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Original Article

# MORPHOLOGICAL FEATURES AND MORPHOMETRIC PARAMETERS OF HUMAN FETAL VERMIFORM APPENDIX AT DIFFERENT GESTATIONAL AGES

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## ABSTRACT

**Background:** Vermiform appendix is a vestigial organ of variable position in the abdomen. Its location, size and shape are subject to alterations with the race of the population and limited information is available on developmental morphology and morphometry of fetal appendix. **Materials and Methods:** In the present study 60 appendix specimens from aborted human fetuses of 17-40 weeks gestational age and both sexes were studied by dissection method for age related morphological features and morphometric parameters. The morphological parameters observed include its location in relation to abdominal region, caecum and ileum, clock position, position of base in relation to caecal wall and direction of tip of appendix. The morphometric parameters of length, diameter and distance between ileo-caecal orifice and appendicular orifice were measured. **Results:** The location of appendix in relation to abdominal region presented higher incidence of sub-hepatic position in less than 30 weeks fetuses and right iliac fossa location in more than 30 weeks fetuses. **Discussion**: in comparision with the literature available on adult vermiform appendix the observations in the present study are in favor of influence of developmental processes on the localization of appendix including its base, ileo-caecal orifice, direction of tip, distance from McBurney's point. **Conclusion:** Results of this work suggests variability in localization of appendix during prenatal development and the influence of gestational age, sex, size, growth of caecum and gut on its final position and was different from that of adults. There is increase in the morphometric parameters of appendix with increase in gestational age. Both morphological and morphometric parameters were different between sexes.

**KEY WORDS:** VESTIGIAL; VERMIFORM APPENDIX; MCBURNEY'S POINT; GESTATIONAL AGE; MORPHOLOGY; MORPHOMETRY.

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## INTRODUCTION

Vermiform appendix is a blind ended tube originating from posteromedial wall of caecum. It is absent in fish, amphibians, reptiles, birds and most mammals. It is found in few marsupials and few rodents. Among primates it is present in anthropoid apes and man. In man appendix develops through evolution from the old world monkeys [1]. It was stated that the function of appendix is similar to that of a lymph node.

Its location, size and shape are highly diverse. It is normally located in the right lower quadrant of the abdomen (right iliac fossa) nearer to the right hip bone in the adult. Its position in the abdomen corresponds to a point on the surface of the anterior abdominal wall known as Mc Burney's point. The position of base of appendix is constant lying 2.0cms below ileo-caecal valve.

During embryonic development its position in the abdomen is not constant. It is found at different locations in the abdominal cavity depending upon stage of development and rotation of gut [2, 3, and 4]

Vermiform appendix has greater clinical significance as it is involved in different disease process such as appendicitis, carcinoma and diverticulitis. Inflammation of appendix is the most common cause of emergency laparotomy. But appendicitis is rare in children below 2 years of age due to its anatomical characteristics and its relation with caecum [5].

With the recent understanding of immunological importance of appendix removal of appendix as a precautionary method to prevent future possibility of appendicitis is stopped during other surgical procedures in the abdomen [2]. Its mucosa was found to be a substitute in repair of ruptured urethra (urethroplasty), because of its size, cylindrical structure and easy resection. It can also be successfully transplanted in to the urinary tract to rebuild sphincter muscle and to reconstruct functional urinary bladder [6].

A review of literature did not indicate unanimity in the anatomical changes during development of caecum-appendicular region for the ultimate appearance of vermiform appendix as is observed in the adults [7, 8].

The present study on developmental morphology and morphometry of the vermiform appendix in human fetuses of both sexes and different gestational ages was conducted as no literature was available on these aspects in Indian population.

## MATERIALS AND METHODS

A total of 60 formalin preserved dead fetuses of 17 weeks to full term obtained from Government Maternity Hospital, Tirupati with relevant obstetric records available in the Department of anatomy, SV Medical College, Tirupati, Andhra Pradesh, India were utilized for the present study. The fetuses were categorized in to three gestational age groups – less than 20 week, 21-30 weeks and more than 31 weeks.

By opening the abdominal cavity the appendix was identified and the following morphological parameters were observed in - situ.

