

# Morphometric Study of the Developing Human Fetal Pancreas and Its Correlation with Gestational Age and Fetal Growth Parameters

Rinkesh Kumar<sup>1</sup>, Rajesh Kumar Pandey<sup>2</sup>, Supriya Sudha<sup>2</sup>, Nishtha Singh<sup>3</sup>

<sup>1</sup>Junior Resident, Department of Anatomy, Moti Lal Nehru Medical College, Lowther Road, George Town, Prayagraj, Uttar Pradesh, India.

<sup>2</sup>Assistant Professor, Department of Anatomy, Moti Lal Nehru Medical College Lowther Road, George Town, Prayagraj, Uttar Pradesh, India.

<sup>3</sup>Associate Professor, Department of Anatomy, Moti Lal Nehru Medical College, Lowther Road, George Town, Prayagraj, Uttar Pradesh, India.

## Abstract

**Background:** The fetal pancreas undergoes progressive enlargement during intrauterine life, and its gross growth parallels overall fetal development. Reliable gestational age wise morphometric reference data are limited, especially from Indian populations. The objective is to study morphometric parameters of the fetal pancreas in different gestational age groups and to correlate pancreatic morphometric parameters with gestational age and general fetal morphometric parameters. **Material and Methods:** This observational cross-sectional study was conducted in the Department of Anatomy, Moti Lal Nehru Medical College, Prayagraj, in collaboration with the Department of Obstetrics and Gynaecology. Thirty - one dead fetuses between 12 and 36 weeks of gestation were included. Fetal weight, crown-rump length, abdominal circumference, and head circumference were recorded. Pancreatic weight, length, width, and thickness were measured after dissection. Data were analysed using descriptive statistics, one way ANOVA, and Pearson's correlation coefficient. **Results:** Mean gestational age was  $25.61 \pm 5.77$  weeks. Mean pancreatic weight, length, width, and thickness were  $1.05 \pm 0.82$  g,  $18.30 \pm 3.32$  mm,  $3.82 \pm 1.13$  mm, and  $2.35 \pm 1.05$  mm, respectively. All pancreatic morphometric parameters increased significantly across gestational age groups ( $p < 0.0001$ ). Pancreatic weight increased from 0.043 g at 12–16 weeks to 2.364 g at 33–36 weeks, while pancreatic length increased from 12.78 mm to 23.04 mm over the same interval. Strong positive correlations were observed between pancreatic morphometry and fetal growth parameters. The strongest association was between crown-rump length and pancreatic length ( $r = 0.912$ ,  $p < 0.0001$ ). **Conclusion:** The fetal pancreas shows a definite and progressive increase in gross morphometric parameters with advancing gestational age. Crown-rump length demonstrated the strongest correlation with pancreatic growth. These findings provide baseline morphometric data for normal fetal pancreatic development and may be useful for anatomical, radiological, and pathological reference.

**Keywords:** fetal pancreas, morphometry, gestational age, crown-rump length, pancreatic length, pancreatic weight.

Received: 04 June 2026

Revised: 21 June 2026

Accepted: 06 July 2026

Published: 20 July 2026

## INTRODUCTION

The pancreas is a soft, elongated gland extending transversely across the posterior abdominal wall from the duodenum toward the spleen.<sup>[1,2]</sup> It is classically divided into the head, neck, body, and tail, and it maintains close developmental and anatomical relations with the duodenum, bile duct, and major abdominal vessels.<sup>[3,4]</sup>

Embryologically, the pancreas develops from dorsal and ventral endodermal buds near the junction of the foregut and midgut.<sup>[5]</sup> Rotation of the duodenum and fusion of these buds establish the definitive gland, its duct system, and its topographic relations.<sup>[6]</sup> This sequence is also the basis for congenital anomalies such as annular pancreas and pancreas divisum.<sup>[7,8]</sup>

During fetal life, pancreatic growth is expected to parallel overall somatic growth.<sup>[7]</sup> Measurement of pancreatic weight, length, width, and thickness across gestation may therefore provide a practical morphometric framework for understanding normal development and for interpreting fetal imaging and pathological specimens.<sup>[9]</sup>

Despite the availability of standard anatomical and embryological descriptions, detailed gestational age wise

morphometric data on the human fetal pancreas remain limited. Many published studies have included modest sample sizes or have focused on restricted developmental windows, and region-specific Indian data are still relatively scarce.<sup>[10]</sup>

Establishing normative baseline morphometric data is essential for improving the understanding of normal pancreatic development and for providing reference standards that support prenatal imaging, anatomical research, and the early identification of developmental abnormalities.

