Original Article

Morphometric Analysis of the Human Fetal Thyroid Gland Across Gestation: A Cross-Sectional Study

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Abstract

Background: The thyroid gland is the first endocrine gland to develop during embryogenesis and plays an essential role in fetal growth, metabolism, and neurodevelopment. Morphometric evaluation of the fetal thyroid provides important baseline data for understanding normal development and identifying congenital abnormalities. **Material and Methods:** This observational cross-sectional study was conducted on 40 human fetuses aged 13–38 weeks gestation. Fetuses with gross malformations or congenital thyroid anomalies were excluded. General fetal morphometric parameters, including fetal weight, crown-rump length (CRL), abdominal circumference, and head circumference, were recorded. Thyroid morphometry included thyroid weight, bilateral lobe length, width, thickness, and isthmus dimensions. Fetuses were categorized into 13–21 weeks (n=17), 22–30 weeks (n=15), and 31–38 weeks (n=8) gestational groups. Data were analyzed using ANOVA and Pearson's correlation coefficient. **Results:** All fetal and thyroid morphometric parameters increased significantly with advancing gestational age ($p<0.0001$). Mean thyroid weight increased from 0.202±0.072 g in the 13–21 weeks group to 0.869±0.107 g in the 31–38 weeks group. Mean right lobe length increased from 7.788±1.076 mm to 14.165±0.571 mm, while left lobe length increased from 7.636±1.061 mm to 14.047±0.759 mm. Strong positive correlations were observed between thyroid dimensions and fetal growth parameters. The strongest correlations were noted between CRL and right lobe length ($r=0.990$), left lobe length ($r=0.986$), and right lobe thickness ($r=0.982$) ($p<0.001$). Thyroid weight also showed strong correlations with right lobe thickness ($r=0.980$) and right lobe length ($r=0.976$). **Conclusion:** The fetal thyroid gland exhibits progressive enlargement with advancing gestation and demonstrates strong associations with overall fetal growth, particularly CRL. These findings provide valuable baseline morphometric data for developmental anatomy, fetal pathology, prenatal imaging, and assessment of fetal thyroid development.

Keywords: Fetal thyroid gland, morphometry, gestational age, crown-rump length, fetal growth.

Received: 1 June 2026 **Revised: 20 June 2026** **Accepted: 06 July 2026** **Published: 20 July 2026**

Introduction

The thyroid gland is the earliest endocrine gland to differentiate during human development and plays a central role in fetal growth, metabolic regulation, and organ maturation.[1,2] It begins to develop from the endoderm of the floor of the primitive pharynx at approximately 3–4 weeks of gestation, reaches its definitive location in the neck by about 7 weeks, and becomes functionally active by around 11 weeks.[3,4]

Because fetal thyroid hormones contribute substantially to somatic growth, neurodevelopment, and prepartum maturation, normal structural growth of the gland is clinically important.[5] Disturbance of thyroid development may result in congenital hypothyroidism and related developmental consequences, including impaired adaptation to extrauterine life and adverse neurodevelopmental outcomes.[6,7]

Morphometric evaluation of the fetal thyroid gland provides a practical way to understand normal developmental enlargement of the gland across gestation.[1] Previous anatomical work has shown that thyroid size increases progressively during fetal life and that gland growth may parallel overall fetal growth, particularly crown-rump length and other external biometric parameters.[8]

Detailed morphometry of the thyroid gland is also relevant to radiologists, pathologists, pediatric endocrinologists, and anatomists.[3] The baseline developmental data can help distinguish normal developmental variation from congenital anomalies or abnormal growth patterns.4 Such data are particularly valuable in settings where fetal age estimation, prenatal imaging correlation, or postmortem developmental assessment is required.[9]

Although previous studies have described fetal thyroid development, relatively fewer studies have focused on

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DOI:
10.21276/amit.2026.v13.i2.841

How to cite this article: Kumar K, Singh N, Singh B, Anand M. Morphometric Analysis of the Human Fetal Thyroid Gland Across Gestation: A Cross-Sectional Study. Acta Med Int.2026;13(2):1157-1162.

comprehensive gross morphometry with bilateral lobe measurements, isthmus measurements, and correlation with multiple fetal biometric parameters in the same cohort.[8-10] Although previous studies have explored fetal thyroid development, detailed morphometric data correlating thyroid growth with fetal biometric parameters remain limited. Therefore, the present study was undertaken to assess the morphometric development of the fetal thyroid gland across different gestational ages and its relationship with overall fetal growth. The findings may provide useful baseline data for developmental anatomy, fetal pathology, and prenatal diagnostic assessment.

