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Original Article

Variations in the Anatomical Location of the Appendix in Plastinated Cadaver Specimens

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Abstract

Background: Anatomical diversity in the location of the vermiform appendix is a major obstacle to diagnosis and surgery in the treatment of acute appendicitis. Plastinated specimens provide a non-toxic, long-lasting, and dimensionally stable alternative to standard anatomical investigations that depend on fresh or formalin-preserved cadavers. The purpose of this research is to examine the differences in vermiform appendix location among plastinated human cadaveric specimens obtained from Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences, College of Medicine, Department of Anatomy. **Methods:** This observational cross-sectional study was carried out during a 12-month period at the Department of Anatomy, College of Medicine, Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences. The study included the examination of twenty-eight adult plastinated cadaveric specimens. After determining its relationship to the cecum and ileum, the vermiform appendix was classified using classical anatomy's accepted nomenclature: retrocecal, pelvic, pre-ileal, post-ileal, and paracecal. **Results:** Of the 28 plastinated specimens that were examined, 39.29% (n = 11) were found in the retrocecal position, whereas 28.57% (n = 8) were found in the pelvic position. Specimens positioned post-ileally accounted for 10.71% (n = 3), while specimens positioned pre-ileally accounted for 17.86% (n = 5). With just one specimen showing this variation (3.57%, n = 1), paracecal variation was the least prevalent. **Conclusion:** The results show that the majority of the vermiform appendixes in the study group are located in the retrocecal and pelvic regions. Plastinated specimens have excellent structural fidelity, which allows one to accurately record anatomy. Understanding these regional demographic differences is important to optimize surgical techniques in general surgery and emergency care in Iraq, reduce diagnostic delays, and improve imaging accuracy.

Keywords: Vermiform appendix, plastination, human cadaver, retrocecal appendix, Iraqi population.

1. Introduction

The vermiform appendix is a slender, tubular, blind-ending structure that arises from the posteromedial wall of the cecum approximately 2 centimeters below the ileocecal junction. Although it is consistently shaped at the base where the three teniae coli meet, there is a lot of anatomical variation in the location of its apex and body among various human populations [1]. Acute appendicitis is one of the most prevalent surgical emergencies globally, and its clinical presentation is greatly affected by the appendix's varied spatial arrangement [2].

Appendiceal perforation is more common, delayed diagnosis is common, and unusual localized

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tenderness is common as a result of positional anomalies [3]. Examples of such anomalies include retrocecal appendicitis causing lumbar pain and pelvic appendicitis causing pelvic pain that mimics gynecological pathology. Ultrasonographic assessment, laparoscopic procedures, open appendectomies, and correct clinical diagnosis rely on precise understanding of regional anatomical variances.

The use of formalin-embalmed cadavers has long been standard in traditional anatomy research. The distortion of spatial connections inside the peritoneal cavity may occur as a result of the stiffness of muscles and joints as well as the shrinking of tissues caused by formalin preservation. Gunther von Hagens pioneered the preservation technique known as plastination in the late 1970s. It involves substituting curable polymers like silicone, epoxy, or polyester resins for tissue fluids and lipophilic components [4, 5]. Plastinated specimens are perfect for accurate topographic measurements and instructive displays since they do not shrink and maintain their three-dimensional shape.

Quantitative data concentrating particularly on plastinated human models in the Middle Eastern and Iraqi populations is scarce, despite the vast documentation of appendix anatomical variants worldwide. Thus, the purpose of this 12-month research was to compare 28 high-fidelity plastinated human cadaveric specimens from various Iraqi medical institutions in order to determine if there were any differences in the anatomical position of the vermiform appendix.

2. Materials and Methods

2.1: Study Design and Ethical Approval

A descriptive, observational cross-sectional approach was used in this 12-month (2025-2026) investigation. The College of Medicine's Institutional Ethics Committee of Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences in Najaf, Iraq, examined and approved the procedure. All procedures involving the use of human cadavers in medical teaching and research were carried out in full compliance with national ethical standards.

