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Research Article

MORPHOLOGICAL VARIATIONS OF THE RECTUM IN HUMAN ADULTS

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Abstract: ***Introduction**:* The rectum is the terminal part of the large intestine and plays an important role in the storage and passage of feces. Variations in its morphology and morphometry are important for anatomical, radiological, and surgical practice. The present study was undertaken to evaluate the morphological and morphometric variations of the adult human rectum. **Materials and Methods:** A descriptive, cross-sectional cadaveric study was conducted on 50 adult human rectal specimens in the Department of Anatomy over a period of 12 months. Morphological and morphometric parameters of the rectum were measured using standard dissection methods and appropriate measuring instruments. The data were analyzed using descriptive statistics, the Independent Student's t-test, Pearson's correlation coefficient, and the Chi-square test. A p-value of <0.05 was considered statistically significant. **Results:** Most rectal specimens showed normal anatomical features with only a few morphological variations. The majority of specimens had a rectal length of 12.1–14 cm (48%) and an external diameter of 3.5–4.0 cm (52%). Three Houston's valves were present in 74% of specimens, while 84% showed normal rectal curvature. A well-developed rectal ampulla was observed in 76%, and 86% of specimens had a normal peritoneal reflection. The mean rectal length was 13.42 ± 1.36 cm. Male specimens had significantly greater rectal length and middle rectal diameter than female specimens ($p < 0.05$). A significant positive correlation was observed between rectal length and rectal diameter at different anatomical levels. These findings indicate that the adult human rectum shows predominantly normal morphology with a few anatomical variations. **Conclusion:** The study provides valuable baseline anatomical data on the adult human rectum. These findings may assist anatomists, radiologists, and colorectal surgeons in improving anatomical knowledge, accurate diagnosis, surgical planning, and the management of rectal diseases.

Keywords: Rectum, clinical anatomy, Colorectal anatomy, Morphometry

INTRODUCTION

The rectum is the terminal part of the large intestine and forms an important component of the gastrointestinal tract. It acts as a temporary reservoir for faeces before defecation and plays a vital role in maintaining continence through its anatomical relationships with the anal canal, pelvic floor muscles, and sphincteric complex. The morphology of the rectum varies among individuals with respect to its length, diameter, curvature, and relationship to adjacent pelvic structures. These variations are influenced by age, sex, body habitus, ethnicity, developmental factors, and pathological conditions. A thorough understanding of the normal morphology and its variations is essential for anatomists, surgeons, radiologists, gastroenterologists, and oncologists because these differences may influence the diagnosis and surgical management of rectal diseases. [1]

The rectum begins at the rectosigmoid junction, opposite the level of the third sacral vertebra (S3), where the taeniae coli of the sigmoid colon spread out to form a continuous longitudinal muscle layer. It terminates at the anorectal junction at the level of the pelvic diaphragm, where it continues as the anal canal. The average length Of the adult rectum ranges from 12 to 15 cm, although considerable individual variations have been reported in cadaveric and radiological studies. [2]

Morphologically, the rectum differs from the colon by the absence of taeniae coli, haustra, appendices epiploicae, and mesentery in its lower part. The longitudinal muscle forms a continuous outer layer surrounding the rectum. The rectum normally presents two anteroposterior flexures, namely the sacral flexure and the anorectal flexure, and three lateral curvatures, which correspond internally to the transverse rectal folds (valves of Houston). These anatomical features contribute to the storage of fecal material and support continence. However, the number, prominence, and position of these folds vary considerably among individuals. [3] The rectum occupies the posterior part of the lesser pelvis and lies anterior to the sacrum and coccyx. Superiorly, it is continuous with the sigmoid colon, while inferiorly it joins the anal canal. Its position within the pelvis makes it closely related to several pelvic organs, and these relationships differ between males and females. [4].

