Original Article

Gestational Age - Wise Morphometric Analysis of the Human Foetal Large Intestine: A Cross - Sectional Cadaveric Study

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Abstract

Background: Gestational age wise morphometric data for the human foetal large intestine remain limited, despite the clinical importance of these measurements in the interpretation of congenital intestinal disorders and prenatal imaging. **Material and Methods:** This observational cross - sectional study was conducted in the Department of Anatomy, Motilal Nehru Medical College, Prayagraj. Fifty-one human foetal specimens were included. Foetuses were grouped into 15–20 weeks (n=8), 21–25 weeks (n=10), 26–30 weeks (n=16), 31–35 weeks (n=7), and 36–40 weeks (n=10). Full colonic length and segmental transverse, anteroposterior, and average diameters from the caecum to the sigmoid colon were measured and correlated with crown-rump length (CRL), abdominal circumference (AC), and head circumference (HC). **Results:** Mean gestational age was 27.94 ± 6.198 weeks. Mean full colonic length was 20.82 ± 3.88 cm and increased from 18.63 ± 3.249 cm at 15–20 weeks to 26.60 ± 1.838 cm at 36–40 weeks. All transverse diameters increased significantly with gestational age, and the sigmoid colon showed the highest mean transverse diameter (5.18 ± 1.76 mm). Anteroposterior diameters also increased significantly in all segments except the sigmoid colon ($p = 0.167$). Average diameters increased significantly across all segments, with the sigmoid colon again showing the highest mean value (4.29 ± 1.41 mm). All foetal morphometric parameters showed positive significant correlations with colonic measurements; the strongest correlation between CRL and transverse diameter was observed in the sigmoid colon ($r = 0.613$, $p < 0.001$). **Conclusion:** The human foetal large intestine shows progressive morphometric enlargement with advancing gestation. Colonic length and segmental diameters increase significantly, and the sigmoid colon emerges as the largest and most dynamic segment. These findings provide baseline morphometric reference data for anatomical, radiological, and paediatric surgical applications.

Keywords: Foetal large intestine, morphometry, colon, caecum, sigmoid colon, gestational age.

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Introduction

The large intestine forms the terminal part of the gastrointestinal tract and plays a central role in water and electrolyte absorption, fecal compaction, storage, and elimination.[1,2] Grossly, it extends from the ileo-caecal junction through the caecum and colon to the rectum, and its segmental anatomy is closely related to the arrangement of mesenteries, vascular pedicles, and fixation patterns within the abdomen.[3-6]

During intrauterine life, the large intestine develops from the caudal midgut and cranial hindgut, undergoes physiological herniation, 270° counter-clockwise rotation, returns to the abdominal cavity, and progressively becomes fixed to the posterior abdominal wall.[7] Parallel with these developmental events, the bowel undergoes rapid growth in length, calibre, and positional orientation, gradually attaining the anatomical configuration observed near term.[8]

Accurate morphometric data on the developing foetal large intestine are essential because abnormalities in intestinal growth, fixation, and segmental configuration may result in congenital intestinal obstruction, malrotation, volvulus, intestinal atresia, and difficulties in prenatal image interpretation.[9]

Despite considerable advances in foetal imaging and neonatal surgical care, comprehensive normative morphometric data describing the sequential growth of the foetal large intestine remain scarce. Most published studies have evaluated only selected intestinal segments or limited gestational age groups, making it difficult to establish reliable gestational age-specific reference values. Such baseline morphometric information is important for understanding normal intestinal development, differentiating physiological developmental variations from congenital abnormalities, improving the accuracy of prenatal ultrasonography and magnetic resonance imaging, and providing essential anatomical guidance for anatomists, radiologists, neonatologists, and paediatric surgeons.[10]

The present study was undertaken to evaluate the gross morphometric parameters of the human foetal large intestine in aborted and stillborn foetuses across different gestational age groups. The findings of this study are expected to establish

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normative morphometric reference data and contribute to a better understanding of the prenatal development of the large intestine, thereby supporting future anatomical, radiological, and clinical research.

Materials and Methods

Study Design and Setting: This observational cross-sectional study was conducted in the Department of Anatomy, Motilal Nehru Medical College, Prayagraj, in collaboration with the Department of Obstetrics and Gynaecology. The study was carried out after obtaining approval from the Institutional Ethics Committee.