1. Location of appendix in relation to abdominal regions.
2. Position of base of appendix in relation to wall of caecum.
3. Position of the appendicular orifice in relation to Mc Burney's point.
4. Direction of tip of appendix.
5. Clock position of tip of appendix.
6. Position of appendix in relation to caecum and ileum.

The following morphometric parameters were recorded with the help of a measuring scale.

1. Distance between ileo-caecal orifice and appendicular orifice.
2. Length of appendix: As a linear measurement from its tip to its point of origin from the caecum (base).
3. Diameter of the appendix: The transverse diameter was measured at three levels. One at its base, second one at the middle and the third towards the tip.

## RESULTS

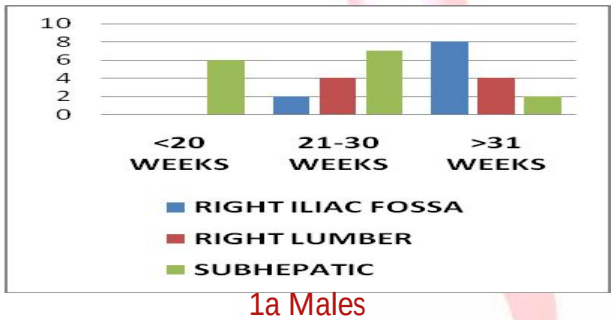
A total of 33 male and 27 female fetuses were observed in the present study. An equal incidence (40%) of sub hepatic (Fig.1) and right iliac (Fig.2) and a lower incidence of right lumbar location (20%, Fig.3) were observed in the present study. Table.1 shows higher incidence of sub-hepatic position in less than 30 weeks and a higher incidence of right iliac fossa location in more than 30 weeks and an equal incidence of

right lumbar location between these groups incidence Graph.1 indicates higher incidence of sub hepatic position in males, right iliac fossa in females and equal in right lumbar between sexes.

**Fig.1: Sub-hepatic and 2'o clock position.**

**Table.1 Gestational age (GA) and sex wise distribution of location of Appendix.**

| GESTATIONAL AGE | | RIGHT ILIAC FOSSA | RIGHT LUMBER | SUBHEPATIC | TOTAL |
|---|---|---|---|---|---|
| <20 WEEKS | MALE | - | - | 6 | 6 |
| | FEMALE | - | 2 | 2 | 4 |
| 21-30 WEEKS | MALE | 2 | 4 | 7 | 13 |
| | FEMALE | 8 | 2 | 5 | 15 |
| >31 WEEKS | MALE | 8 | 4 | 2 | 14 |
| | FEMALE | 6 | - | 2 | 8 |
| TOTAL | | 24 | 12 | 24 | **60** |




1a Males

Percentage incidence of location of base of appendix in relation to the wall of caecum in the present study as shown in Table.2 indicates a higher percentage for posterior wall (58%) followed by lower Pole (29%), anterior Wall (7%) and lateral and medial walls (3% each). Chart.2 represents higher incidence of posterior wall location in males, anterior wall in females with an equal incidence for lower pole in both sexes. Medial and lateral wall location of base was observed in male fetuses only.

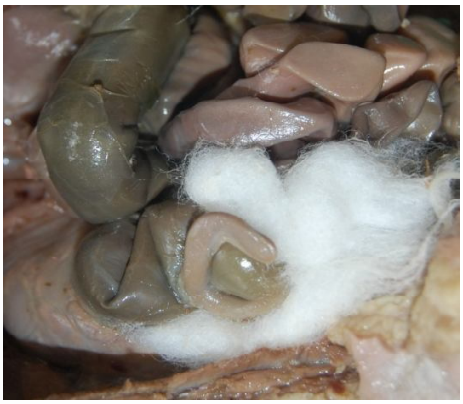
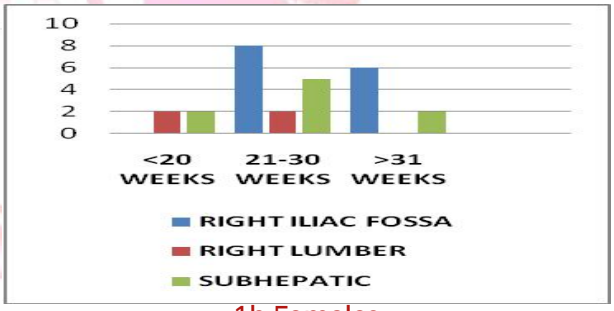