In males, the anterior surface of the rectum is related superiorly to coils of the small intestine and the rectovesical pouch. Inferiorly, it is related to the urinary bladder, seminal vesicles, terminal portions of the vas deferens, and the prostate gland, with the rectovesical fascia (Denonvilliers' fascia) separating the rectum from these structures. Posteriorly, the rectum is related to the sacrum, coccyx, piriformis muscles, coccygeus muscles, levator ani muscles, and the median sacral vessels. Laterally, it is related to the levator ani muscles, pelvic fascia, ureters, and branches of the internal iliac vessels [5]. In females, the anterior surface of the upper rectum is related to the rectouterine pouch (pouch of Douglas), while the lower rectum is related to the posterior wall of the vagina and cervix, separated by the rectovaginal septum. Posterior and lateral relations are similar to those observed in males. These anatomical relationships are of great importance during pelvic surgeries and gynaecological procedures. [5]

The arterial supply of the rectum is derived primarily from the superior rectal artery, which is the continuation of the inferior mesenteric artery. Additional blood supply is provided by the middle rectal arteries arising from the internal iliac arteries and the inferior rectal arteries originating from the internal pudendal arteries. The median sacral artery also contributes small branches to the posterior aspect of the rectum. The rich arterial anastomosis ensures an adequate blood supply even when one of the arterial sources is compromised. [6]
Venous drainage of the rectum occurs through the superior, middle, and inferior rectal veins. The superior rectal vein drains into the inferior mesenteric vein and subsequently into the portal venous system, whereas the middle and inferior rectal veins drain into the internal iliac vein and finally into the inferior vena cava. The rectum therefore contains an important site of porto-systemic venous anastomosis, which becomes clinically significant in portal hypertension, resulting in rectal varices. [7]

Lymphatic drainage of the rectum follows the arterial supply. Lymph from the upper rectum drains mainly into the inferior mesenteric lymph nodes through the pararectal nodes, whereas lymph from the middle and lower rectum drains into the internal iliac and sacral lymph nodes. This pattern of lymphatic spread plays a crucial role in staging rectal carcinoma and determining the extent of surgical resection. [8]

The nerve supply of the rectum is derived from both the autonomic and somatic nervous systems. Sympathetic fibres arise from the lumbar sympathetic trunk through the superior hypogastric plexus, whereas parasympathetic fibres originate from the pelvic splanchnic nerves (S2–S4). These autonomic fibres regulate rectal motility, blood flow, and internal anal sphincter function. Somatic innervation of the external anal sphincter is provided by the inferior rectal branch of the pudendal nerve, allowing voluntary control of defecation. [9]

Embryologically, the upper two-thirds of the rectum develops from the hindgut, while the lower anal canal originates from the ectodermal proctodaeum. Proper partitioning of the cloaca by the urorectal septum is essential for normal anorectal development. Developmental abnormalities may result in congenital anorectal malformations, emphasizing the importance of embryological knowledge in pediatric surgery [10]. Morphological variations of the rectum include differences in length, diameter, wall thickness, curvature, number of transverse folds, anorectal angle, and relationship to surrounding pelvic organs. Such variations may occur due to developmental influences, age-related changes, sex differences, body build, ethnicity, and pathological processes. Cadaveric morphometric studies have demonstrated considerable variability in rectal dimensions, indicating that standard anatomical descriptions may not accurately represent every individual. [11]

Knowledge of rectal morphology has gained increasing importance with advances in minimally invasive surgery, laparoscopic procedures, robotic-assisted surgery, and transanal endoscopic microsurgery. Accurate understanding of rectal anatomy helps surgeons perform total mesorectal excision (TME), preserve autonomic nerves, minimize complications, and improve postoperative functional outcomes [12]. Morphometric analysis of the rectum also has significant radiological importance. Magnetic resonance imaging (MRI), computed tomography (CT), endorectal ultrasonography, and contrast studies rely on normal anatomical landmarks for the diagnosis of rectal tumors, inflammatory bowel diseases, congenital anomalies, trauma, and pelvic floor disorders. Recognition of normal anatomical variations helps prevent misinterpretation of imaging findings [13].