Study Sample: A total of 51 human foetal specimens between 15 and 40 weeks of gestation were included in the study. The specimens were obtained from intrauterine foetal deaths, stillbirths, premature deliveries, and medically terminated pregnancies. Morphometric evaluation of the large intestine was performed in all specimens.

Inclusion and Exclusion Criteria

Foetuses with a known gestational age of 15–40 weeks were included in the study. Foetuses with gross congenital malformations, congenital anomalies involving the gastrointestinal tract, significant maceration, or maternal conditions likely to affect foetal growth and development were excluded.

Grouping of Foetuses: Gestational age was determined from available obstetric records and verified using crown-rump length (CRL). Based on gestational age, the foetuses were categorized into five groups:

a) 15–20 weeks (n = 8)
b) 21–25 weeks (n = 10)
c) 26–30 weeks (n = 16)
d) 31–35 weeks (n = 7)
e) 36–40 weeks (n = 10)

Parameters Recorded: Measurements were obtained using a digital Vernier calliper and measuring tape, as appropriate. All measurements were recorded three times, and the mean value was used for statistical analysis.

I) General foetal morphometric parameters

a) Crown - rump length (CRL) (mm)
b) Abdominal circumference (AC) (mm)
c) Head circumference (HC) (mm)

II) Large intestinal morphometric parameters

a) Total large intestinal length (mm)
b) Caecal transverse diameter (mm)
c) Caecal anteroposterior diameter (mm)
d) Ascending colon transverse diameter (mm)
e) Ascending colon anteroposterior diameter (mm)
f) Transverse colon transverse diameter (mm)
g) Transverse colon anteroposterior diameter (mm)
h) Descending colon transverse diameter (mm)
i) Descending colon anteroposterior diameter (mm)
j) Sigmoid colon transverse diameter (mm)
k) Sigmoid colon anteroposterior diameter (mm)
l) Mean external diameter of each colonic segment (calculated as the average of the transverse and anteroposterior diameters)

Dissection and Measurement Technique: After opening the abdominal cavity, the large intestine was identified and carefully dissected from the ileocaecal junction to the sigmoid colon. The total colonic length was measured using a measuring tape. The external transverse and anteroposterior diameters of the caecum, ascending colon, transverse colon, descending colon, and sigmoid colon were measured using a digital Vernier calliper following standard anatomical techniques. The mean external diameter of each segment was calculated by averaging the transverse and anteroposterior measurements.

Statistical Analysis: Data were entered into Microsoft Excel and analysed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation. One-way analysis of variance (ANOVA) was used to compare morphometric parameters among the different gestational age groups. Pearson's correlation coefficient was used to determine the relationship between foetal biometric parameters (CRL, AC, and HC) and large intestinal morphometric measurements. A p-value of <0.05 was considered statistically significant.

Figure 1: Measurement of Foetal weight

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

Figure 3: Measurement of foetal chest circumference

Figure 4: Measurement of Foetal Abdominal circumference

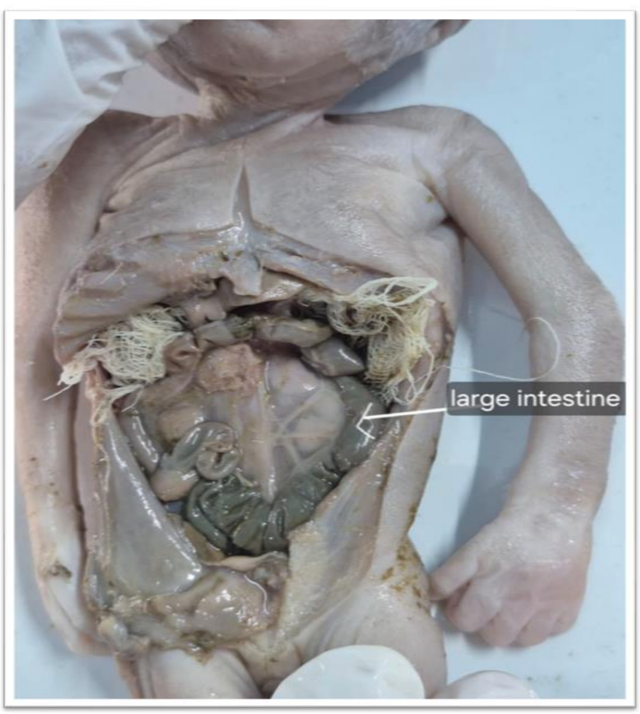

Figure 5: Image shows the abdominal cavity exposed with the foetal large intestine in-situ.