**Fig.2: Right iliac fossa and 6'o clock position.**

**Fig.3 - Right lumbar and appendicular orifice in relation to McBurney's point.**

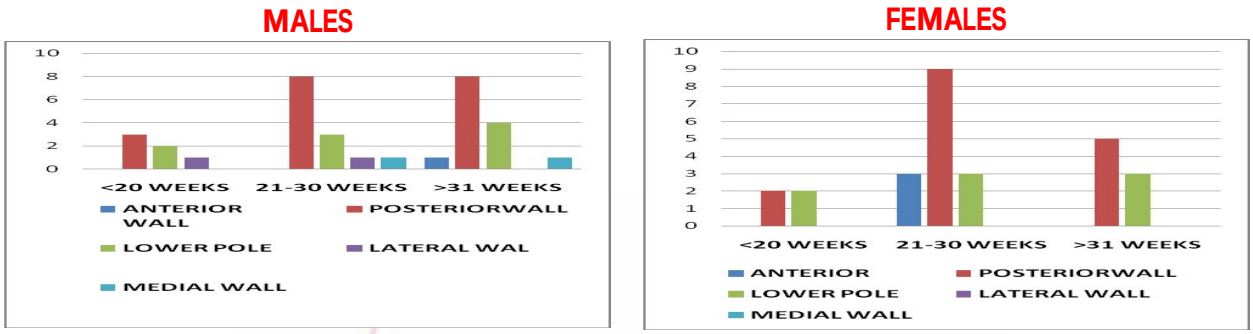



1b Females

**Graph.1a & b. Location of Appendix in male and female fetuses of different GA groups**

**Table.2 Gestational age (GA) and sex wise position of base of appendix**

| GESTATIONAL AGE | | ANTERIOR WALL | POSTERIORWALL | LOWER POLE | LATERAL WALL | MEDIAL WALL | TOTAL |
|---|---|---|---|---|---|---|---|
| <20 WEEKS | MALE | - | 3 | 2 | 1 | - | 6 |
| | FEMALE | - | 2 | 2 | - | - | 4 |
| 21-30 WEEKS | MALE | - | 8 | 3 | 1 | 1 | 13 |
| | FEMALE | 3 | 9 | 3 | - | - | 15 |
| >31 WEEKS | MALE | 1 | 8 | 4 | - | 1 | 14 |
| | FEMALE | - | 5 | 3 | - | - | 8 |
| TOTAL | | **4** | **35** | **17** | **2** | **2** | **60** |



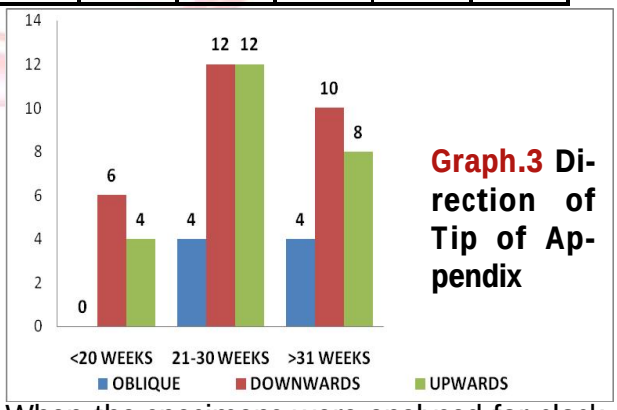

**Graph.2 Position of base of appendix in relation to caecum in GA groups and sexes**

Percentage incidence of position of appendicular orifice (Table.3) at Mc Burney's point (24%) is > a position of 1.0cms Medial (17%) > 1.5cms medial (15%) > 2.0cms medial (13%) > 1.5cms lateral (10%) > 2.0cms lateral (8%) > 0.5cms medial (7%) > 1.0cms lateral (5%) > 0.5cms lateral (1%) to Mc Burney's point. The position of 0.5cms medial and lateral to Mc Burney's point presented equal incidence in male foetuses. The percentage incidence of a position medial to Mc Burney's is nearly two times higher than that of a position lateral to it. The incidence of appendicular orifice at Mc Burney's point (Fig.3) presented higher incidence in female fetuses when compared to male fetuses.