Therefore, the present study was undertaken to evaluate the morphometric growth of the human fetal pancreas and correlate its measurements with gestational age and general fetal biometric

**Address for correspondence:** Dr. Nishtha Singh, Associate Professor, Department of Anatomy, Moti Lal Nehru Medical College, Lowther Road, George Town, Prayagraj, Uttar Pradesh, India. E-mail: [1998singhnishtha@gmail.com](mailto:1998singhnishtha@gmail.com)

**DOI:**  
10.21276/amt.2026.v13.i2.843

**How to cite this article:** Kumar R, Pandey RK, Sudha S, Singh N. Morphometric Study of the Developing Human Fetal Pancreas and Its Correlation with Gestational Age and Fetal Growth Parameters. Acta Med Int. 2026;13(2):1168-1173.

parameters.

## MATERIALS AND METHODS

**Study Design:** This observational, cross sectional study was conducted in the Department of Anatomy, Moti Lal Nehru Medical College, Prayagraj, Uttar Pradesh, India, in collaboration with the Department of Obstetrics and Gynaecology, from January 2025 to March 2026, after obtaining approval from the Institutional Ethics Committee.

**Study Specimens:** The study included 31 dead human fetuses of known gestational age (12 - 36 weeks) obtained by consecutive sampling after informed parental consent. The sample size was derived from a previous fetal pancreatic morphometric study. Gestational age was confirmed using crown-rump length (CRL), and the fetuses were categorized into six gestational age groups:

- 12 - 16 weeks foetus
- 17 - 20 weeks foetus
- 21 - 24 weeks foetus
- 25 - 28 weeks foetus
- 29 - 32 weeks foetus
- 33 - 36 weeks foetus

### Inclusion criteria

- Dead human fetuses with known gestational age between 12 and 36 weeks
- No evidence of external congenital anomalies.

### Exclusion criteria

- Macerated fetuses
- Fetuses with gross congenital malformations
- Damaged abdominal viscera affecting pancreatic morphology

### Instruments Used

- Digital weighing balance (accuracy: 0.01 g) for fetal and pancreatic weight.
- Digital vernier caliper (least count: 0.01 mm) for pancreatic dimensions.
- Measuring tape and non - stretchable thread (accuracy: 1 mm) for fetal biometric measurements.

### Dissection Procedure

A vertical midline abdominal incision with a transverse extension was made to expose the abdominal cavity. After careful dissection, the pancreas was identified, photographed in situ, and removed. Pancreatic length was measured from the head (including the uncinate process) to the tail along its longitudinal axis. Width was measured perpendicular to the longitudinal axis at the midpoint of the body, while thickness was measured in the supero - inferior dimension at the same level. All the dissection steps was strictly followed using Cunningham Dissection Manual

### Parameters Recorded

- Fetal weight
- Crown-rump length (CRL)
- Abdominal circumference
- Head circumference
- Pancreatic weight
- Pancreatic length
- Pancreatic width
- Pancreatic thickness

**Statistical Analysis:** Data were entered into Microsoft Excel 2019 and analysed using appropriate statistical software. Continuous variables were expressed as mean  $\pm$  standard deviation (SD), minimum, and maximum values. Differences among gestational age groups were analysed using one-way analysis of variance (ANOVA). Pearson's correlation coefficient was used to determine the relationship between pancreatic morphometric parameters, gestational age, and general fetal morphometric parameters. A p value  $<0.05$  was considered statistically significant.