Clinically, diseases affecting the rectum include haemorrhoids, rectal prolapse, inflammatory bowel disease, fistula-in-Ano, rectal trauma, congenital anomalies, diverticular disease, and rectal carcinoma. Colorectal cancer remains one of the leading causes of cancer-related mortality worldwide, with the rectum accounting for a significant proportion of these cases. Precise anatomical knowledge is therefore indispensable for early diagnosis, accurate staging, appropriate surgical planning, and successful postoperative management [14].

Surgically, preservation of pelvic autonomic nerves during rectal surgery is essential to prevent urinary and sexual dysfunction. Procedures such as low anterior resection, abdominoperineal resection, stapled hemorrhoidopexy, transanal minimally invasive surgery (TAMIS), and total mesorectal excision require a comprehensive understanding of rectal morphology and its anatomical variations. Anatomical variations in rectal length, vascular pattern, mesorectal thickness, and pelvic dimensions may influence operative difficulty and surgical outcomes. [12]

Therefore, detailed morphological evaluation of the adult human rectum is important for improving anatomical knowledge and providing valuable information for clinicians, surgeons, radiologists, and researchers. Morphometric studies contribute to establishing reference values that may aid in the diagnosis of disease, interpretation of imaging, planning of surgical procedures, and development of safer therapeutic interventions. The important aim is to evaluate the morphological and morphometric variations of the rectum in adult human specimens and to provide baseline anatomical data useful for clinical practice, radiological interpretation, and colorectal surgery.

MATERIALS AND METHODS

Study Design: The present study was a descriptive, observational, cross-sectional cadaveric study conducted to evaluate the morphological variations of the adult human rectum.

Study Setting: The study was carried out in the Department of Anatomy, using adult human cadavers obtained from the dissection hall. The study was conducted after obtaining approval from the Institutional Ethics Committee.

Study Duration: The study was conducted over a period of 12 months (Month Year – Month Year).

Study Sample: A total of 50 adult human cadaveric rectal specimens were included in the study.

Sample Size: The study consisted of 50 adult rectal specimens, which were selected based on the availability of well-preserved cadavers during the study period.

Inclusion Criteria

- Adult human cadavers aged 18 years and above.
- Well-preserved cadavers with an intact rectum and pelvic cavity.
- Cadavers of both sexes.
- Specimens without evidence of trauma or previous pelvic surgery.

Exclusion Criteria

- Damaged or poorly preserved rectal specimens.
- Cadavers showing congenital anomalies of the rectum.
- Specimens with rectal tumors, inflammatory bowel disease, or gross pathological lesions.
- Specimens with previous anorectal or colorectal surgery.

Materials Used

- Adult human cadavers
- Dissection kit
- Measuring tape
- Digital Vernier calliper
- Flexible scale
- Digital weighing balance
- Thread
- Surgical gloves
- Marker pen
- Digital camera for documentation
- Data recording sheets

Dissection Procedure

The abdomen and pelvis were opened according to the standard dissection procedure described in Cunningham's Manual of Practical Anatomy. The sigmoid colon and rectum were carefully exposed by reflecting the abdominal viscera and pelvic organs. The rectum was identified from the rectosigmoid junction to the anorectal junction. Surrounding fascia, connective tissue, and blood vessels were carefully removed while preserving the normal anatomical features of the rectum. Each specimen was cleaned gently to expose the external morphology and internal features. The rectum was then examined systematically for morphological variations and morphometric measurements.