Materials and Methods

Study Design and Setting: This observational cross sectional study was conducted in the Department of Anatomy, Moti Lal Nehru Medical College, Prayagraj, in collaboration with the Departments of Obstetrics and Gynaecology and Pathology from March 2024 to March 2026 after obtaining Institutional Ethics Committee approval.

Study Sample: A total of 42 fetuses were obtained through consecutive sampling from intrauterine deaths, stillbirths, premature deliveries, and medical terminations of pregnancy. Two fetuses with visible congenital thyroid anomalies were excluded, leaving a final sample of 40 fetuses.

Inclusion and Exclusion Criteria

Fetuses with a known gestational age of 13 - 38 weeks were included in the study. Fetuses with gross congenital malformations, visible thyroid anomalies, or significant maceration were excluded.

Grouping of Fetuses: Based on gestational age determined by ultrasonography, fetuses were categorized into three groups. The Crown - Rump length was used to verify gestational age.

a) 13 - 21 weeks (n = 17)
b) 22 - 30 weeks (n = 15)
c) 31 - 38 weeks (n = 8)

Parameters Taken: Measurements were obtained using a digital weighing balance, measuring tape, and digital vernier caliper as appropriate. All the measurements were taken thrice to avoid bias.

a) General fetal morphometric parameters

- Fetal weight (g)
- Crown-rump length (mm)
- Abdominal circumference (mm)
- Head circumference (mm)

b) Thyroid morphometric parameters

- Thyroid weight (g)
- Right lobe length (mm)
- Left lobe length (mm)
- Right lobe width (mm)
- Left lobe width (mm)
- Right lobe thickness (mm)
- Left lobe thickness (mm)
- Isthmus length (mm)
- Isthmus width (mm)
- Isthmus thickness (mm)

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using appropriate statistical tests. Continuous variables were expressed as mean ± standard deviation. One-way ANOVA was used to compare gestational age groups, while Pearson's correlation coefficient was applied to assess relationships between fetal biometric parameters and thyroid morphometry. A p-value <0.05 was considered statistically significant.

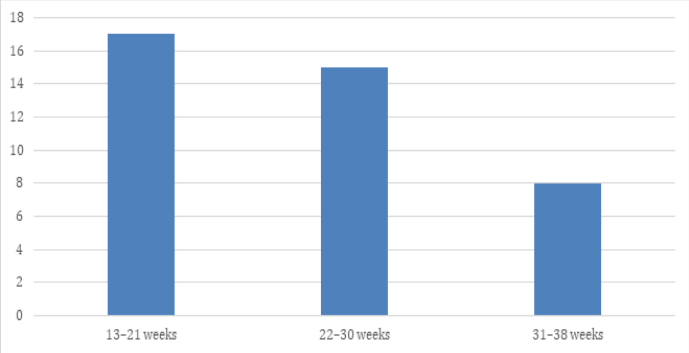
Figure 1. Measurement of crown-rump length (CRL) using a non-stretchable thread and measuring scale.

Figure 2. Measurement of chest circumference using a flexible measuring tape at the level of the nipples.

Figure 3. Measurement of abdominal circumference using a

flexible measuring tape at the level of the umbilicus.

Figure 4. Measurement of the length of the fetal thyroid gland.



Graph 1: Bar Distribution of study fetuses according to gestational age group

Results

Table 1: Distribution of study fetuses according to gestational age group

Gestational age group	n	Percentage	Range (weeks)
13–21 weeks	17	42.5	13–21
22–30 weeks	15	37.5	22–30
31–38 weeks	8	20.0	31–38
Total	40	100.0	13–38

Table 2: Descriptive statistics of general fetal morphometric parameters

General fetal morphometry	Mean	SD	Minimum	Maximum
Gestational age (weeks)	24.07	7.536	13	37
Fetal weight (g)	852.98	679.128	85	2150
Crown-rump length (mm)	210.73	88.354	72	349
Abdominal circumference (mm)	201.08	81.410	84	337
Head circumference (mm)	223.35	74.539	107	341