**Table.3.Position of Appendicular Orifice in relation to Burney's Point**

| GESTATIONAL AGE | | 0.5CM LATERAL | 0.5CM MEDIAL | 1CM LATERAL | 1CM MEDIAL | 1.5CM LATERAL | 1.5CM MEDIAL | 2CM LATERAL | 2CM MEDIAL | CORRES PONDE | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| <20 WEEKS | M | - | - | - | 2 | - | 3 | 1 | - | - | 6 |
| | F | - | 2 | - | - | - | 1 | 1 | - | - | 4 |
| 21-30 WEEKS | M | - | 1 | 2 | 2 | 3 | - | 2 | 3 | - | 13 |
| | F | 1 | - | - | 3 | 2 | 2 | - | 2 | 5 | 15 |
| >31 WEEKS | M | - | 1 | 1 | 3 | 1 | 2 | 1 | 1 | 4 | 14 |
| | F | - | - | - | - | - | 1 | - | 2 | 5 | 8 |
| **TOTAL** | | **1** | **4** | **3** | **10** | **6** | **9** | **5** | **8** | **14** | **60** |

Incidence of downward direction of tip of appendix (Table.4, Graph3) is greater (47%) than upward direction (40%) and oblique direction (13%). Downward direction is slightly higher in male fetuses of more than 20 weeks gestation when compared to female fetuses. The incidence of oblique direction is equal between sexes.




**Graph.3 Direction of Tip of Appendix**

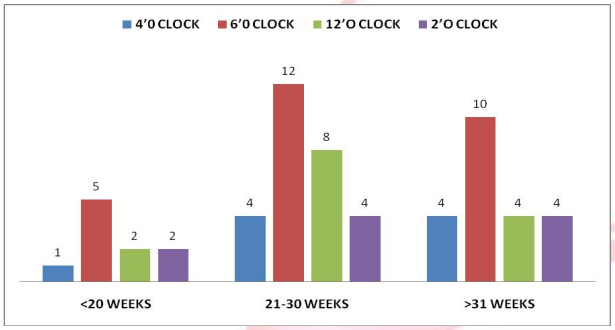
**Table.4 Gestational Age and Sex Wise Direction of Tip of Appendix**

| GESTATIONAL AGE | | OBLIQUE | DOWNWARDS | UPWARDS | TOTAL |
|---|---|---|---|---|---|
| <20 WEEKS | MALE | - | 3 | 3 | 6 |
| | FEMALE | - | 3 | 1 | 4 |
| 21-30 WEEKS | MALE | 2 | 7 | 4 | 13 |
| | FEMALE | 2 | 5 | 8 | 15 |
| >31 WEEKS | MALE | 2 | 6 | 6 | 14 |
| | FEMALE | 2 | 4 | 2 | 8 |
| **TOTAL** | | **8** | **28** | **24** | **60** |

When the specimens were analysed for clockwise position of appendix (Table.5) the incidence of 6'0 clock position is higher (45%, Fig.2). This is followed by 12'0 clock (24%, Fig.4), 2'0 clock (16%, Fig.1) and 4'0 clock positions (15%Fig.5). The incidence of 4'o clock position is more in female fetuses (55%), when compared to male fetuses (45%). Percentage incidence of 6'0 clock position is more in male fetuses (60%), when compared to female fetuses (40%). 12'0 clock percentage is equal in two sexes. 2'0 clock position percentage is more in male fetuses (60%), when compared to female fetuses (40%).

