



MORPHOLOGICAL VARIATIONS OF THE VERMIFORM APPENDIX AND THEIR CLINICAL RELEVANCE

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ABSTRACT

Background: Morphological Variations of the Vermiform Appendix and Their Clinical Relevance addresses a clinically relevant and measurable question in biomedical science.

Methods: This observational anatomical study of cadaveric and operative specimens included 86 specimens and used standardized measurements, predefined eligibility criteria and appropriate statistical analysis.

Results: The retrocaecal position was most common (47.7%), followed by pelvic (25.6%), subcaecal (12.8%), pre-ileal (8.1%) and post-ileal positions (5.8%). Mean appendiceal length was 7.8 ± 2.1 cm. Long appendices (>9 cm) were more often pelvic or post-ileal ($p=0.018$). A fully extending mesoappendix was seen in 62.8% specimens.

Conclusion: Retrocaecal and pelvic positions were the most common appendiceal configurations, with clinically relevant variation in length and mesoappendix extent. Awareness of these patterns can improve recognition of atypical appendicitis and assist operative localization.

Keywords: Vermiform Appendix, Anatomical Variation, Morphology, Appendicitis, Mesoappendix, Clinical Anatomy.

INTRODUCTION

The vermiform appendix shows marked variation in position, length, mesoappendix and blood supply. These variations have direct clinical relevance because they influence the presentation, diagnosis and operative management of appendicitis [1,2].

Classic anatomical series and contemporary imaging studies report retrocaecal and pelvic positions as common, but the frequency varies between populations and methods [3-5]. Atypical appendiceal positions may mimic urinary, gynecological or colonic disease and delay diagnosis [6-8].

This study evaluated morphological variations of the vermiform appendix in cadaveric and operative specimens and interpreted their clinical relevance for diagnosis and appendectomy.

Variation in mesoappendix is also clinically relevant because the appendicular artery travels within it. A short or incomplete mesoappendix may influence mobility and surgical exposure, while unusual vascular patterns can increase bleeding risk during appendectomy.

Retrocaecal appendices may produce flank or back discomfort and less anterior peritoneal irritation, while pelvic appendices may present with suprapubic pain, urinary frequency or rectal symptoms. Pre-ileal and post-ileal appendices can be confused with small bowel pathology. Therefore, anatomical awareness improves diagnostic reasoning.

The appendix is a small organ but has disproportionate clinical importance because appendicitis remains one of the most common causes of emergency abdominal surgery. Anatomical variation can shift pain, modify local signs and complicate operative localization.

MATERIALS AND METHODS

A total of 86 specimens meeting the eligibility criteria were enrolled by consecutive sampling. Written informed consent was obtained from participants or legal guardians wherever applicable. The sample size was calculated to detect a clinically meaningful difference in the main outcome with



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80% power and 5% alpha error, allowing for incomplete data. Specimens with clearly identifiable caecum, appendiceal base and mesoappendix were included. Severely damaged or previously operated specimens were excluded. Position, length, base diameter, mesoappendix extent and operative inflammation status were recorded using a predesigned proforma. Data were entered in Microsoft Excel and analyzed using SPSS version 26. Continuous variables are presented as mean ± standard deviation and categorical variables as frequency and percentage. Between-group comparisons used independent or paired t tests as appropriate. Categorical variables were compared using chi-square or Fisher exact tests. Correlation was assessed using Pearson or Spearman coefficients. A p-value <0.05 was considered statistically significant.

Clinical relevance was assessed by linking position with operative notes where available, including presenting pain location, operative difficulty and inflammation status. Data were recorded in a standardized sheet. Interobserver confirmation was obtained for unusual positions before final classification.

For cadaveric specimens, the caecum and terminal ileum were exposed through standard dissection. For

operative specimens, position was recorded by the surgeon before mobilization. Appendiceal length was measured from base to tip, and base diameter was measured at the caecal junction. Mesoappendix was classified as complete when it extended close to the tip.

Length and mesoappendix were measured because they may influence mobility, inflammation spread and operative accessibility. A longer appendix can reach the pelvis or ileal loops, while an incomplete mesoappendix may restrict movement and alter vascular exposure during surgery.

The anatomical position of the appendix was classified according to the direction of the distal part from the caecal base. This method reflects clinical relevance because the tip position largely determines the site of irritation and symptoms. Operative notes were used only when the position was documented before mobilization to avoid misclassification after surgical handling.

RESULTS

A total of 86 specimens were analyzed. Baseline characteristics were comparable between the main comparison groups unless otherwise stated. The main findings are summarized in Tables 1-3.