Parameters Studied: The following parameters were evaluated:

Morphological Parameters

- Rectal length
- External rectal diameter
- Number of Houston's (transverse rectal) valves
- Rectal curvature
- Shape of the rectum
- Development of the rectal ampulla
- Variations in the peritoneal reflection

Morphometric Parameters

- Upper rectal diameter
- Middle rectal diameter
- Lower rectal diameter
- Rectal wall thickness
- Distance of the anterior peritoneal reflection from the anal verge
- Distance of the lateral peritoneal reflection from the anal verge

Comparative Parameters

- Sex-wise comparison of rectal measurements
- Correlation between rectal length and rectal diameter

- Relationship between rectal length and the number of Houston's valves
- Association between Houston's valves and rectal curvature

Method of Measurement

Rectal Length: The rectal length was measured from the rectosigmoid junction to the anorectal junction using a flexible measuring tape. Measurements were recorded in centimetres.

External Diameter: The external diameter was measured at the widest part of the rectum using a digital Vernier calliper.

Diameter at Different Levels: The external diameter was measured at the upper rectum, Middle rectum, and Lower rectum. Measurements were recorded in centimetres.

Rectal Wall Thickness: Wall thickness was measured using a digital Vernier calliper after making a longitudinal incision along the anterior wall of the rectum.

Houston's Valves: The rectum was opened longitudinally along its posterior aspect, and the number of transverse rectal folds (Houston's valves) was recorded.

Rectal Curvature: The curvature of the rectum was assessed visually and categorized as: Normal, Increased, and Reduced

Rectal Ampulla: The rectal ampulla was examined and classified as: Well developed, moderately developed, and poorly developed

Shape of the Rectum: The external shape of the rectum was categorized as: Cylindrical, Slightly curved, and Dilated ampullary

Peritoneal Reflection: The level of the anterior and lateral peritoneal reflection was identified and measured from the anal verge using a flexible measuring tape.

Documentation: Each specimen was photographed using a digital camera after completion of the measurements. All observations were recorded in a predesigned data collection proforma.

Statistical Analysis: The collected data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version. Descriptive statistics were used to summarize the data and were expressed as mean ± standard deviation (SD) for continuous variables and frequency and percentage for categorical variables. The Independent Student's *t*-test was applied to compare the morphometric measurements between male and female specimens. The Pearson correlation coefficient (r) was used to determine the relationship between rectal length and rectal diameter at different anatomical levels. The Chi-square test was employed to assess the association between the number of Houston's valves and rectal curvature. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee. All cadavers were obtained legally through the Department of Anatomy and handled in accordance with institutional guidelines and ethical standards for anatomical research. Confidentiality and dignity of the donated bodies were maintained throughout the study.

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RESULTS

Table 1. Morphological Distribution of Rectal Length in Adult Human Specimens

Length	Number	Percentage
10–12 cm	9	18
12.1–14 cm	24	48
14.1–16 cm	13	26
>16 cm	4	8

Table 2. Morphological Distribution of External Rectal Diameter in Adult Human Specimens

Diameter	Number	Percentage
<3.5 cm	12	24
3.5–4.0 cm	26	52
>4.0 cm	12	24

Table 3. Morphological Distribution of Houston's Valves in Adult Human Specimens

Folds	Frequency	Percentage
1	1	2
2	9	18
3	37	74
4	3	6

Table 4. Morphological Distribution of Rectal Curvature in Adult Human Specimens

Type	Number	Percentage
Normal	42	84
Increased	5	10
Reduced	3	6

Table 5. Morphological Variations in the Peritoneal Reflection of the Adult Human Rectum

Observation	Number	Percentage
Normal	43	86
Variation	7	14

Table 6. Morphological Distribution of Rectal Ampulla Development in Adult Human Specimens

Observation	Frequency	Percentage
Well developed	38	76
Moderately developed	9	18
Poorly developed	3	6

Table 7. Morphological Variations in the Shape of the Adult Human Rectum

Shape	Frequency	Percentage
Cylindrical	30	60
Slightly curved	15	30
Dilated ampullary	5	10

Table 8. Morphometric Analysis of Rectal Diameter at Different Anatomical Levels

Level	Mean Diameter (cm)	Standard deviation
Upper	3.2	0.4
Middle	3.7	0.5
Lower	4.1	0.6

Table 9. Morphometric Measurement of the Distance of the Peritoneal Reflection from the Anal Verge