Figure 6: Measurement of external Diameter of foetal large intestine.

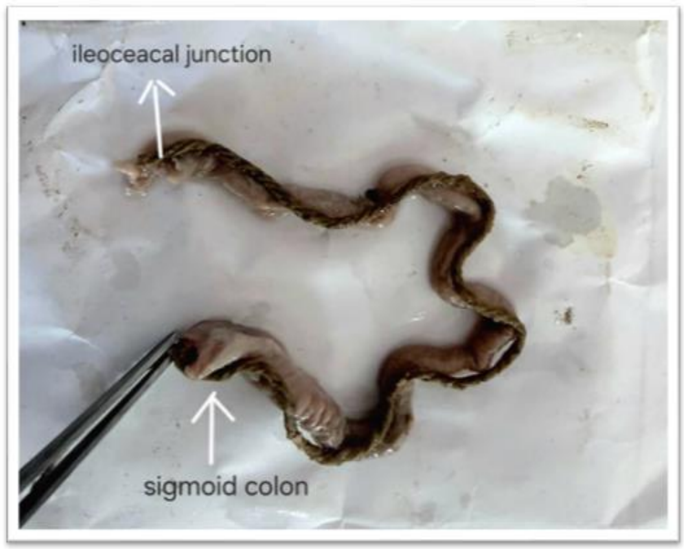

Figure 7: Measurement of length of large intestine with the help of a black-coloured thread showing the ileo-caecal junction up to the sigmoid colon

RESULTS

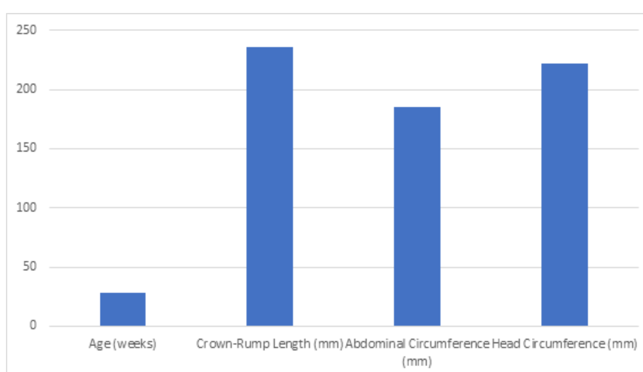

Figure 8: Bar Representation of general foetal morphometric profile.

Table 1: General foetal morphometric profile

Variable	Mean ± SD	Range
Age (weeks)	27.94 ± 6.198	15–39
Crown Rump Length (mm)	235.69 ± 61.368	125–335
Abdominal Circumference(mm)	184.647 ± 52.757	86–289
Head Circumference (mm)	222.35 ± 69.458	110–365

Table 2: Morphometric parameters of the foetal large intestine

Parameter	Mean ± SD	Range
Full length of colon (cm)	20.82 ± 3.88	13–30
Transverse diameter of caecum (mm)	3.64 ± 1.89	0.21–9.21
Transverse diameter of ascending colon (mm)	3.47 ± 1.72	0.64–8.15
Transverse diameter of transverse colon (mm)	3.10 ± 1.61	0.62–7.08
Transverse diameter of descending colon (mm)	3.43 ± 1.61	0.54–7.74
Transverse diameter of sigmoid colon (mm)	5.18 ± 1.76	1.93–9.26
Anteroposterior diameter of caecum (mm)	2.78 ± 1.35	0.35–6.95
Anteroposterior diameter of ascending colon (mm)	2.36 ± 1.39	0.16–5.51
Anteroposterior diameter of transverse colon (mm)	2.08 ± 1.16	0.17–5.11
Anteroposterior diameter of descending colon (mm)	2.40 ± 1.21	0.38–5.92
Anteroposterior diameter of sigmoid colon (mm)	3.38 ± 1.30	1.03–7.14
Average diameter of cecum (mm)	3.22 ± 1.54	0.28–6.61
Average diameter of ascending colon (mm)	2.92 ± 1.53	0.41–6.83
Average diameter of transverse colon (mm)	2.60 ± 1.33	0.60–5.80
Average diameter of descending colon (mm)	2.92 ± 1.33	0.46–6.10
Average diameter of sigmoid colon (mm)	4.29 ± 1.41	1.83–8.20