**Table.5 Gestational Age and Sex Wise Clock Position of Appendix.**

| GESTATIONAL AGE | | 4'O CLOCK | 6'O CLOCK | 12'O CLOCK | 2'O CLOCK | TOTAL |
|---|---|---|---|---|---|---|
| <20 WEEKS | MALE | 0 | 3 | 2 | 1 | 6 |
| | FEMALE | 1 | 2 | 0 | 1 | 4 |
| 21-30 WEEKS | MALE | 2 | 7 | 2 | 2 | 13 |
| | FEMALE | 2 | 5 | 6 | 2 | 15 |
| >31 WEEKS | MALE | 2 | 6 | 3 | 3 | 14 |
| | FEMALE | 2 | 4 | 1 | 1 | 8 |
| TOTAL | | 9 | 27 | 14 | 10 | 60 |




**Graph.4 Clock Position of Appendix.**

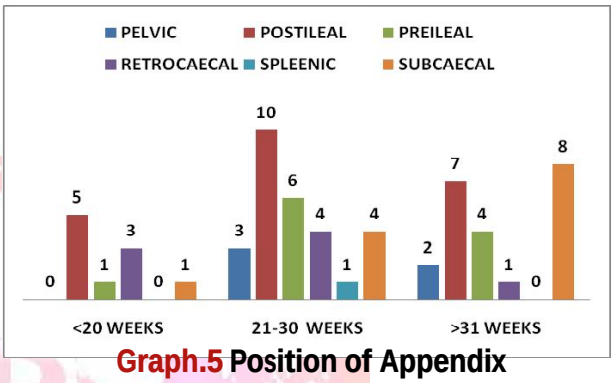
**Fig.4. 12'o clock position**

**Fig.5. 4'o clock position.**

Percentage incidence of position of appendix with reference to ileum and caecum (Table.6, Graph.4) observed in the present study are post-ileal (37%), sub-caecal (22%), pre-ileal (18%), retrocaecal (13%), Pelvic (8%) and spleenic (2%). The percentage incidence of post –ileal was higher in less than 30 weeks especially in females. Only one case of splenic was observed in a female fetus.

**Table.6 Gestational Age and Sex Wise Position Of Appendix**

| GESTATIONAL AGE | | PELVIC | POSTILEAL | PREILEAL | RETROCAECAL | SPLEENIC | SUBCAECAL | TOTAL |
|---|---|---|---|---|---|---|---|---|
| <20 WEEKS | M | - | 2 | - | 3 | - | 1 | 6 |
| | F | - | 3 | 1 | - | - | - | 4 |
| 21-30 WEEKS | M | 1 | 4 | 3 | 3 | - | 2 | 13 |
| | F | 2 | 6 | 3 | 1 | 1 | 2 | 15 |
| >31 WEEKS | M | - | 5 | 2 | 1 | - | 6 | 14 |
| | F | 2 | 2 | 2 | - | - | 2 | 8 |
| TOTAL | | 5 | 22 | 11 | 8 | 1 | 13 | 60 |




**Graph.5 Position of Appendix**

The distance between the ostium of appendix and the ileo-caecal junction is in the range of 16-40 mms with average distance of 24.2mm.When analysed gestational age group-wise it presented an increase with increase in gestational age (Table.7) with a higher value for males when compared to females

| GESTATIONAL AGE | MALE | FEMALE |
|---|---|---|
| <20 WEEKS | 3.8(6) | 3.5(4) |
| 21-30 WEEKS | 8.4(13) | 8.2(15) |
| >31 WEEKS | 9.7(14) | 9.5(8) |