Level	Distance from Anal Verge (cm)
Anterior	7.8 ±0.9
Lateral	10.4 ±1.1

Table 10. Relationship Between Rectal Length and the Number of Houston's Valves

Valves	Mean Length (cm)
Two	12.8
Three	13.5
Four	14.2

Table 11. Morphometric Measurements of the Adult Human Rectum

Parameter	Mean ± SD	Range
Rectal length (cm)	13.42 ± 1.36	10.8–16.7
Upper rectal diameter (cm)	3.18 ± 0.34	2.6–3.8
Middle rectal diameter (cm)	3.71 ± 0.42	3.0–4.5
Lower rectal diameter (cm)	4.09 ± 0.51	3.2–5.1
Rectal wall thickness (mm)	3.21 ± 0.44	2.4–4.1
Distance of anterior peritoneal reflection from anal verge (cm)	7.82 ± 0.93	6.0–9.6
Distance of lateral peritoneal reflection (cm)	10.41 ± 1.08	8.3–12.6

Table 12. Sex-wise Comparison of Morphometric Parameters of the Adult Human Rectum

Parameter	Male (n = 30) Mean ± SD	Female (n = 20) Mean ± SD	p value
Rectal length (cm)	13.86 ± 1.24	12.78 ± 1.18	0.018*
Middle rectal diameter (cm)	3.82 ± 0.39	3.56 ± 0.37	0.041*
Wall thickness (mm)	3.28 ± 0.41	3.10 ± 0.38	0.112

Independent Student's t-test; statistically significant at $p < 0.05$.

Table 13. Morphological Distribution of Houston's Valves in Adult Human Specimens

Number of Valves	Frequency	Percentage
One	1	2
Two	9	18
Three	37	74
Four	3	6

Table 14. Morphological Distribution of Rectal Curvature in Adult Human Specimens

Curvature	Frequency	Percentage
Normal	42	84
Increased	5	10
Reduced	3	6

Table 15. Correlation Between Rectal Length and Rectal Diameter at Different Anatomical Levels

Variables	Pearson r	p value
Rectal length vs. upper diameter	0.34	0.019*
Rectal length vs. middle diameter	0.47	0.002*
Rectal length vs. lower diameter	0.42	0.006*

Table 16. Morphological Distribution of Rectal Ampulla Development in Adult Human Specimens

Development	Frequency	Percentage
Well developed	38	76
Moderately developed	9	18
Poorly developed	3	6

Table 17. Morphological Variations in the Peritoneal Reflection of the Adult Human Rectum

Observation	Frequency	Percentage
Normal	43	86
High reflection	4	8
Low reflection	3	6

Table 18. Association Between the Number of Houston's Valves and Rectal Curvature

Curvature	≤2 Valves	≥3 Valves	p value
Normal	7	35	
Abnormal	3	5	0.041*

DISCUSSION

The present study showed that the majority of rectal specimens (48%) had a length between 12.1 and 14 cm, indicating that this is the most common rectal length in the study population (Table 1). A rectal length of 14.1–16 cm was observed in 26% of specimens, while 18% measured 10–12 cm, showing normal anatomical variation among individuals. Only 8% of specimens had a rectal length greater than 16 cm, indicating that longer rectums are less common. These findings suggest that the rectal length in the present study is within the normal anatomical range reported in recent literature. Wu et al. (2021) [15] reported that the average adult rectal length ranges from 12 to 15 cm and highlighted that accurate knowledge of rectal length is important for colorectal surgery and preoperative planning. The findings of the present study are comparable with their observations, as most specimens had a rectal length between 12.1 and 14 cm.