Table 3: General foetal morphometric parameters according to gestational age

Variable	15–20 weeks (n=8)	21–25 weeks (n=10)	26–30 weeks (n=16)	31–35 weeks (n=7)	36–40 weeks (n=10)	P value
Crown Rump Length (mm)	143.13 ± 13.611	193.00 ± 18.439	233.75 ± 13.964	280.71 ± 12.051	324.00 ± 11.255	< 0.001
Abdominal Circumference (mm)	111.75 ± 14.310	148.90 ± 20.157	188.56 ± 29.915	200.71 ± 7.319	261.20 ± 22.075	< 0.001
Head Circumference (mm)	130.00 ± 11.019	180.50 ± 23.268	209.06 ± 6.638	257.14 ± 11.127	335.00 ± 33.582	< 0.001

Table 4: Full colonic length and transverse diameters according to gestational age

Parameter	15–20 weeks (n=8)	21–25 weeks (n=10)	26–30 weeks (n=16)	31–35 weeks (n=7)	36–40 weeks (n=10)	P value
Full length of colon (cm)	18.63 ± 3.249	19.70 ± 2.003	18.19 ± 2.073	22.71 ± 2.215	26.60 ± 1.838	< 0.001
Transverse diameter of caecum (mm)	2.619 ± 0.708	3.685 ± 0.872	3.241 ± 1.658	2.679 ± 1.833	5.763 ± 2.264	<0.001
Transverse diameter of ascending colon (mm)	2.311 ± 0.714	3.311 ± 0.477	3.267 ± 1.718	2.257 ± 1.068	5.752 ± 1.428	< 0.001
Transverse diameter of transverse colon (mm)	2.153 ± 0.449	2.923 ± 0.532	2.699 ± 1.415	2.210 ± 1.428	5.335 ± 1.414	< 0.001
Transverse diameter of descending colon (mm)	2.644 ± 0.390	3.315 ± 0.556	2.887 ± 1.579	2.630 ± 1.380	5.606 ± 1.328	< 0.001
Transverse diameter of sigmoid colon (mm)	4.375 ± 1.219	4.791 ± 0.913	4.424 ± 1.531	5.174 ± 1.907	7.461 ± 1.221	< 0.001

Table 5: Anteroposterior and average diameters according to gestational age

Parameter	15–20 weeks (n=8)	21–25 weeks (n=10)	26–30 weeks (n=16)	31–35 weeks (n=7)	36–40 weeks (n=10)	P value
Anteroposterior diameter of caecum (mm)	1.863 ± 0.575	2.921 ± 0.471	2.622 ± 1.333	2.010 ± 1.559	4.204 ± 1.265	<0.001
Anteroposterior diameter of ascending colon (mm)	1.229 ± 0.567	2.203 ± 0.432	2.264 ± 1.159	1.430 ± 1.310	4.232 ± 1.143	< 0.001
Anteroposterior diameter of transverse colon (mm)	1.565 ± 0.297	1.890 ± 0.419	1.962 ± 1.229	1.077 ± 0.900	3.576 ± 0.828	< 0.001
Anteroposterior diameter of descending colon (mm)	2.049 ± 0.382	1.948 ± 0.429	2.028 ± 1.228	2.454 ± 1.798	3.739 ± 0.825	<0.001
Anteroposterior diameter of sigmoid colon (mm)	2.885 ± 0.810	3.104 ± 0.849	3.307 ± 1.341	3.249 ± 1.997	4.277 ± 1.170	0.167
Average diameter of caecum (mm)	2.242 ± 0.578	3.305 ± 0.576	2.933 ± 1.484	2.346 ± 1.611	4.985 ± 1.437	< 0.001
Average diameter of ascending colon (mm)	1.772 ± 0.623	2.758 ± 0.388	2.769 ± 1.411	1.846 ± 1.094	4.995 ± 1.251	< 0.001
Average diameter of transverse colon (mm)	1.860 ± 0.341	2.408 ± 0.386	2.333 ± 1.226	1.644 ± 1.090	4.457 ± 1.059	< 0.001
Average diameter of descending colon (mm)	2.349 ± 0.244	2.634 ± 0.320	2.460 ± 1.293	2.544 ± 1.561	4.676 ± 0.999	< 0.001

Average diameter of sigmoid colon (mm)	3.634 ± 0.997	3.949 ± 0.748	3.869 ± 1.336	4.214 ± 1.767	5.871 ± 0.988	0.0009

