Case Series

Morphological Variants of Colon: A Cadaveric Study

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Abstract

Background:Outcome of colorectal surgery is greatly influenced by regional variation of colonic morphology and its abnormal peritoneal attachments to the adjacent structures. The present study has been conducted to describe the morphology of colon, anatomical variations and to discuss their embryogenesis and surgical implications. **Methods:**Out of 32 cadavers dissected, two were excluded for extensive pathological adhesions of intestine. The detailed anatomy i.e, length, position and attachment of mesentery along with abnormal peritoneal attachments were observed in each segment of colon. **Results:**Out of 30 cadavers, 4 cadavers showed abnormal morphology. The ascending colon, transverse colon, descending colon and sigmoid colon were abnormally long in 3.3%, 6.6%, 3.3% and 6.6% respectively. In another two cases (6.6%)very short and fixed sigmoid colon were found. Elongated ascending and descending colon were mobile colons with persistence of their mesentery and shortened sigmoid colons got fixed to the pelvic wall by mesenteric absorption. Abnormally long colonic segments had shifted to abnormal positions and were retained there by abnormal peritoneal attachments to their adjacent structures. **Conclusion:**Sigmoid colon is more variable in length in comparison to other segments of colon. Redundancy can affect any segment of colon. Transverse colon and sigmoid colons are more often elongated than ascending and descending colon. Anomalous internal fixation of the fetal mesentery disturbs the colon's normal disposition and its relations to adjacent viscera. A fundamental awareness of these variations and preoperative diagnosis through imaging study is particularly important to avert surgical risk.

Keywords: Fixation of Colon; Mobile Colon; Supra Pelvic Sigmoid Colon;Peritoneal Bands; Peritoneal Recesses.

Introduction

The regional variation in human colon is increasingly important in surgical practice.

The length and mobility of the colon greatly influences the surgical outcome of laparoscopic colorectal surgery.[1] A long colon is often associated with a failure of zygosis of its mesocolon with the parietal peritoneum. As a result of this the elongated colon is not fixed to posterior abdominal wall and can swing free on a long mesentery which makes it a potential risk for volvulus.[2] The overall colonic length as well as morphology of individual segment of colon has been investigated previously both on living patients as well as on formalin fixed cadavers. A great variation in the result has been noticed in different studies. Sigmoid colon has been described to be the most variable segment of colon as regards its length, position and shape.[3,4] Racial variation has been noted in some groups, particularly Ethiopians, the incidence of a suprapelvic loop, perhaps conducive to volvulus is very high. [4]Though the previous studies have described the morphology of colon, the relation that exists between different morphological characters have not been analysed. In the present study the focus was not only on the morphological variations in length, position, mobility, abnormal peritoneal bands but also to find out if there exists any relation between them and to discuss their embryogenesis and clinical implications.

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Materials and methods

This study was undertaken in the department of Anatomy with the approval of institutional review board and ethics committee. 32 cadavers within the age of 35- 75,out of which 24 were male and 8 females were dissected for MBBS teaching during the year August 2012 to July 2020. Those cadavers without any visible pathology of colon were included in our study. One male and one female cadaver with extensive adhesions of intestine were excluded. The length, position and mobility of colon were studied in each segment of colon.Any abnormal peritoneal band and peritoneal recess associated with any segment of colon were also documented. Length was measured with the help of a flexible measuring tape. Length of the ascending colon was measured from ilio-cecal junction to the hepatic flexure, transverse colon from hepatic to splenic flexure on its antimesenteric border, descending colon from left colic flexure to the pelvic brim and sigmoid colon, from pelvic brim to the middle of third piece of sacrum along its antimesenteric border.The normal range for length of each colonic segmentwas determined by taking the values given in Gray's Anatomy to be the standard [Table 1].For mobile segments like, transverse and sigmoid colon SD of 10cm was taken as their length is more variable. For fixed segments like, ascending and descending colon SD of 5cm was taken. Ascending and descending colons when suspended from the posterior abdominal wall by a double layered peritoneal fold were described as mobile colons. The normal position of ascending and descending colons are the right and left flank of abdominal cavity respectively. Sigmoid colon is normally formed in the left side near the pelvic inlet as the continuation of descending colon and runs from left to right to become rectum in the midline at the level of third piece of sacrum.

Any deviation from these positions were described as abnormal positions.

Results

Morphological Variations in Length: Out of the 30 cadavers included in our study, the length of ascending colon was abnormally increasedto 50cm in 1 case,the transverse colon was increased in length to 65 and 70cm in two cases and the descending colon was increased in length to 58cm in 1 case. The length of the sigmoid colon was very much increased in 2 cases (63 & 72 cm) and decreased in 2 cases (18 & 20cm) [Table 2].