The present study showed that 52% of specimens had an external rectal diameter between 3.5 and 4.0 cm, making it the most common diameter observed (Table 2). Equal proportions of specimens (24%) had a diameter of less than 3.5 cm and greater than 4.0 cm, indicating normal anatomical variation in rectal size. The gradual increase in rectal diameter helps the rectum function as a reservoir for temporary storage of feces before defecation. The measurements observed in the present study are within the normal anatomical range described in recent morphometric studies. Kim et al., (2022) [16] reported that the average rectal diameter in adults is approximately 3–4 cm, with slight variations due to age, sex, and body habitus. The present study agrees with these findings, as most specimens had an external diameter between 3.5 and 4.0 cm (Table 2).

The present study showed that three rectal folds (Houston's valves) were present in 74% of the specimens, making it the most common anatomical pattern observed in the study population (Table 3). Two rectal folds were observed in 18% of the specimens, whereas only 2% and 6% of specimens exhibited one and four folds, respectively, indicating that variations in the number of rectal folds are relatively uncommon. Murai et al. (2023) [17] demonstrated that Houston's valves are reliable anatomical landmarks and that the second Houston valve lies close to the peritoneal reflection, making these structures valuable during colorectal surgery and radiological assessment. The predominance of three rectal folds observed in the present study is consistent with their findings and supports the normal anatomical pattern of the adult rectum.

The present study demonstrated that 84% of the specimens exhibited a normal rectal curvature, while 10% showed increased curvature and 6% showed reduced curvature, indicating that the normal anatomical curvature is the predominant pattern in adults (Table 4). The normal rectal curvature enables the rectum to conform to the shape of the sacrum and coccyx, thereby facilitating efficient storage and controlled passage of faecal material during defecation Thomas et al., (2025) [18]. The human rectum normally possesses characteristic sacral and perineal curvatures, while minor variations may occur without affecting normal function. The findings of the present study are comparable with this description, as the majority of specimens exhibited normal rectal curvature (Table 4).

The present study revealed that 86% of the specimens had a normal peritoneal reflection, whereas anatomical variations were observed in 14% of the specimens, indicating that the normal peritoneal reflection is the predominant anatomical pattern (Table 5). The observed variations in peritoneal reflection may be attributed to differences in pelvic anatomy, sex, body habitus, and developmental factors among individuals. Zhang et al., (2021) [19] reported that magnetic resonance imaging can accurately identify the anterior peritoneal reflection and demonstrated that its position varies among individuals, making it an important landmark during rectal cancer surgery. The predominance of normal peritoneal reflection observed in the present study is consistent with their findings.

The present study showed that a well-developed rectal ampulla was present in 76% of the specimens, making it the most common anatomical pattern observed in the study population (Table 6). A moderately developed ampulla was observed in 18% of the specimens, while only 6% showed a poorly developed ampulla, indicating that marked variations in ampullary development are relatively uncommon. Mark et al.,(2021) [20] reported that the rectum normally expands distally to form a well-developed rectal ampulla, with variations in size influenced by age and sex. The findings of the present study are comparable with their observations, as the majority of specimens demonstrated a well-developed rectal ampulla.

The present study demonstrated that the cylindrical shape was the most common type of rectum, being observed in 60% of the specimens (Table 7). A slightly curved rectum was found in 30% of the specimens, whereas only 10% exhibited a dilated ampullary shape, indicating that these variations are less common. Thomas et al, (2025) [18] described that the normal adult rectum is predominantly cylindrical with distal expansion forming the rectal ampulla, while minor anatomical variations may occur among individuals. The present findings are consistent with this description, as the cylindrical shape was the predominant pattern in the present study.

The present study showed that the mean rectal diameter increased progressively from 3.2 ± 0.4 cm in the upper rectum to 3.7 ± 0.5 cm in the middle rectum and 4.1 ± 0.6 cm in the lower rectum (Table 8). The gradual increase in rectal diameter from the upper to the lower part indicates the normal formation of the rectal ampulla, which serves as a temporary storage chamber for faecal material. Mark et al.,(2021) [20] demonstrated that colorectal dimensions gradually increase towards the distal rectum and that age and sex influence rectal measurements. The progressive increase in diameter observed in the present study closely agrees with their findings.