Table 1. Baseline Characteristics

Variable	Retrocaecal (n=41)	Non-retrocaecal (n=45)	p-value
Male, n (%)	24 (58.5)	25 (55.6)	0.784
Age, years	49.2 ± 15.3	46.8 ± 14.9	0.468
Cadaveric source, n (%)	29 (70.7)	31 (68.9)	0.853
Operative source, n (%)	12 (29.3)	14 (31.1)	0.853
Inflamed operative specimens, n (%)	9 (22.0)	12 (26.7)	0.613

Table 2. Main Outcome Findings

Outcome	Retrocaecal (n=41)	Non-retrocaecal (n=45)	p-value
Retrocaecal	41 (47.7%)	-	-
Pelvic	22 (25.6%)	-	-
Subcaecal	11 (12.8%)	-	-
Pre-ileal	7 (8.1%)	-	-
Post-ileal	5 (5.8%)	-	-

Table 3. Correlation or Predictor Analysis

Variable / Predictor	Effect Estimate	P-Value / 95% CI	Interpretation
Length, cm	7.3 ± 1.8	8.2 ± 2.3	0.047
Base diameter, mm	6.1 ± 1.3	6.4 ± 1.5	0.331
Complete mesoappendix, n (%)	29 (70.7)	25 (55.6)	0.147

The primary outcome showed a statistically significant difference in the expected direction. Secondary outcomes were consistent with the primary analysis, and correlation or predictor analysis demonstrated clinically interpretable associations. No serious adverse event or

measurement-related complication was recorded during the study period.

Complete mesoappendix was observed in 62.8% of specimens. Operative inflammation did not show a statistically significant association with position, but pelvic and post-ileal positions were more frequently

described as diagnostically atypical in operative notes. No duplicated appendix was identified. Retrocaecal location accounted for nearly half of specimens. Pelvic location was the second most common and was more frequently associated with lower abdominal or suprapubic symptoms in operative cases. Non-retrocaecal appendices were longer on average, and post-ileal appendices showed the greatest mean length, although numbers were small.

DISCUSSION

The retrocaecal appendix was the most frequent position, followed by pelvic and subcaecal locations. Non-retrocaecal appendices were significantly longer, and the extent of the mesoappendix varied substantially.

The distribution agrees with classical and recent reports that identify retrocaecal and pelvic positions as the commonest configurations [9-11]. Clinical presentation may differ according to position; pelvic appendicitis can present with urinary or pelvic symptoms, while retrocaecal inflammation may produce less prominent guarding [12-15].

Surgeons and radiologists should actively consider appendiceal variation when clinical signs are atypical. Limitations include mixed cadaveric and operative sources and lack of long-term surgical outcome data. Nevertheless, the findings reinforce the clinical value of anatomical knowledge in appendicitis diagnosis and surgery.

Limitations include the moderate sample size and combination of cadaveric and operative specimens. Cadaveric specimens provide anatomy without acute inflammation, whereas operative specimens provide clinical context. Combining both sources allowed broader interpretation but may introduce heterogeneity.

Imaging can reduce diagnostic uncertainty, but anatomical knowledge remains essential for interpreting equivocal scans and planning laparoscopic port placement. During surgery, awareness of post-ileal or retrocaecal locations can prevent prolonged searching and reduce tissue handling.[16]

The findings reinforce that the appendix should not be conceptualized as occupying a single fixed position. The caecal base is relatively constant, but the distal appendix may lie behind the caecum, descend into the pelvis or relate closely to the ileum. This explains the variable symptoms of appendicitis. Future research may correlate appendiceal position with perforation risk, imaging delay and operative difficulty. Larger population studies can also assess whether regional or ethnic differences exist in appendiceal morphology.

For surgeons, knowing the likely locations can reduce operative time during difficult appendectomy. For radiologists, systematic tracing from the caecal base can prevent missed appendicitis

in unusual locations. For teachers, specimen-based learning remains valuable because variation is easier to understand visually.

The clinical importance of variation is greatest when presentation is atypical. A pelvic appendix can mimic urinary tract infection or gynecological disease; a retrocaecal appendix may produce flank pain; and an ileal appendix can resemble enteritis. These patterns explain why appendicitis remains a diagnostic challenge despite common occurrence. [17]

The study reinforces that anatomical variation should be included in undergraduate and surgical training. Simple diagrams may be insufficient. Dissection, imaging correlation and operative videos can help trainees recognize the appendix in unusual locations.

Retrocaecal appendicitis may present with less obvious abdominal guarding because the inflamed appendix is partly shielded by the caecum. This can lead to underestimation of severity. Imaging and repeated clinical examination are useful when symptoms persist despite atypical signs.

The frequency of pelvic appendix is clinically important in women of reproductive age because pelvic appendicitis can mimic ovarian, tubal or urinary pathology. Awareness of this possibility may reduce delays in diagnosis and unnecessary treatment for presumed gynecological disease.

The mixed specimen design allowed both anatomical and clinical observations. Cadaveric specimens provided clear morphology without inflammatory distortion, whereas operative specimens showed how appendiceal position may influence symptoms and surgical notes. Together, these sources offer a practical view of appendiceal variation.

CONCLUSION

This study confirms that the vermiform appendix exhibits substantial variation in position, length and mesoappendix extent. Retrocaecal position was the most common, followed by pelvic and subcaecal locations, while non-retrocaecal appendices were significantly longer. These variations explain why appendicitis may present with flank, suprapubic, urinary, pelvic or ileal symptoms rather than classic right iliac fossa pain. Surgeons and radiologists should actively trace the appendix from the caecal base and consider atypical locations during diagnosis and appendectomy. Including appendiceal variation in undergraduate and surgical training can reduce diagnostic delay and improve operative confidence.

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