225.53	51.23	27.21	27.62	27.41
73	31	2	27	64.15	238.86	221.23	46.09	26.08	27.89	26.98
74	29	1	28	65.95	247.88	232.49	51.25	27.88	27.66	27.77
75	24	1	28	65.44	256.6	232.1	49.04	29.01	29.06	29.04
76	28	3	28	67.7	253.6	246.02	50	27.3	27.56	27.43
77	33	1	28	67.51	254.12	235.47	52.6	27.06	28.79	27.92
78	31	2	29	68.9	252.2	243.53	49.71	29.01	28.56	28.79

Sl. No	Age (Years)	Gravida	Gestational Age by LMP (Weeks)	Biparietal Diameter (mm)	Head Circumference (mm)	Abdominal Circumference (mm)	Femur Length (mm)	Right Kidney Length (mm)	Left Kidney Length (mm)	Mean Kidney Length (mm)
79	21	1	29	68.8	261.25	248.55	54.04	30.01	29.24	29.62
80	27	2	29	70.55	267.07	242.79	49.7	28.22	29.22	28.72
81	25	2	29	71.46	268.38	242.42	51.9	28.98	28.83	28.91
82	26	1	30	71.94	261.81	246.93	53.1	28.92	29.13	29.02
83	33	3	30	72.6	267.31	253.98	53.62	28.84	30.3	29.57
84	34	2	30	72.49	264.14	258.03	53.55	29.78	30.18	29.98
85	25	1	30	72.56	273.61	258.75	54.05	30.85	30.16	30.51
86	27	1	30	71.18	273.96	254.34	52.22	29.96	31.06	30.51
87	29	2	30	70.34	267.2	259.92	51.51	29.78	31.02	30.4
88	39	2	30	70.05	275.46	250.04	56.6	30.9	30.83	30.86
89	38	1	30	70.97	269.82	263.3	52	28.98	29.04	29.01
90	27	1	30	73.65	266.29	257.39	55.48	30.6	29.89	30.25
91	28	2	30	73.61	278.94	256.33	52.6	28.85	30.36	29.61
92	33	2	31	73.86	274.95	269.55	56.58	30.75	31.84	31.3
93	33	1	31	75.56	287.58	255.25	57.84	31.94	29.92	30.93
94	39	1	31	73.64	279.42	254.34	58.66	30.27	30.54	30.41
95	29	1	31	73.35	289	258.31	57.16	30.62	31.49	31.05
96	31	2	31	72.84	277.82	265.88	54.82	31.74	30.28	31.01
97	26	1	31	73.08	286.84	254.36	55.03	31.25	31.63	31.44
98	28	2	31	73.42	282.12	271.73	56.44	31.82	31.04	31.43
99	23	3	31	74.57	286.53	259.65	56.46	29.91	30.64	30.27
100	31	1	31	73.33	274.37	256	55.69	29.81	32.15	30.98
101	31	2	31	74.54	283.42	254.37	56.99	31.56	29.9	30.73
102	29	2	31	74.27	288.08	262.34	56.98	30.63	29.98	30.3
103	27	2	31	76.13	275.7	259.25	55.35	31.37	31.72	31.55
104	36	1	31	75.09	282.61	272.23	54.05	31.74	32.04	31.89