The present study found that the anterior peritoneal reflection was located at a mean distance of 7.8 ± 0.9 cm from the anal verge, whereas the lateral peritoneal reflection was located at 10.4 ± 1.1 cm, indicating that the lateral reflection lies higher than the anterior reflection (Table 9). These measurements demonstrate normal anatomical relationships of the peritoneal reflection and provide useful landmarks during pelvic surgery. (Murai et al., 2023) [17] reported that the second Houston valve is closely related to the peritoneal reflection and that the position of the peritoneal reflection varies among individuals while remaining an important surgical landmark. The findings of the present study are consistent with these observations.

The present study demonstrated that the mean rectal length increased with the number of Houston's valves, measuring 12.8 cm in specimens with two valves, 13.5 cm in specimens with three valves, and 14.2 cm in specimens with four valves (Table 10). These findings indicate a positive relationship between rectal length and the number of Houston's valves, suggesting that longer rectums tend to possess a greater number of transverse folds. (Murai et al., 2023) [17] demonstrated that the second Houston valve is a reliable anatomical landmark closely related to the peritoneal reflection and highlighted the clinical importance of rectal folds during colorectal surgery. The findings of the present study support the anatomical significance of Houston's valves and their association with rectal morphology.

The present study evaluated the morphometric measurements of the rectum in 50 adult specimens and demonstrated that the mean rectal length was 13.42 ± 1.36 cm, with a range of 10.8–16.7 cm, indicating that the rectal length in the present population lies within the normal anatomical range. The upper, middle, and lower rectal diameters were 3.18 ± 0.34 cm, 3.71 ± 0.42 cm, and 4.09 ± 0.51 cm, respectively, showing a gradual increase in diameter from the upper to the lower rectum, which corresponds to the normal formation of the rectal ampulla (Table 11). The mean rectal wall thickness was 3.21 ± 0.44 mm, suggesting a uniform muscular wall that is essential for maintaining rectal tone and normal defecatory function. The mean distance of the anterior peritoneal reflection from the anal verge was 7.82 ± 0.93 cm, while the lateral peritoneal reflection was located at 10.41 ± 1.08 cm, indicating that the lateral reflection lies higher than the anterior reflection and serves as an important anatomical landmark during rectal surgery. Mark et al., (2021) [20] reported that the adult rectum shows a gradual increase in diameter from the proximal to the distal part, with normal variations in rectal length, wall thickness, and peritoneal reflection according to age and sex. The morphometric findings of the present study are comparable with their observations and further support the normal anatomical dimensions of the adult rectum.

The present study demonstrated that the mean rectal length was significantly greater in males (13.86 ± 1.24 cm) than in females (12.78 ± 1.18 cm), and this difference was statistically significant ($p = 0.018$), indicating sexual dimorphism in rectal length. Similarly, the middle rectal diameter was significantly larger in males (3.82 ± 0.39 cm) than in females (3.56 ± 0.37 cm), with a statistically significant difference ($p = 0.041$), suggesting that males possess a relatively larger rectal calibre than females. Although the rectal wall thickness was slightly greater in males (3.28 ± 0.41 mm) than in females (3.10 ± 0.38 mm), the difference was not statistically significant ($p = 0.112$), indicating that rectal wall thickness remains relatively similar in both sexes (Table 12). Mark et al. (2021) [20] reported that males generally have greater colorectal dimensions than females because of differences in pelvic anatomy and body size, whereas rectal wall thickness shows minimal sex-related variation. The findings of the present study closely agree with their observations.

The present study showed that three Houston's valves were present in 74% of the specimens, making this the most common anatomical arrangement observed. Two valves were observed in 18% of the specimens, whereas one valve and four valves were found in only 2% and 6% of specimens, respectively, indicating that variations in the number of rectal folds are relatively uncommon (Table 13). Murai et al., (2023) [17] demonstrated that Houston's valves are constant anatomical landmarks and reported that the second Houston valve is closely related to the peritoneal reflection, making it useful during colorectal surgery. The predominance of three valves in the present study is consistent with their findings.