Figure 1: Measurement of fetal weight



Figure 2: Depicting the measurement of Crown rump length (CRL)



Figure 3: Measurement of head circumference



**Figure 4: Measurement of Abdominal circumference**



**Figure 5: Pancreas In-situ**



**Figure 6: Measurement of Pancreatic weight**



**Figure 7: Measurement of Pancreatic Length**

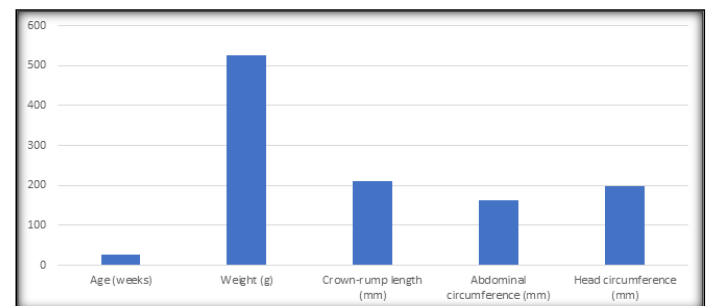


**Figure 8: Measurement of Pancreatic Width**

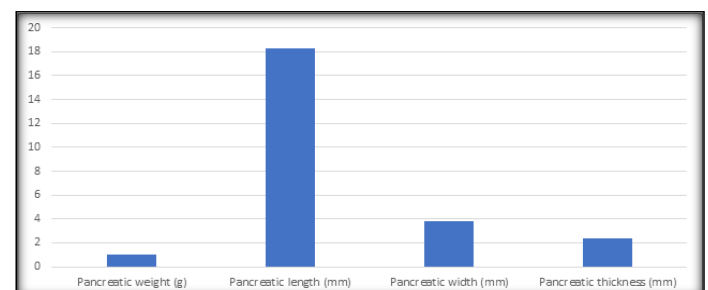


**Figure 9: Measurement of Pancreatic thickness**

## RESULTS



**Chart 1: Bar Representation of general fetal morphometric parameters**



**Chart 2: Bar Representation of pancreatic morphometric parameters.**



**Table 1: Descriptive statistics of general fetal morphometric parameters**

| Variable                     | Mean   | SD     | Minimum | Maximum |
|------------------------------|--------|--------|---------|---------|
| Age (weeks)                  | 25.61  | 5.77   | 14      | 36      |
| Weight (g)                   | 524.97 | 352.47 | 88      | 1710    |
| Crown-rump length (mm)       | 211.52 | 55.80  | 102     | 330     |
| Abdominal circumference (mm) | 161.50 | 44.65  | 80      | 270     |
| Head circumference (mm)      | 198.55 | 54.52  | 100     | 350     |

**Table 2: Descriptive statistics of fetal pancreatic morphometric parameters**

| Variable                  | Mean  | SD   | Minimum | Maximum |
|---------------------------|-------|------|---------|---------|
| Pancreatic weight (g)     | 1.05  | 0.82 | 0.04    | 3.10    |
| Pancreatic length (mm)    | 18.30 | 3.32 | 9.75    | 25.25   |
| Pancreatic width (mm)     | 3.82  | 1.13 | 1.18    | 5.85    |
| Pancreatic thickness (mm) | 2.35  | 1.05 | 0.20    | 4.12    |

**Table 3: General fetal morphometric parameters across different gestational age groups**

| Gestational group | n  | Weight (g)       | CRL (mm)       | AC (mm)        | HC (mm)        |
|-------------------|----|------------------|----------------|----------------|----------------|
| 12–16 weeks       | 2  | 99.00 ± 5.66     | 113.50 ± 16.26 | 83.20 ± 4.53   | 105.00 ± 7.07  |
| 17–20 weeks       | 3  | 109.00 ± 18.19   | 136.67 ± 10.41 | 106.67 ± 5.77  | 125.00 ± 5.00  |
| 21–24 weeks       | 10 | 380.60 ± 166.63  | 183.50 ± 16.51 | 138.50 ± 19.30 | 183.00 ± 26.99 |
| 25–28 weeks       | 5  | 502.80 ± 49.29   | 222.50 ± 5.00  | 180.00 ± 18.71 | 211.00 ± 13.42 |
| 29–32 weeks       | 7  | 702.14 ± 192.56  | 252.86 ± 9.94  | 193.57 ± 19.94 | 224.29 ± 35.76 |
| 33–36 weeks       | 4  | 1128.50 ± 397.81 | 301.25 ± 20.16 | 220.00 ± 33.67 | 278.75 ± 47.68 |