2.2: Selection of Specimens and Number of Samples

The sample size was 28 adult human abdomen plastinated specimens. These specimens were carefully preserved and kept in the anatomical archives of Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences, College of Medicine, Department of Anatomy.

2.3: Procedure of Plastination

Typical S10 silicone cold-plastination procedures were used to prepare the specimens for this investigation: **Fixation is t**he first step is to solidify the protein structures by employing a 10% formalin solution for deep fixing.
The second step in dehydration is to gradually replenish the water content of the tissues by immersing them in cold acetone baths (-20 °C to -25 °C). The third step, forced impregnation, involves submerging the sample in a vacuum-protected combination of silicone and polymer (Biodur S10/S3) in lieu of acetone.
The fourth step, gas curing, involves exposing the silicone resin to a curing agent (Biodur S6) in order to polymerize it. This process produces anatomically accurate specimens that are long-lasting, dry, and odorless.

2.4 Anatomical Evaluation and Classification

Under typical laboratory circumstances, each specimen was set on a lit inspection table. The right iliac fossa may be seen clearly after mobilizing or resecting the larger omentum and anterior abdominal wall. The meeting point of the three teniae coli on the cecum was used to identify the base of the appendix.
Based on Wakefield's traditional anatomical criteria, five distinct variants were identified in the orientation of the appendix's free tip:

1. Retrocecal: Located in the retrocecal fossa, behind the cecum or lower ascending colon.
2. Pelvic: Aimed downwards into the actual pelvis, passing over the pelvic brim.
3. Pre-ileal: Protruding behind the terminal ileum and to the front and upper sides.
4. Post-ileal: Protruding medially and superiorly from the posterior ileum.
5. Paracecal: Located in the paracolic gutter, laterally to the cecum.

To guarantee inter-observer reliability and remove observational bias, data were independently validated by two expert anatomists.

2.5 Statistical Analysis

We used IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA) to code, compile, and analyze the collected data. The frequency distribution of each appendix location was expressed using descriptive statistics, which included absolute numbers (n) and relative percentages (%).

3. Results

The five classical anatomical variants of the vermiform appendix were present in all 28 plastinated adult human specimens studied (N = 28).

The most common spatial arrangement, the retrocecal position (as is shown in Figure 1), was identified in eleven specimens (39.59%). Pelvic position was the second most common pattern (as is shown in Figure 2), observed in 8 specimens (28.57%).

The secondary group of positions in relation to the terminal ileum included five specimens (17.86%) in a pre-ileal position and three specimens (10.71%) in a post-ileal position (as is shown in Figure 3). The paracecal orientation represented the least common pattern, with only 1 specimen (3.57%) (as is shown in Figure 4).

The distribution and calculated percentages and counts are shown in Table 1.

Table 1: Distribution of appendiceal locations in plastinated specimens, N=28. Frequency and percentage

Anatomical Position	Number of Specimens (n)	Percentage (%)
Retrocecal	11	39.29%
Pelvic	8	28.57%
Pre-ileal	5	17.86%
Post-ileal	3	10.71%
Paracecal	1	3.57%
Total	**28**	**100.00%**