Table 3: Descriptive statistics of fetal thyroid gland morphometric parameters

Fetal thyroid morphometry	Mean	SD	Minimum	Maximum
Thyroid weight (g)	0.467	0.271	0.10	0.98
Right lobe length (mm)	10.587	2.710	6.20	15.05
Left lobe length (mm)	10.406	2.730	6.09	15.31
Right lobe width (mm)	6.027	1.136	4.04	7.75
Left lobe width (mm)	5.942	1.040	4.15	7.92
Right lobe thickness (mm)	2.987	0.671	1.98	4.22
Left lobe thickness (mm)	3.066	0.648	1.94	4.21
Isthmus length (mm)	4.621	1.276	2.55	6.51
Isthmus width (mm)	3.901	0.828	2.13	5.04
Isthmus thickness (mm)	1.044	0.201	0.70	1.35

Table 4: General fetal morphometric parameters according to gestational age group

Parameter	13–21 weeks (n=17)	22–30 weeks (n=15)	31–38 weeks (n=8)	p value
Fetal weight (g)	214.35 ± 102.42	1029.60 ± 345.80	1878.88 ± 215.29	<0.0001
Crown-rump length (mm)	121.88 ± 34.11	246.73 ± 30.24	332.00 ± 15.76	<0.0001
Abdominal circumference (mm)	121.24 ± 24.39	229.27 ± 34.78	317.88 ± 19.25	<0.0001
Head circumference (mm)	148.53 ± 27.507	255.47 ± 32.937	322.13 ± 10.006	<0.0001

Table 5: Fetal thyroid gland morphometric parameters according to gestational age group

Parameter	13–21 weeks (n=17)	22–30 weeks (n=15)	31–38 weeks (n=8)	p value
Thyroid weight (g)	0.202 ± 0.072	0.554 ± 0.084	0.869 ± 0.107	<0.0001
Right lobe length (mm)	7.788 ± 1.076	11.851 ± 0.667	14.165 ± 0.571	<0.0001
Left lobe length (mm)	7.636 ± 1.061	11.604 ± 0.874	14.047 ± 0.759	<0.0001
Right lobe width (mm)	4.876 ± 0.558	6.622 ± 0.458	7.360 ± 0.238	<0.0001
Left lobe width (mm)	4.895 ± 0.494	6.456 ± 0.362	7.202 ± 0.405	<0.0001
Right lobe thickness (mm)	2.334 ± 0.240	3.211 ± 0.231	3.956 ± 0.238	<0.0001
Left lobe thickness (mm)	2.416 ± 0.240	3.364 ± 0.309	3.887 ± 0.175	<0.0001
Isthmus length (mm)	3.311 ± 0.508	5.256 ± 0.487	6.217 ± 0.246	<0.0001
Isthmus width (mm)	3.051 ± 0.450	4.402 ± 0.302	4.768 ± 0.175	<0.0001

Isthmus thickness (mm)	0.848 ± 0.097	1.148 ± 0.104	1.266 ± 0.092	<0.0001

Table 6: Correlation of general fetal morphometry with fetal thyroid gland morphometry

Thyroid parameter	Fetal weight (r)	CRL (r)	AC (r)	HC (r)
Right lobe length	0.947	0.990	0.978	0.984
Left lobe length	0.950	0.986	0.979	0.982
Right lobe width	0.934	0.981	0.961	0.981
Left lobe width	0.930	0.975	0.967	0.975
Right lobe thickness	0.959	0.982	0.975	0.972
Left lobe thickness	0.947	0.973	0.973	0.976
Isthmus length	0.937	0.979	0.969	0.977
Isthmus width	0.881	0.943	0.932	0.941
Isthmus thickness	0.909	0.949	0.937	0.953

Table 7: Correlation of thyroid weight with selected fetal thyroid gland dimensions

Parameter correlated with thyroid weight	r value	p value
Right lobe length	0.976	<0.001
Left lobe length	0.975	<0.001
Right lobe width	0.951	<0.001
Left lobe width	0.957	<0.001
Right lobe thickness	0.980	<0.001
Left lobe thickness	0.949	<0.001
Isthmus length	0.951	<0.001
Isthmus width	0.911	<0.001
Isthmus thickness	0.934	<0.001

A total of 40 fetuses were included in the study. Of these, 17 (42.5%) belonged to the 13–21 weeks gestational age group, 15 (37.5%) to the 22–30 weeks group, and 8 (20.0%) to the 31–38 weeks group [Table 1]. The mean gestational age was 24.07 ± 7.54 weeks.

The overall mean fetal weight was 852.98 ± 679.13 g, mean crown-rump length (CRL) was 210.73 ± 88.35 mm, mean abdominal circumference was 201.08 ± 81.41 mm, and mean head circumference was 223.35 ± 74.54 mm [Table 2].