The present study demonstrated that 84% of the specimens exhibited normal rectal curvature, while 10% showed increased curvature and 6% showed reduced curvature, indicating that the normal anatomical curvature is the predominant pattern in adults (Table 14).

The normal rectal curvature enables the rectum to follow the contour of the sacrum and coccyx, thereby facilitating efficient storage and controlled evacuation of faecal material. Thomas et al, (2025) [18] described that the adult rectum normally exhibits sacral and perineal curvatures, with only minor anatomical variations among individuals. The findings of the present study are comparable with this description, as most specimens demonstrated normal rectal curvature.

The present study demonstrated a significant positive correlation between rectal length and rectal diameter at all measured levels, indicating that an increase in rectal length was associated with an increase in rectal diameter. The correlation was weakly positive between rectal length and upper rectal diameter ($r = 0.34$, $p = 0.019$), suggesting that longer rectums tend to have a slightly larger upper rectal diameter. A moderate positive correlation was observed between rectal length and middle rectal diameter ($r = 0.47$, $p = 0.002$), indicating that the middle rectum shows the strongest association with rectal length among the measured segments. Similarly, rectal length showed a significant positive correlation with lower rectal diameter ($r = 0.42$, $p = 0.006$), demonstrating that longer rectums generally possess a wider lower rectum (Table 15). (Mark et al., 2021) [20] reported that rectal dimensions increase proportionately, with longer rectums generally showing larger diameters, and highlighted that these morphometric relationships are important for colorectal surgical planning. The findings of the present study are in agreement with their observations, demonstrating a significant positive correlation between rectal length and rectal diameter.

The present study showed that a well-developed rectal ampulla was observed in 76% of the specimens, making it the most common anatomical pattern in the study population. A moderately developed ampulla was present in 18% of the specimens, whereas only 6% exhibited a poorly developed ampulla, indicating that developmental variations are relatively uncommon (Table 16). Mark et al. (2021) [20] observed that the distal rectum normally expands to form a well-developed ampulla and reported that anatomical variations in its size may occur because of age and sex. The predominance of a well-developed ampulla in the present study agrees with their findings.

The present study demonstrated that 86% of the specimens exhibited a normal peritoneal reflection, while 8% showed a high peritoneal reflection and 6% had a low peritoneal reflection, indicating that normal anatomy predominates with only minor variations (Table 17). Zhang et al., (2021) [19] reported that the level of the anterior peritoneal reflection shows individual anatomical variation and can be accurately identified using magnetic resonance imaging, making it an important landmark during rectal surgery. The predominance of normal peritoneal reflection observed in the present study is consistent with their findings.

The present study demonstrated a significant association between the number of Houston's valves and rectal curvature ($p = 0.041$), indicating that these anatomical features are related (Table 18). Among specimens with three or more Houston's valves, the majority (35 specimens) exhibited normal rectal curvature, whereas only 5 specimens showed abnormal curvature. Similarly, among specimens with two or fewer valves, 7 specimens had normal curvature and 3 specimens showed abnormal curvature, indicating that normal rectal curvature is more frequently associated with a greater number of Houston's valves. (Murai et al., 2023) [17] reported that Houston's valves are consistent anatomical landmarks closely related to rectal morphology and the peritoneal reflection, emphasizing their importance during colorectal surgery. The significant association observed in the present study further supports the anatomical relationship between rectal folds and rectal morphology.

Conclusion

The present study provides a detailed evaluation of the morphological and morphometric features of the adult human rectum. The findings showed that most specimens exhibited normal anatomical characteristics, with only a few variations observed. Significant differences were found in some morphometric parameters between males and females, and a positive relationship was observed between rectal length and rectal diameter. Overall, this study provides valuable baseline anatomical data that may be useful for anatomists, radiologists, and colorectal surgeons in improving anatomical knowledge, surgical planning, and the management of rectal diseases.

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