**Table 4: Fetal pancreatic morphometric parameters across different gestational age groups**

| Gestational group | N  | Weight (g)    | Length (mm)  | Width (mm)  | Thickness (mm) |
|-------------------|----|---------------|--------------|-------------|----------------|
| 12–16 weeks       | 2  | 0.043 ± 0.004 | 12.78 ± 4.28 | 1.39 ± 0.30 | 0.21 ± 0.01    |
| 17–20 weeks       | 3  | 0.058 ± 0.010 | 14.16 ± 0.87 | 3.30 ± 0.61 | 2.05 ± 0.87    |
| 21–24 weeks       | 10 | 0.711 ± 0.126 | 16.50 ± 1.06 | 3.33 ± 0.85 | 1.78 ± 0.88    |
| 25–28 weeks       | 5  | 0.938 ± 0.066 | 19.40 ± 0.55 | 4.43 ± 0.73 | 2.80 ± 0.65    |
| 29–32 weeks       | 7  | 1.614 ± 0.129 | 20.74 ± 1.32 | 4.28 ± 0.68 | 2.95 ± 0.36    |
| 33–36 weeks       | 4  | 2.364 ± 1.250 | 23.04 ± 1.51 | 5.11 ± 0.50 | 3.47 ± 0.52    |

**Table 5: Correlation of fetal pancreatic morphometry with general fetal morphometric parameters**

| Pancreatic parameter      | Weight (g)              | CRL (mm)                | AC (mm)                 | HC (mm)                 |
|---------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Pancreatic weight (g)     | $r = 0.794; p < 0.0001$ | $r = 0.881; p < 0.0001$ | $r = 0.817; p < 0.0001$ | $r = 0.796; p < 0.0001$ |
| Pancreatic length (mm)    | $r = 0.781; p < 0.0001$ | $r = 0.912; p < 0.0001$ | $r = 0.857; p < 0.0001$ | $r = 0.813; p < 0.0001$ |
| Pancreatic width (mm)     | $r = 0.602; p < 0.0001$ | $r = 0.719; p < 0.0001$ | $r = 0.772; p < 0.0001$ | $r = 0.677; p < 0.0001$ |
| Pancreatic thickness (mm) | $r = 0.541; p = 0.002$  | $r = 0.751; p < 0.0001$ | $r = 0.709; p < 0.0001$ | $r = 0.565; p = 0.001$  |

**Table 6: Inter-correlation among fetal pancreatic morphometric parameters**

| Parameter                 | Weight (g)              | Length (mm)             | Width (mm)              | Thickness (mm)          |
|---------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Pancreatic weight (g)     | 1                       | $r = 0.822; p < 0.0001$ | $r = 0.623; p < 0.0001$ | $r = 0.649; p < 0.0001$ |
| Pancreatic length (mm)    | $r = 0.822; p < 0.0001$ | 1                       | $r = 0.709; p < 0.0001$ | $r = 0.706; p < 0.0001$ |
| Pancreatic width (mm)     | $r = 0.623; p < 0.0001$ | $r = 0.709; p < 0.0001$ | 1                       | $r = 0.590; p < 0.0001$ |
| Pancreatic thickness (mm) | $r = 0.649; p < 0.0001$ | $r = 0.706; p < 0.0001$ | $r = 0.590; p < 0.0001$ | 1                       |

A total of 31 fetuses between 12 and 36 weeks of gestation were included in the study. All general fetal morphometric parameters increased progressively with advancing gestational age, indicating normal fetal growth.

The fetal pancreas also showed a progressive increase in all morphometric parameters. The pattern of growth was as follows:

- 12–20 weeks: Slow growth.
- 21–28 weeks: Marked increase in pancreatic dimensions.
- 29–36 weeks: Rapid growth, with the greatest increase observed in pancreatic weight.

All pancreatic measurements showed significant positive correlations with fetal biometric parameters ( $p < 0.05$ ). Pancreatic length had the strongest correlation with crown-rump length ( $r = 0.912$ ), indicating that pancreatic growth closely follows overall fetal growth. Pancreatic weight,

width, and thickness also correlated significantly with fetal weight, abdominal circumference, and head circumference.