The mean thyroid weight was 0.467 ± 0.271 g. Mean right and left lobe lengths were 10.587 ± 2.710 mm and 10.406 ± 2.730 mm, respectively. Mean right and left lobe widths were 6.027 ± 1.136 mm and 5.942 ± 1.040 mm, while mean right and left lobe thicknesses were 2.987 ± 0.671 mm and 3.066 ± 0.648 mm, respectively. The mean isthmus length, width, and thickness were 4.621 ± 1.276 mm, 3.901 ± 0.828 mm, and 1.044 ± 0.201 mm, respectively [Table 3].

All general fetal morphometric parameters increased significantly with advancing gestational age ($p<0.0001$). Mean fetal weight increased from 214.35 ± 102.42 g in the 13–21 weeks group to 1029.60 ± 345.80 g in the 22–30 weeks group and 1878.88 ± 215.29 g in the 31–38 weeks group. Similar significant increases were observed in CRL, abdominal circumference, and head circumference across the three gestational age groups [Table 4].

All thyroid morphometric parameters also demonstrated a significant increase with advancing gestational age ($p<0.0001$). Mean thyroid weight increased from 0.202 ± 0.072 g in the 13–21 weeks group to 0.554 ± 0.084 g in the 22–30 weeks group and 0.869 ± 0.107 g in the 31–38 weeks group. Mean right lobe length increased from 7.788 ± 1.076 mm to 11.851 ± 0.667 mm and 14.165 ± 0.571 mm, while mean left lobe length increased from 7.636 ± 1.061 mm to 11.604 ± 0.874 mm and 14.047 ± 0.759 mm across the corresponding groups. Significant increases were also observed in bilateral lobe width, thickness, and all isthmus dimensions [Table 5].

Correlation analysis showed strong positive correlations between fetal morphometric parameters and thyroid gland dimensions. The strongest correlation was observed between CRL and right lobe length ($r=0.990$), followed by CRL and left lobe length ($r=0.986$) and CRL and right lobe thickness ($r=0.982$) (Table 6). Thyroid weight also showed strong positive correlations with right lobe thickness ($r=0.980$), right lobe length ($r=0.976$), and left lobe length ($r=0.975$) (Table 7). All correlations were statistically significant ($p<0.001$).

Discussion

The present study focused exclusively on morphometric growth of the fetal thyroid gland across three gestational age groups. The findings demonstrate a clear, progressive, and statistically highly significant increase in thyroid weight, bilateral lobe dimensions, and isthmus dimensions with advancing gestation. This indicates that thyroid enlargement proceeds in an orderly and proportionate manner during intrauterine life and parallels overall fetal growth

In the present study, thyroid weight increased from 0.202 ± 0.072 g in the 13 - 21 weeks group to 0.554 ± 0.084 g in the 22 - 30 weeks group and 0.869 ± 0.107 g in the 31 - 38 weeks group. A similar rising pattern has been reported by Jalaja Y et al,[11] who observed thyroid weights of 0.188 ± 0.110 g, 464.4 ± 133.2 mg, and 678.5 ± 374 mg across successive gestational groups, and by Joshi R et al,[12] who reported progressive increase in gland weight with advancing age. Falcão - Tebas et al.[13] also showed increasing thyroid size in fetuses and newborns, supporting the concept that gland mass expands consistently with fetal maturation.

Bilateral lobe measurements in the present study were closely comparable with those of previous morphometric studies. During 13 - 21 weeks, right and left lobe lengths measured 7.788 ± 1.076 mm and 7.636 ± 1.061 mm, respectively, which closely match the values reported by Jalaja Y et al,[11] in the 10 -

20 week group (7.6 ± 1.7 mm and 7.4 ± 1.7 mm). During 22 - 30 weeks, right and left lobe lengths increased to 11.851 ± 0.667 mm and 11.604 ± 0.874 mm, again closely approximating the values reported by Jalaja Y et al,[11] for the 21–30 week group (11.3 ± 1.6 mm and 10.9 ± 1.7 mm). In the late gestational group, right and left lobe lengths reached 14.165 ± 0.571 mm and 14.047 ± 0.759 mm, which are similar to the late gestational values recorded by Jalaja and Joshi R et al.[11,12]

The present study also showed progressive increases in lobe width, lobe thickness, and isthmus dimensions across gestational age groups, indicating that fetal thyroid growth is three - dimensional rather than limited to simple elongation. This finding is in agreement with Anupriya A et al,[14] who described increasing lobe breadth, thickness, and isthmus size with advancing gestation, and with Devi RR et al,[15] who also documented progressive enlargement of thyroid dimensions in aborted and stillborn fetuses. Bocian - Sobkowska et al,[16] although primarily concerned with late fetal morphometry, similarly showed that thyroid volume continues to increase during late fetal life.