Table 6: Correlation of foetal large intestinal morphometry with CRL, AC, and HC

Variable	CRL r (p value)	AC r (p value)	HC r (p value)
Transverse diameter of caecum (mm)	0.433 (0.001)	0.320 (0.022)	0.476 (<0.001)
Transverse diameter of ascending colon (mm)	0.516 (<0.001)	0.416 (0.002)	0.535 (<0.001)
Transverse diameter of transverse colon (mm)	0.543 (<0.001)	0.452 (0.001)	0.594 (<0.001)
Transverse diameter of descending colon (mm)	0.498 (<0.001)	0.366 (0.008)	0.536 (<0.001)
Transverse diameter of sigmoid colon (mm)	0.613 (<0.001)	0.462 (0.001)	0.594 (<0.001)
Anteroposterior diameter of caecum (mm)	0.464 (0.001)	0.350 (0.012)	0.485 (<0.001)
Anteroposterior diameter of ascending colon (mm)	0.577 (<0.001)	0.486 (<0.001)	0.581 (<0.001)
Anteroposterior diameter of transverse colon (mm)	0.451 (0.001)	0.447 (0.001)	0.487 (<0.001)
Anteroposterior diameter of descending colon (mm)	0.476 (<0.001)	0.361 (0.009)	0.463 (0.001)
Anteroposterior diameter of sigmoid colon (mm)	0.403 (0.003)	0.333 (0.017)	0.382 (0.006)
Average diameter of cecum (mm)	0.472 (<0.001)	0.352 (0.011)	0.508 (<0.001)
Average diameter of ascending colon (mm)	0.554 (<0.001)	0.456 (0.001)	0.567 (<0.001)
Average diameter of transverse colon (mm)	0.526 (<0.001)	0.469 (0.001)	0.573 (<0.001)
Average diameter of descending colon (mm)	0.520 (<0.001)	0.387 (0.005)	0.536 (<0.001)
Average diameter of sigmoid colon (mm)	0.572 (<0.001)	0.445 (0.001)	0.551 (<0.001)

Discussion

One of the major findings of the present study was the significant increase in full colonic length with advancing gestation. The mean full colonic length increased from 18.63 ± 3.25 cm in the 15–20-week group to 26.60 ± 1.84 cm in the 36–40-week group ($p < 0.001$), although a slight reduction was observed in the 26–30-week group, probably reflecting biological variability and the relatively small sample size rather than a true decrease in growth. A comparable pattern was reported by Koyuncu et al,[11] who demonstrated rapid growth of the foetal large intestine, particularly during the mid-gestational period, with continuous elongation of the colon as gestation advanced. Likewise, Ben-Nun et al,[12] using foetal magnetic resonance imaging, demonstrated progressive enlargement of the colon and rectum throughout gestation. Thus, the findings of the present cadaveric study are consistent with both anatomical and imaging-based studies, confirming that colonic length increases steadily as part of normal intrauterine development.

Another important finding of the present study was the significant increase in the transverse diameters of all colonic segments with advancing gestation. Among all segments, the sigmoid colon consistently demonstrated the greatest transverse diameter, increasing from 4.38 ± 1.22 mm at 15–20 weeks to 7.46 ± 1.22 mm at 36–40 weeks. Similar observations were reported by Malas et al,[13] who found progressive enlargement of all colonic segments during foetal development and also identified the sigmoid colon as the widest segment of the large intestine. Furthermore, Nehra et al,[14] in their morphometric study of the foetal caecum and appendix, demonstrated significant gestational increases in caecal dimensions. The present findings therefore agree with previous reports, indicating that enlargement of colonic calibre occurs uniformly throughout gestation, with the sigmoid colon exhibiting the greatest degree of expansion.

The anteroposterior diameters in the present study also showed significant gestational enlargement in all colonic segments except the sigmoid colon, where the increase, although numerically evident (2.89–4.28 mm), did not reach statistical significance ($p = 0.167$). This lack of statistical significance is likely attributable to the greater anatomical variability of the sigmoid loop and mesocolon during late foetal life rather than the absence of developmental growth. Similar observations have been described by, Devi et al,[15] described continuous morphogenetic remodelling of the foetal colon throughout prenatal development. In addition, Wozniak et al,[16] who reported increasing tortuosity, redundancy, and positional variability of the foetal sigmoid colon and its mesentery with advancing gestation. Therefore, both the present study and previous investigations indicate that although the sigmoid colon continues to enlarge during gestation, its complex anatomical configuration may contribute to greater variability in morphometric measurements.