A strong positive relationship was observed among all pancreatic morphometric parameters, with the highest correlation between pancreatic weight and pancreatic length ( $r = 0.822; p < 0.0001$ ), suggesting coordinated growth of the developing gland.

Overall, the study establishes gestational age-specific baseline morphometric data for the fetal pancreas, which may serve as a useful reference for anatomical studies, prenatal imaging, and the early detection of developmental abnormalities.

## DISCUSSION

The present study demonstrated a statistically significant increase in pancreatic weight with advancing gestational age, from 0.043 g in the 12–16-week group to 2.364 g in the 33–36-week group. The marked increase in pancreatic weight during

later gestation reflects the rapid growth of the fetal pancreas accompanying overall fetal development. A similar progressive increase in pancreatic weight was reported by Jakhar et al,<sup>[11]</sup> who observed increasing pancreatic weight across all gestational age groups. Dhende et al,<sup>[12]</sup> also documented a gradual increase in pancreatic weight with advancing gestation, although the absolute values reported in their study were higher than those observed in the present study in several gestational groups. Kumar et al,<sup>[13]</sup> likewise reported continuous enlargement of the fetal pancreas throughout gestation. The differences in absolute pancreatic weight between studies may be attributed to variations in sample size, gestational age grouping, population characteristics, dissection techniques, and measurement methodology.

The present study also demonstrated a progressive increase in pancreatic length from 12.78 mm at 12–16 weeks to 23.04 mm at 33–36 weeks of gestation, indicating continuous longitudinal growth of the gland during fetal life.

Comparable findings were reported by Jakhar et al,<sup>[11]</sup> who observed increasing pancreatic length with gestational age. Dhende et al,<sup>[12]</sup> similarly reported progressive elongation of the pancreas throughout fetal development. Davis et al,<sup>[14]</sup> and Manupati et al,<sup>[15]</sup> also demonstrated increasing pancreatic dimensions with advancing gestation, supporting the findings of the present study. Although the absolute measurements differed among studies, the overall trend of progressive enlargement remained consistent.

In the present study, pancreatic width and thickness showed an overall increase with advancing gestational age, indicating proportionate enlargement of the gland in all dimensions. These findings suggest coordinated growth of the developing pancreas rather than enlargement in a single dimension alone. Similar observations were made by Jakhar et al,<sup>[11]</sup> Kumar et

al,<sup>[13]</sup> and Manupati et al,<sup>[15]</sup> who also reported progressive increases in pancreatic width and thickness during fetal development. Minor differences in measurements between studies may reflect methodological variations and differences in the study population.

The present study demonstrated significant positive correlations between pancreatic morphometric parameters and general fetal morphometric measurements. Among these, pancreatic length showed the strongest correlation with crown-rump length ( $r = 0.912$ ,  $p < 0.0001$ ), while pancreatic weight showed strong positive correlations with fetal weight, abdominal circumference, and head circumference. A strong positive inter-correlation was also observed among pancreatic parameters, with the highest correlation between pancreatic weight and pancreatic length ( $r = 0.822$ ,  $p < 0.0001$ ), indicating coordinated pancreatic growth.

These findings are in agreement with Jakhar et al,<sup>[11]</sup> who also reported strong positive correlations between pancreatic morphometry and fetal biometric parameters, particularly crown-rump length. Their observations support the conclusion that pancreatic growth closely parallels overall fetal growth and that crown-rump length is a reliable indicator of pancreatic development.

Overall, the present study confirms that fetal pancreatic morphometric parameters increase progressively with advancing gestational age and correlate strongly with general fetal growth. The findings are consistent with those reported in previous studies despite differences in absolute measurements, which may be explained by variations in sample size, gestational age distribution, population characteristics, measurement techniques, and tissue handling. The gestational age-specific morphometric data generated in the present study provide useful baseline reference values for anatomists, fetal pathologists, and radiologists evaluating normal fetal pancreatic development.