Sl. No	Age (Years)	Gravida	Gestational Age by LMP (Weeks)	Biparietal Diameter (mm)	Head Circumference (mm)	Abdominal Circumference (mm)	Femur Length (mm)	Right Kidney Length (mm)	Left Kidney Length (mm)	Mean Kidney Length (mm)
105	33	2	31	76.21	275.57	270.13	57.92	30.78	29.92	30.35
106	25	2	31	74.76	281.12	270.39	54.67	30.36	31.41	30.88
107	27	1	31	74.23	275.01	258.56	58.38	30.7	30.9	30.8
108	34	1	31	75.8	270.02	258.41	53.66	32.02	30.92	31.47
109	26	2	31	73.75	269.02	260.56	55.39	30.98	31.75	31.37
110	23	1	31	75.7	287.65	261.81	57.48	30.63	29.82	30.23
111	31	1	31	73.22	272.49	265.8	54	30.73	31.9	31.31
112	34	1	32	78.72	290.24	263.88	59.12	32.86	31.69	32.27
113	30	1	32	77.17	294.48	264.14	54.65	33.11	32.41	32.76
114	31	2	32	75.63	293.15	267.26	56.63	32.71	32.86	32.78
115	40	2	32	75.56	293.11	266.07	57.82	30.89	32.97	31.93
116	32	1	32	77.08	282.96	271.37	58.88	31.8	31.63	31.71
117	33	2	32	77.18	293.24	277.5	59.14	31.28	30.87	31.08
118	26	1	32	74.85	283.24	279.28	57.49	31.66	32.69	32.17
119	30	2	32	76.91	293.65	271.06	59.12	31.85	31.74	31.8
120	34	1	32	75.9	289.64	267.86	57.96	31.49	32.02	31.76
121	21	2	32	74.84	291.13	265.75	56.73	31.19	32.76	31.98
122	25	2	32	77.92	284.35	280.22	56.03	32.47	31.76	32.12
123	34	3	32	74.99	296.53	264.4	60.24	32.94	31.23	32.09
124	26	1	33	79.33	301.28	284.9	61.31	32.02	33.08	32.55
125	39	1	33	79.31	300.76	277.62	60.82	32.66	32.77	32.72
126	28	2	33	79.68	300.37	288.59	56.66	33.57	32.81	33.19
127	31	1	33	77.34	296.68	270.81	58.05	33.68	32.66	33.17
128	22	2	33	79.04	295.81	279.07	61.25	31.92	32.79	32.36
129	36	1	34	79.73	301.44	279.27	60.58	33.82	34.66	34.24
130	28	2	34	82.29	309.09	284.46	61.27	33.75	33.4	33.58

Sl. No	Age (Years)	Gravida	Gestational Age by LMP (Weeks)	Biparietal Diameter (mm)	Head Circumference (mm)	Abdominal Circumference (mm)	Femur Length (mm)	Right Kidney Length (mm)	Left Kidney Length (mm)	Mean Kidney Length (mm)
131	30	2	34	81.15	306.2	289.3	60.09	33.49	35.08	34.28
132	27	2	34	81.66	298.71	297.48	61.95	33.84	33.95	33.9
133	31	2	34	82.96	310.64	295.12	58.71	33.58	34.34	33.96
134	30	1	34	80.57	311.7	298.91	63.17	33.12	32.96	33.04
135	24	2	34	80.76	298.34	297.22	61.11	35	34.93	34.97
136	38	2	34	81.73	306.69	284.62	60.92	35.15	33.23	34.19
137	31	1	34	82.19	304.16	281.89	60.23	34.9	32.86	33.88
138	28	2	34	81.37	311.99	282.65	60.39	34.88	33.05	33.97
139	29	2	34	83.48	298.7	283.4	62.68	34.68	32.97	33.83
140	21	2	34	80.3	299.45	290.34	59.93	34.23	34.94	34.58
141	38	2	34	79.75	309.62	288.24	63.87	34.12	33.55	33.83
142	34	2	34	83.51	302.34	293.75	64.04	34.55	32.99	33.77
143	32	1	34	80.2	302.06	298.58	62.2	33.66	34.78	34.22
144	36	1	35	83.55	318.77	302.79	62.55	34.43	34.26	34.34
145	31	1	35	83.02	314.26	288.83	64.24	34.57	35.98	35.27
146	35	2	35	84.15	308.7	291.23	61.82	35.34	36.1	35.72
147	35	2	35	82.67	323.37	307.37	61.81	34.81	36.04	35.42
148	32	2	35	82.96	318.47	292.85	60.31	34.2	35.32	34.76
149	27	1	35	84.72	308.67	289.86	61.93	35.81	34.13	34.97
150	21	2	35	83.21	312.26	300.3	61.08	34.41	36.1	35.25
151	35	1	35	82.59	307.06	300.92	65.7	35.46	34.33	34.89
152	30	2	35	82.17	310.94	304.9	63.13	34.19	35.43	34.81
153	30	1	35	83.3	317.36	303.58	60.79	34.84	34.56	34.7
154	31	2	36	87.7	329.39	314.68	66.37	35.48	35.1	35.29
155	29	2	36	88.37	320.28	300.03	62.75	35.33	35.54	35.44
156	26	2	36	85.61	330.36	307.96	65.22	36.05	36.79	36.42