A major finding of the present study was the strong positive correlation between fetal thyroid morphometry and general fetal biometric parameters. All thyroid parameters correlated significantly with fetal weight, crown-rump length, abdominal circumference, and head circumference. Among these, crown - rump length showed the strongest relationship, particularly with right lobe length (r = 0.990), left lobe length (r = 0.986), and right lobe thickness (r=0.982). This suggests that fetal thyroid growth is closely linked to overall longitudinal fetal growth. Similar observations have been reported by Bocian - Sobkowska et al,[16] who demonstrated a strong association between thyroid volume and crown-rump length, and by Jalaja Y et al,[11] who described correlation between thyroid weight and fetal growth parameters. The relationship between thyroid size and anthropometric measures reported by Turcios et al,[17] in healthy infants further supports the biological relevance of such growth associations.

The strong positive inter-correlations among thyroid dimensions in the present study indicate closely coordinated growth of the right lobe, left lobe, and isthmus. Thyroid weight correlated most strongly with right lobe thickness (r = 0.980), right lobe length (r = 0.976), and left lobe length (r = 0.975), while right and left lobe lengths were themselves very strongly correlated. These findings suggest that bilateral glandular growth is proportionate, rather than asymmetric or irregular. Joshi RR et al,[12] and Devi RR et al,[15] also documented broadly symmetrical and progressively increasing bilateral lobe measurements in developing fetal thyroid glands.

Another important observation in the present study was that morphometric progression remained consistent across all gestational age groups, with highly significant p values for every analyzed thyroid parameter. This uniform statistical significance strengthens the view that gestational age is a major determinant of fetal thyroid growth. Developmental and embryological reviews have similarly emphasized that normal thyroid enlargement reflects orderly organogenesis and progressive functional maturation.[9,10]

The present study has clinical and anatomical relevance because it provides reference values for thyroid weight, lobe measurements, and isthmus dimensions in the north Indian fetal population.[7] Such baseline data may help in anatomical teaching, fetal pathology, and prenatal imaging interpretation, particularly when thyroid size needs to be assessed in relation to fetal growth or suspected congenital thyroid disorders.[18,19]

A major strength of this study is that multiple fetal biometric parameters and multiple thyroid dimensions were evaluated in the same cohort, allowing thyroid enlargement to be interpreted in the context of overall fetal growth. The main limitations are the relatively small sample size, uneven group distribution, and cross-sectional study design. Nevertheless, the consistency of the observed growth pattern and its agreement with previous studies support the validity of the findings.

Table 8: Comparison of morphometric findings with previous studies

Study	Sample/gestational range	Thyroid weight	Representative lobe length	Key observation
Present study	40 fetuses 13 -38 weeks	0.202 g (13–21 weeks) to 0.869 g (31–38 weeks)	RL: 7.788 mm to 14.165 mm	All thyroid dimensions increased significantly with gestation
Bocian-Sobkowska et al,[16] (1997)	Late fetal life	Progressive increase in thyroid weight and volume	NR	Thyroid volume strongly associated with crown-rump length
Anupriya A et al,[14] (2016)	10–36 weeks	NR	Mean lateral lobe length 5.6 mm in 10–17 weeks group	Lobe and isthmus dimensions increased with gestation
Jalaja Y et al,[11] (2022)	Human fetuses; grouped by gestational age	0.188 ± 0.110 g to 678.5 ± 374 mg	RL: 7.6 ± 1.7 mm to 13.3 ± 1.6 mm	Progressive increase in weight and bilateral lobe dimensions
Joshi R et al,[12] (2023)	Developing human fetuses	0.111 g in 10–20 weeks group; progressive rise later	Bilateral lobe length about 0.631 cm in early group; 1.470 cm right lobe late	Progressive thyroid enlargement with gestation

Conclusion

The study highlights a clear and progressive growth of the fetal thyroid gland with advancing gestational age, closely mirroring overall fetal development. The strong correlation between thyroid dimensions and fetal biometric parameters, particularly crown-rump length, underscores the importance of thyroid morphometry as a marker of normal fetal growth. These findings provide valuable baseline data for anatomists, radiologists, pathologists, and fetal medicine specialists, aiding in the assessment of normal thyroid development, early

detection of congenital thyroid anomalies, interpretation of prenatal imaging, and planning of future fetal and neonatal thyroid research.

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