**Table 7: Comparison of fetal pancreatic weight and length in the present study and previous studies**

| Gestational group | Present study weight (g) | Jakhar et al. (2022), <sup>[11]</sup> | Dhende et al. (2016), <sup>[12]</sup> | Present study length (mm) | Jakhar et al. (2022) | Dhende et al. (2016) |
|-------------------|--------------------------|---------------------------------------|---------------------------------------|---------------------------|----------------------|----------------------|
| 12–16 weeks       | 0.043                    | 0.52                                  | 0.40–0.60                             | 12.78                     | 3.40                 | 18.0–19.0            |
| 17–20 weeks       | 0.058                    | 0.64                                  | 0.67–0.81                             | 14.16                     | 12.10                | 22.8–26.0            |
| 21–24 weeks       | 0.711                    | 0.75                                  | 0.74–0.92                             | 16.50                     | 20.80                | 22.3–27.5            |
| 25–28 weeks       | 0.938                    | 0.85                                  | 1.15–1.64                             | 19.40                     | 21.60                | 31.5–35.0            |
| 29–32 weeks       | 1.614                    | 2.35                                  | 1.65–1.91                             | 20.74                     | 25.60                | 29.5–34.5            |
| 33–36 weeks       | 2.364                    | 3.16                                  | 3.00–3.40                             | 23.04                     | 28.10                | 38.0–39.0            |

## CONCLUSION

The present study provides gestational age specific baseline morphometric data for the developing human fetal pancreas between 12 and 36 weeks of gestation. These findings contribute to a better understanding of normal fetal pancreatic growth and serve as a valuable anatomical reference for researchers and anatomists. The data may also assist radiologists, fetal medicine specialists, and pathologists in interpreting prenatal imaging and postmortem examinations, facilitating the assessment of normal pancreatic development and the early recognition of developmental abnormalities. Furthermore, this study establishes a foundation for future research on fetal pancreatic growth and congenital pancreatic disorders.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Standring S, editor. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 41st ed. Edinburgh: Elsevier; 2016. p. 1177-84.
2. Moore KL, Dalley AF, Agur AMR. Clinically Oriented Anatomy. 8th ed. Philadelphia: Wolters Kluwer; 2018. p. 488-93.
3. Snell RS. Clinical Anatomy by Regions. 9th ed. Philadelphia: Lippincott Williams & Wilkins; 2012.
4. Casillas J, Levi JU, Quiroz AO, Ruiz-Cordero R, Garcia-Buitrago MT, Sleeman D. Multidisciplinary Teaching Atlas of the Pancreas:

- Radiological, Surgical, and Pathological Correlations. 1st ed. Berlin: Springer; 2016.
5. Sadler TW. Langman's Medical Embryology. 13th ed. Philadelphia: Wolters Kluwer; 2015.
  6. Singh I. Human Embryology. 8th ed. New Delhi: Jaypee Brothers; 2018. p. 167-74.
  7. Moore KL, Persaud TVN, Torchia MG. The Developing Human: Clinically Oriented Embryology. 11th ed. Philadelphia: Elsevier; 2020. p. 219-21.
  8. Dudek RW. High-Yield Embryology. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2013.
  9. Talathi SS, Zimmerman R, Young M. Anatomy, Abdomen and Pelvis, Pancreas. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan.
  10. Malhotra V, Jakhar B, Bisht K, et al. A comparative morphometric and histological study of human fetus and fetal pancreas in hyperglycemic and normoglycemic mothers. Cureus. 2022;14(12):e33008.
  11. Jakhar B, Malhotra R, Bisht K, Kant R, Singh A, Khoiwal K, Singh B. Morphometric analysis of human fetus and fetal pancreas in different gestational age groups. Acta Med Int. 2022;9(1):60-72.
  12. Dhende AS, Kathole MA, Joshi DS. Morphometric study of pancreas in human fetuses. J Clin Diagn Res. 2016;10(11):AC05-AC07.
  13. Kumar BIN, Sailaja K, Rajasree TK, Sreelatha S, Paul GR. Morphometric analysis of fetal pancreas. MRIMS J Health Sci. 2016;4(2):97-99.
  14. Davis L, Ramar SS. Microscopic and morphometric study of human fetal pancreas. Int J Sci Res. 2019;8(4):1-3.
  15. Manupati S, Sugavasi R, Indira DB, et al. Morphometry and histogenesis of human foetal pancreas. Int J Health Sci Res. 2012;2(9):18-24.