**Table.7 Distances between Ileo-Caecal Orifice & Appendicular Orifice (Cms)**

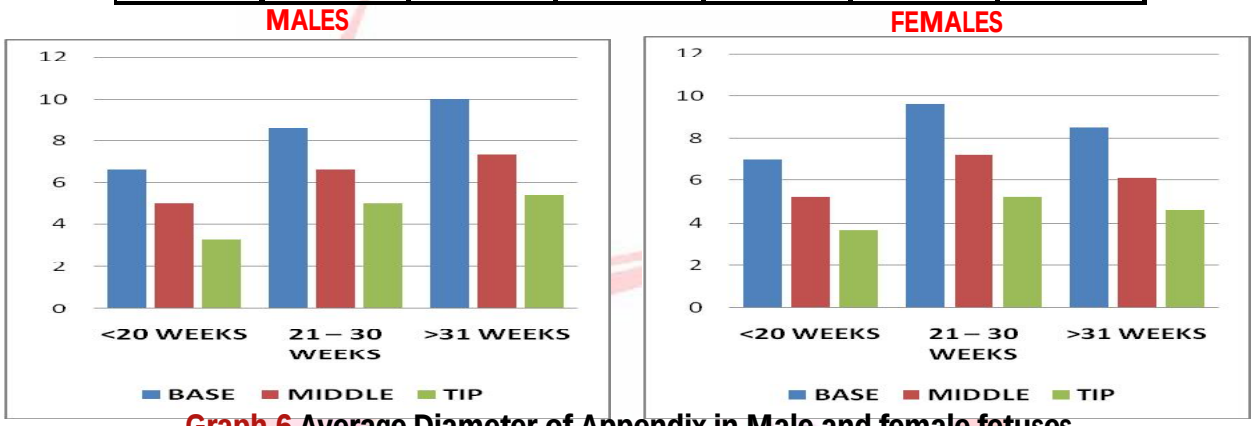
The length of appendix increased with increase in gestational age with a wider range in males when compared to females (Table.8).

**Table.8 Gestational age and sex wise average length of appendix (cms)**

| GESTATIONAL AGE | MALE | FEMALE |
|---|---|---|
| <20 WEEKS | 1.5(6) | 1.9 (4) |
| 21-30 WEEKS | 2.5(13) | 2.2(15) |
| >31 WEEKS | 3.4(14) | 2.2(8) |

**Table.9 Gestational Age and Sex Wise Average Diameter of Appendix**

| GESTATIONAL AGE | MALE AVERAGE | | | FEMALE AVERAGE | | |
|---|---|---|---|---|---|---|
| | BASE | MIDDLE | TIP | BASE | MIDDLE | TIP |
| <20 WEEKS | 6.6 (6) | 5.0 (6) | 3.3 (6) | 7.0 (4) | 5.2 (4) | 3.7 (4) |
| 21 – 30 WEEKS | 8.6 (13) | 6.6 (13) | 5.0 (13) | 9.6 (15) | 7.2 (15) | 5.2 (15) |
| >31 WEEKS | 10.0 (14) | 7.3 (14) | 5.4 (14) | 8.5 (8) | 6.1 (8) | 4.6 (8) |




**Graph.6 Average Diameter of Appendix in Male and female fetuses**

In the present study increase in the diameter of appendix in female fetuses, when compared to male fetuses (Table.9, Graph.6) was observed up to 30 weeks gestational age and later it is less than in male fetuses. The minimum diameters at base, middle and tip (6.0 mm, 3.0 mm, and 2.0 mm) are higher in females when compared to males (4.0 mm, 3.0 mm, 1.0 mm). The maximum diameter of appendix at base, middle and tip in males(20.0 mm,15.0 mm,10.0 mm) is higher than that of females (15.0 mm,10.0 mm,8.0 mm) respectively.

## DISCUSSION

Origin and position of appendix are subject to alterations with the race of the population [9, 10, 11, 12, 13, 14, 15, and 16]. Limited information is available on this aspect of appendicular anatomy in the population of Indian subcontinent [17]. In the literature detailed report on various morphological and morphometric parameters of human fetal appendix was not available for comparison except that of Malas et.al. [18, 19] on Turkish population.

Developmentally human vermiform appendix is both a complex and organized structure. It is the continuation of caecum and undergoes a very early and rapid developmental process. The vermiform appendix occupies different positions in relation to quadrants of abdomen and in relation to caecum and ileum during development. Development of the appendix indicates that viscera are subject to positional variations. Its location varies widely since it depends on herniation of mid-gut loop through umbilical ring, its re-entry in to the abdomen, differential growth of mid-gut and elongation of proximal part of hindgut.

During various stages of intra-abdominal migration after re-entry it moves from left iliac, subhepatic, right lumbar regions and finally reaches its adult position in right iliac fossa. Elongation of large intestine causes migration of caecum and appendix towards right iliac fossa. Increase in its size, stage of development and rotation of gut influence position of appendix. During its migration it may occupy a position posterior to caecum (retocaecal), posterior to ileum (retroileal) or descends in to the pelvis (Pelvic).