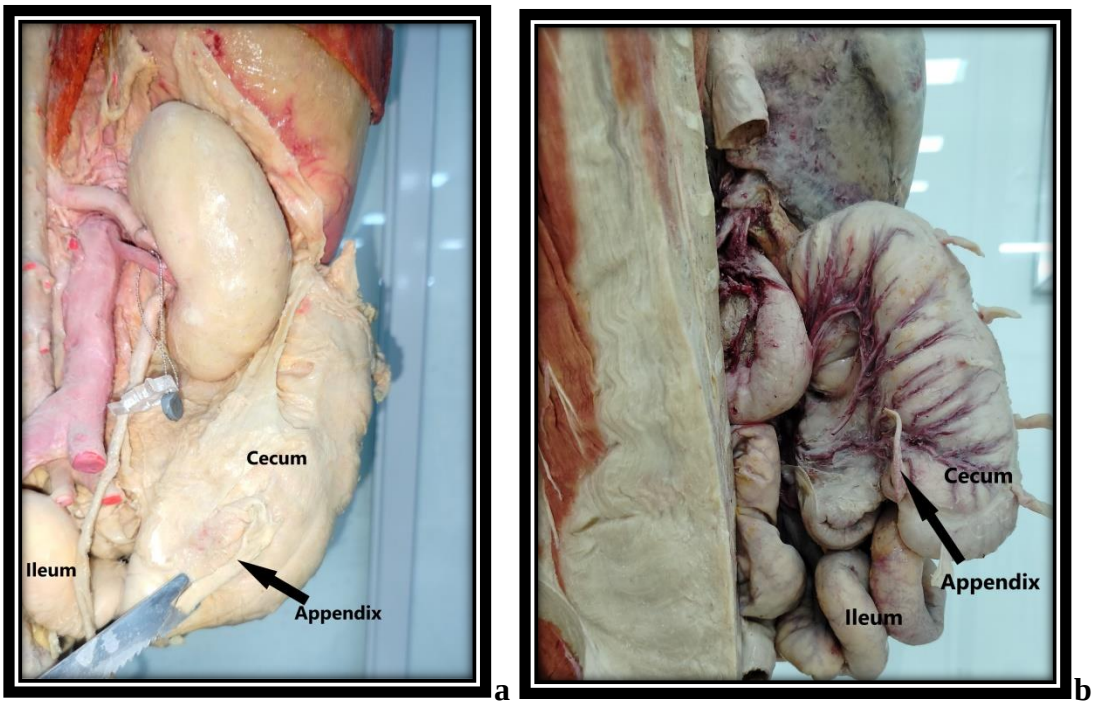


Fig. 1 (a & b): Showing posterior view of the abdominal viscera with the appendix situated retrocecally.