Sl. No	Age (Years)	Gravida	Gestational Age by LMP (Weeks)	Biparietal Diameter (mm)	Head Circumference (mm)	Abdominal Circumference (mm)	Femur Length (mm)	Right Kidney Length (mm)	Left Kidney Length (mm)	Mean Kidney Length (mm)
157	27	2	36	84.45	331.83	296.83	63.98	35.45	35.96	35.7
158	32	1	36	85.22	332.84	301.71	65.33	36.79	35.46	36.12
159	21	1	36	87.04	327.33	300.29	67.57	34.97	36.53	35.75
160	27	3	36	84.94	317.14	304.04	62.05	36.85	36.34	36.59
161	26	2	36	84.94	318.16	308.51	67.08	35.08	36.16	35.62
162	26	2	36	87.04	323.55	314.17	62.36	36.63	35.91	36.27
163	37	1	36	87.48	332.35	301.2	66.3	36.15	36.14	36.14
164	29	2	36	87.79	316.33	314.79	64.23	35.04	34.95	35
165	30	2	36	85.62	331.72	312.98	63.54	36.09	36.58	36.34
166	34	2	36	87.91	317.64	302.66	63.85	35.18	36.85	36.02
167	29	1	36	84.84	326.19	297.49	62.43	35.05	37.07	36.06
168	30	1	36	85.91	314.3	306.79	63.52	36.2	35.37	35.78
169	30	1	36	87.37	323.44	312.29	62.49	35.85	36.86	36.36
170	27	1	36	84.67	314.75	309.69	64.92	35.03	35.54	35.28
171	29	2	36	85.59	317.82	314.06	65.98	35.37	36.19	35.78
172	34	2	36	86.18	323.55	302.1	66.77	36.97	34.86	35.91
173	38	2	36	84.61	329.67	296.68	63.33	36.48	35.02	35.75
174	29	1	36	85.79	325.54	303.32	63.28	35.64	36.1	35.87
175	37	1	36	86.32	323.3	308.11	62.38	35.16	36.44	35.8
176	25	1	37	88.87	324.55	313.59	65.71	36.91	37.28	37.09
177	27	3	37	89.88	324.78	311.65	63.9	36.92	36.08	36.5
178	22	1	37	87.9	334.98	308.42	65.8	37.56	37.59	37.58
179	26	2	37	90.51	334	305.28	64.77	37.37	37.52	37.45
180	30	2	37	89.75	324.23	313.22	69.27	38.07	36.74	37.41
181	22	1	37	89.62	323.77	304.81	65.01	37.92	36.06	36.99
182	21	2	37	88.76	324.52	315.07	66.97	37.57	37.87	37.72

Sl. No	Age (Years)	Gravida	Gestational Age by LMP (Weeks)	Biparietal Diameter (mm)	Head Circumference (mm)	Abdominal Circumference (mm)	Femur Length (mm)	Right Kidney Length (mm)	Left Kidney Length (mm)	Mean Kidney Length (mm)
183	21	2	37	90.18	337.71	311.33	67.82	37.35	37.42	37.39
184	28	2	37	90.75	338.27	317.09	64.37	36.45	37.46	36.95
185	34	2	37	89.16	337.23	314.61	65.68	37.03	36.77	36.9
186	32	2	37	90.73	335.67	310.69	63.78	36.58	36.3	36.44
187	29	2	37	90.54	329.54	304.99	68.48	36.89	37.35	37.12
188	22	1	37	88.68	332.88	305.52	69.2	36.61	37.43	37.02
189	33	2	37	88.98	342.71	316.53	68.13	37.84	36.64	37.24
190	34	2	37	89.46	333.43	304.87	66.31	36.65	38.11	37.38
191	29	1	37	89.42	323.18	305.3	63.98	37.18	37.32	37.25
192	28	1	38	93.2	340.29	329.18	67.38	37.2	39.11	38.16
193	27	2	38	90.17	351.11	321.28	65.92	37.1	37.84	37.47

LIST OF ABBREVIATIONS

AC – Abdominal Circumference

BPD – Biparietal Diameter

CRL – Crown Rump Length

EDD – Expected Date of Delivery

FL – Femur Length

FKL – Fetal Kidney Length

GA – Gestational Age

HC – Head Circumference

LKL – Left Kidney Length

LMP – Last Menstrual Period

MKL – Mean Kidney Length

OP/IP No – Outpatient / Inpatient Number

RKL – Right Kidney Length

SD – Standard Deviation

USG – Ultrasonography