The average diameters measured in the present study further confirmed the progressive enlargement of the large intestine during foetal life. Significant increases were observed in all colonic segments, with the sigmoid colon consistently demonstrating the largest average diameter throughout gestation. These findings closely correspond with those of Malas et al,[13] who similarly reported progressive increases in colonic diameters with sigmoid predominance. Together, these observations suggest that the sigmoid colon undergoes the greatest overall dimensional expansion among all segments of the developing large intestine.

The descending colon also exhibited significant gestational enlargement in both transverse and average diameters in the present study. Comparable findings were reported by Gworys et al,[17] who described progressive developmental changes in the descending colon during foetal life. Similarly, Harris et al,[18] demonstrated continuous growth of the foetal colon using prenatal radiological evaluation, while Fitzgerald et al,[19] reported ongoing positional changes of the developing caecum throughout gestation. Although Fitzgerald et al. focused primarily on positional development rather than morphometry, both studies emphasise that maturation of the foetal large intestine involves not only dimensional enlargement but also continuous anatomical remodelling and positional changes.

A further important observation of the present study was the significant positive correlation between colonic morphometric parameters and general foetal growth measurements. Nearly all colonic dimensions demonstrated moderate-to-strong positive correlations with CRL, AC, and HC, with the strongest association observed between CRL and the transverse diameter of the sigmoid colon ($r = 0.613$, $p < 0.001$).

The present study provides normative morphometric data for the developing foetal large intestine, which may aid prenatal imaging and the early diagnosis of congenital intestinal anomalies.

Overall, the foetal large intestine showed significant gestational enlargement, with the sigmoid colon emerging as the largest and most variable segment. These findings provide valuable baseline data for developmental anatomy and prenatal evaluation.

Table 7: Comparison of present morphometric findings with previous studies

Study	Population	Key previous finding	Present study	Comparison
Harris et al. (1976),[18]	Human FOETUSes (radiological study)	Progressive radiological growth of the fetal colon during gestation.	Descending colonic transverse and average diameters showed significant gestational increase.	Present findings support continuous gestational growth of the fetal colon.
Gworys et al. (2004),[17]	Human FOETUSes	Progressive development of the descending colon during fetal life.	Descending colonic transverse and average diameters increased significantly with gestation.	Findings confirm continuing enlargement of the descending colon.
Malas et al. (2004),[13]	Human FOETUSes	All colonic diameters increased with gestation; the sigmoid colon was the largest segment.	All segmental diameters increased significantly; the sigmoid colon showed the highest transverse and average diameters.	Strong agreement in segmental growth pattern and sigmoid predominance.
Koyuncu et al. (2014),[11]	Human FOETUSes	Rapid fetal large intestinal growth with marked increase in colonic length during gestation.	Mean full colonic length increased from 18.63 cm at 15–20 weeks to 26.60 cm at 36–40 weeks.	Comparable pattern of progressive gestational enlargement.
Ben-Nun et al. (2018),[12]	Human FOETUSes assessed by fetal MRI	Progressive growth of the colon and rectum throughout gestation.	Average colonic dimensions increased progressively in all studied segments.	Present findings agree with MRI-based evidence of gestational growth.
Wozniak et al. (2018),[16]	Human FOETUSes	Increasing variability of the fetal sigmoid colon and mesentery with advancing gestation.	Sigmoid colon showed the highest diameters and the least consistent anteroposterior trend.	Supports the sigmoid colon as the most dynamic and variable segment.
Nehra et al. (2024),[14]	Human FOETUSes	Gestation-related increase in the size of the fetal caecum and appendix.	Caecal transverse, anteroposterior, and average diameters increased significantly across gestational groups.	Present caecal findings are comparable with previously reported segment-specific enlargement.
Present study (2026)	51 human FOETUSes (15–39 weeks)	—	Progressive increase in colonic length and segmental diameters, with the sigmoid colon being the largest segment.	Provides updated normative morphometric reference data across gestation.

Conclusion

The normative morphometric data generated in the present study may serve as reference standards for prenatal ultrasonography and fetal MRI, facilitating the differentiation of normal intestinal development from congenital anomalies such as intestinal atresia, bowel obstruction, malrotation, and colonic hypoplasia. These findings may also assist anatomists, radiologists, obstetricians, and paediatric surgeons in prenatal diagnosis, surgical planning, and improving neonatal outcomes.

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Conflicts of interest

There are no conflicts of interest.

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