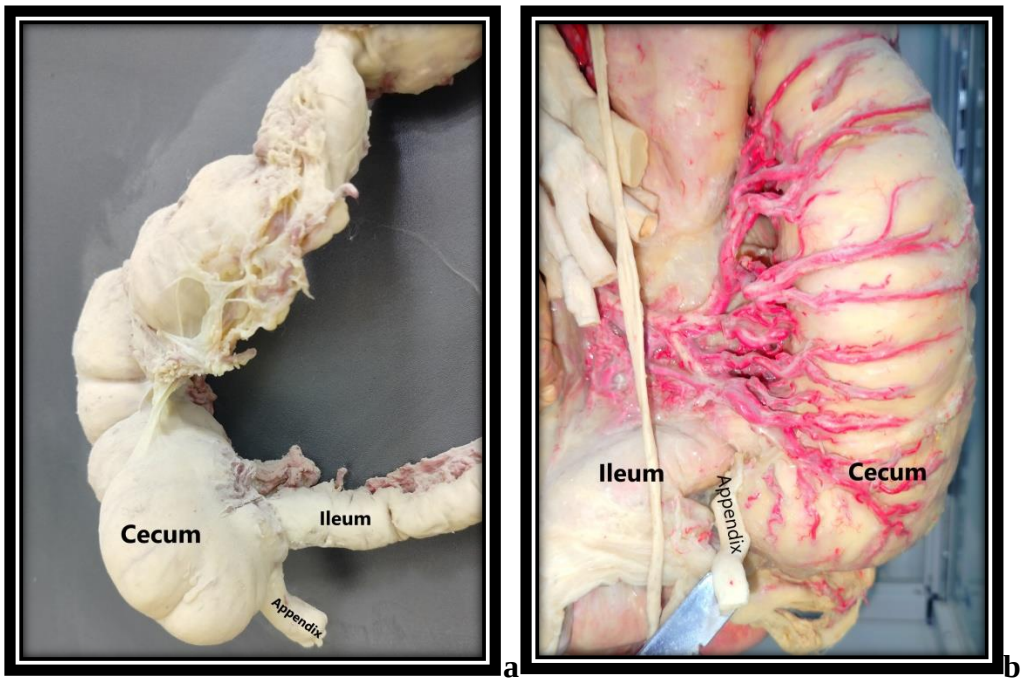


Fig. 2 (a & b): Showing abdominal viscera with the appendix directed toward the pelvis (pelvic appendix).

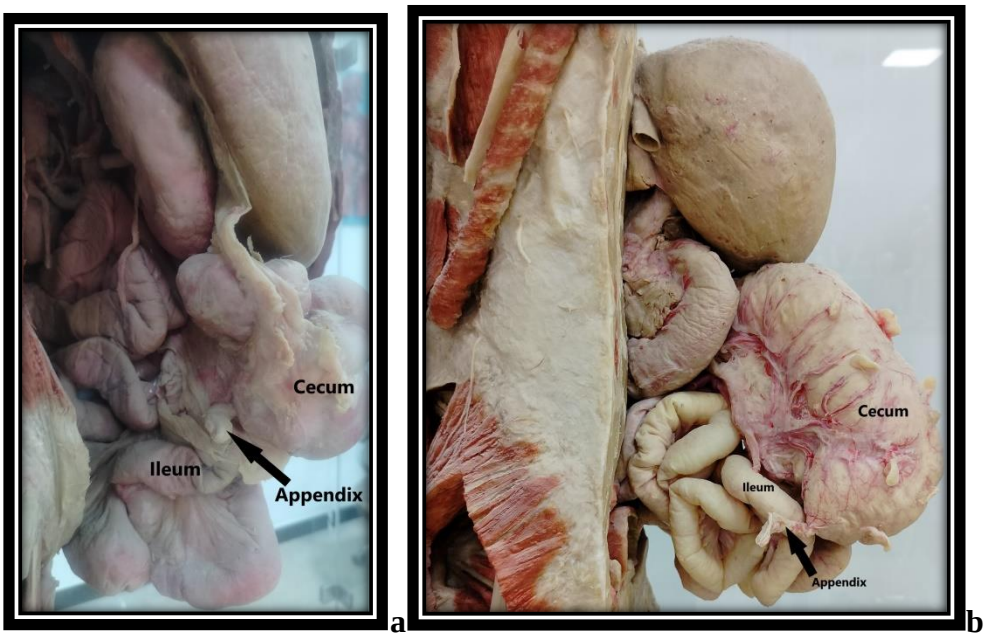


Fig. 3 (a & b): Showing abdominal viscera (posterior view) with the appendix situated behind the ileum (postileal appendix).