Higher incidence of sub hepatic or right lumbar location in younger fetuses and right iliac fossa location in older fetuses in the present study suggests that there is migration of vermiform appendix from the initial sub hepatic or right lumbar region before 30 weeks gestation to right iliac fossa after 30 weeks gestation.

Higher incidence of sub hepatic position in males, right iliac fossa in females were observed in the present study. The incidences of pelvic and right inguinal that were reported in adults [20] were not observed in the present study.

The explanation provided in the literature for varied position of appendix during development is that the most common caecal fixation site is right iliac fossa and pelvic position incidence is higher at birth followed by retro-ileal position during first year after birth (8). During development caecum experiences differential growth in certain parts which is responsible for modifications in shape, size and location. The results in the present study are in agreement with that reported by Jorge et.al. (8).

Though it presents variable location there is a region of vermiform appendix that occupies a fixed site where the base of it located. In adults it is located near the infero medial wall of caecum. Position of base of appendix in the posterior wall of caecum was found to be higher (58%) in the present study. In the literature higher percentage incidence (58 - 64%) was reported for a position at lower pole of caecum [15] in adults. Medial wall incidence was reported higher in adults (32 - 35%) (15) in the literature but it was very less (3%) in the present study. Variations in the position of base of appendix between fetal data of present study and that of reported data in adults suggests that the position of base of appendix undergoes developmental shift in relation to the wall of caecum.

Highest incidence (75%) of position of appendicular orifice corresponding to Mc Burney's point followed by 1.0 cm medial (20%) and 1.5cm lateral (5%) to it in adults was reported in literature [19]. In the present study the percentage incidence at Mc Burney's point is less (24%) suggesting the possible change in its direction during development. In the present study the percentage incidence of its location at various distances ranging from0.5 cm to 2.0 cm medial/lateral to Mc Burney's point were also observed that was not reported in literature in adults [21].

The results in the present study on direction and clock position of tip can be explained in the light of differential growth of caecal bud, contents of caecum, caecal internal pressure and effect of gravity at different growth periods. The caecal diverticulum is formed during the 6$^{th}$ week of embryonic life and the vermiform appendix develops as a continuation of caecal diverticulum from its lower part.

Highest percentage incidence of retrocaecal [7, 14, 16, and 17], Pelvic [4,11 and 22] and post-ileal [4] were reported in the adults of different races in the literature. In the present study majority of appendices are post-ileal in position, similar to the observations of Jorge et.al. [8] in first year of life. According to Jorge et.al. [8] it changes to pelvic position in 2$^{nd}$ year after birth. Maisel [7] reported higher incidence of pelvic position in fetuses though he did not specify the age range. A higher incidence of sub-caecal during fetal period with a higher incidence of post-ileal position in female fetuses and sub-caecal in male fetuses was reported in literature [18]. In the present study post-ileal position presented equal incidence between sexes. A higher incidence of pelvic position in 1- 20 years age group [16] was also reported in the literature. Higher incidence of post-ileal position in the present study can be due to the differential growth of the pre-arterial and post-arterial segments of midgut loop that forms the jejunum and ileum and large intestine respectively. According to Malas et.al. [18] position of appendix changes with the shape of caecum.

In the present study the length of appendix increased with increase in gestational age and is in agreement with that reported in the fetuses in literature [19]. The present study was in agreement with the previous authors [10, 17, and 22] that the length of the appendix in males is more than in females.

The distance between ileo-caecal orifice and appendicular orifice presented a gradual increase with increase in gestational age and presented sex differences with higher values in male fetuses when compared to female fetuses. There are no reported data in the literature on these parameters in fetuses.

## CONCLUSION

Developmental anatomy of VA suggests that viscera are subject to positional variation and the ultimate position of appendix depends on extent of elongation of proximal part of large intestine and the effort exerted by caecum and appendix to dislocate towards the right iliac fossa. The present observations on a small sample of appendix of foetuses forms a data base for undertaking studies on large sample for accurate statistical analysis and for better understanding of the morphology and morphometry of appendix.

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