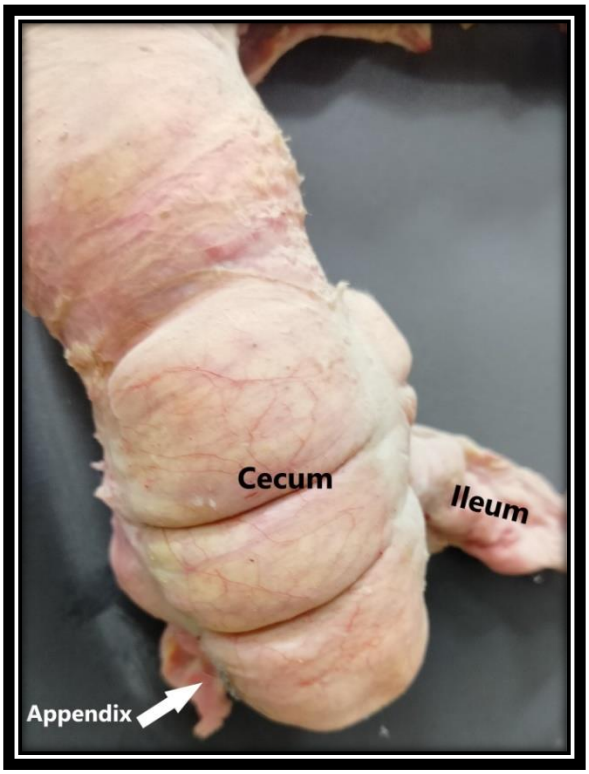


Fig. 4: Showing abdominal viscera (anterior view) with the appendix situated alongside the cecum (paracecal appendix).

4. Discussion

Various variables, including genetics, mechanical forces, and developmental stages such as intestinal rotation and cecal descent, impact the physical location of the vermiform appendix during embryogenesis, which causes a significant amount of variance across human groups [6]. When it comes to clinical settings, decreasing diagnostic uncertainty requires an understanding of regional baseline variances.

The majority of participants in this research were found to be in the pelvic position (28.57 percent), with the retrocecal position coming in second with 39.29 percent. These findings are in agreement with worldwide traditional series, such as the ones by Wakely [7], who renownedly studied 10,000 cases and found a pelvic prevalence of 31.01% and a retrocecal prevalence of 65.28%. The most common configurations, according to recent anatomical studies in nearby areas, are retrocecal and pelvic variants; nevertheless, the relative frequency of these configurations varies [8, 9].

A retrocecal appendix can hide classical McBurney's point tenderness, according to comparative clinical studies. This can cause unusual symptoms like flank or low back pain from irritated psoas major muscle (Psoas sign) or microscopic hematuria from irritation of the ureter [10]. When the obturator internus muscle or other pelvic organs are irritated, symptoms such as tenesmus, diarrhea, or suprapubic discomfort may be experienced [11]. In order to quickly identify the appendix by tracing the taeniae coli to their base, general surgeons in Iraq must be able to recognize these arrangements during both open and laparoscopic appendectomies.

Instead of using typical wet formalin cadavers, this research makes use of plastinated specimens, which is an essential strength. The appendix may be intentionally displaced relative to the ileocecal junction due to the significant abdominal stiffness, mesenteric deformation, and tissue shrinking that are common side effects of formalin preservation. As an alternative, silicone plastination allows for consistent spatial evaluation by immobilizing the abdominal viscera in their correct anatomical connections [5]. In addition, plastination protects delicate anatomical structures from being inadvertently moved during surgical procedures by preserving the mesoappendix and peritoneal folds.

Limitations

Due to the high technical expense, complicated infrastructure requirements, and labor-intensive nature of comprehensive specimen plastination in developing academic contexts, the relatively small sample size (N = 28) is the principal drawback of this work. Coupling cadaveric observations with prospective imaging studies (such as multidetector CT scans) and evaluating any gender-specific variances should be the goals of future research. This may be achieved by establishing bigger, multi-center registries throughout more Iraqi governorates.

5. Conclusion

This research establishes a solid anatomical foundation for future research on the positional variations of the vermiform appendix by using high-fidelity plastinated specimens from medical schools in Iraq. The most frequent position is the retrocecal configuration, which accounts for 39.29% of all positions. The second most common is the pelvic position, which accounts for 28.57 % of positions. The remaining percentage is made up of varieties such as pre-ileal, post-ileal, and paracecal. When studying the human body's structure, plastinated specimens are the way to go since they are accurate and reliable models. The findings of this study emphasize the need for diagnostic imaging specialists and physicians to be watchful for unusual locations of the appendix in their assessment of severe abdominal pain.

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- **The Ethics Committee** of Jabir Ibn Hayyan University for Medical & Pharmaceutical Sciences, College of Medicine gave its stamp of approval.
- **Conflict of Interest:** NIL

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