Morphological Variations in Position: Variation in position of the colonic segment was seen in those cases where there was change in its length. The ascending colon shifted to the left (n=1), descending colon shifted to the right(n=1) and the transverse colon shifted downwards (n=2) where their length was increased. Sigmoid colon shifted upward to the suprapelvic position where their length was increased (n=2) and to the right upto the midline where the length was decreased (n=2) [Table 2].

Morphological Variations in Mobility: One ascending and one descending colon were mobile, because of persistence of mesentery. Two sigmoid colons were fixed to the pelvic wall due to absorption of sigmoid mesocolon.

Abnormal Peritoneal Bands: Colonic segments showing variations in length, position and mobility were found attached to the adjacent structures through abnormal peritoneal bands. These bands were seen extending from ascending and transverse colon to the liver and gall bladder, from descending colon to left colic flexure and from sigmoid colon to transverse colon and descending colon.

Discussion

Elongation and displacement of colon found in autopsy was first described by Monterossi in the year 1820. In 1912, Kienboeck first visualised a redundant colon using bismuth. Later in 1914 Lardennois and Auborg named this anatomic variant as dolichocolon. The criteria to designate a long segment of colon to be dolichocolon were, a sigmoid colon loop rising over the line between the iliac crests, a transverse colon below the same line or extra loops at the flexures. The redundancy may involve the entire colon, or it may be limited to certain segments of the colon, but the distal segment especially the sigmoid colon is the most commonly affected. The incidence of dolichocolon is 1.9% to 28.5%.In the present study,done on 30 cadavers, the incidence of dolichocolon was 20% and the most common segment involved in this was sigmoid colon, which is consistent with the reports reviewed by Raahave D.[2]

There is considerable variation in the literature regarding mobility of the colon. Philips M *et al* in a study on 35 cadavers had reported mobile ascending colon 66% and mobile descending colon 31% [Table 4].[5]Saunders BP et al in a study on 118 patients undergoing laprotomy reported mobile ascending colon 9% and 8% of mobile descending colon and 17 % fixed sigmoid colon[Table 4].[6]Treves reported partial ascending mesocolon in 26% and descending mesocolon in 36% of 100 fresh cadavers[Table 4].[7]Michael SA*et al* in a cadaveric study on sigmoid colon in 31 cadavers reported 8 cases of suprapelvic sigmoid colon and 10 cases of fixed sigmoid colon[Table 4].[8] In the present study the prevalence of mobile ascending colon ,mobile descending colon and fixed sigmoid colon were 3.3%,3.3% and 6.6% respectively [Table 2]. Symington objected that the high incidence of ascending and descending mesocolons are usually not true, but they are due to laxity of peritoneum in fresh condition. In fresh cadavers at autopsy, they can be pulled from the abdominal wall mimicking presence of a mesocolon.[9] In formalin fixed cadaver the incidence is very low.Wolfer, Beaton and Anson in their study of 125 cadavers, reported 4.8% of cases of mobile ascending colon.[10]Keyes estimated that failure of mesenteric fixation occurs to some extent only in little more than 1% of cases.[11]In the present study, two cases (6.6%) with increased length of ascending and descending colon were also associated with abnormal mobility. In another two cases (6.6%) we found that a decrease in length of sigmoid colon led to its fixation to the parietal peritoneum [Table2]. This observation indicates that length of a segment affects its zygosis and ultimately its mobility.

Individual Case Characteristics

Case-1 [Fig 1a,1b]: This was a case of non-rotation of gut, where coils of small intestine occupied the right half of abdominal cavity and large intestine occupied the left half. Ascending colon was abnormally long (50cm), shifted to the left. The small intestine and ascending colon were suspended by a common mesentery, the root of which was limited to a small area about the origin of the superior mesenteric artery. The redundant segment of ascending colon was fixed by an abnormal peritoneal band to the inferior surface of liver. An exceptionally long sigmoid colon (65cm) with a suprapelvic loop occupied the left half of abdominal cavity. Normally in non-rotation of gut the cecum and appendix lie slightly above the pubic symphysis and usually to the left of the midline. From this position the colon loops upward toward its point of fixation at the left colic flexure, and without the interposition of a true transverse colon turns downward to form the descending colon. The two limbs of the loop of large intestine run closely parallel to each other. In the present case of non-rotation of gut, the unusually long ascending colon was pulled to the right and fixed to the liver, from where it ran horizontally to the left colic flexure to form the descending colon. This horizontal segment of ascending colon gave the apparent look of transverse colon.

Fig 1a: Non rotation of gut, entire large intestine on left side of the abdominal cavity, mobile ascending colon and suprapelvic sigmoid colon. AC- Ascending Colon, TC- Transverse Colon, SC- Sigmoid Colon, C- Caecum, A- Appendix

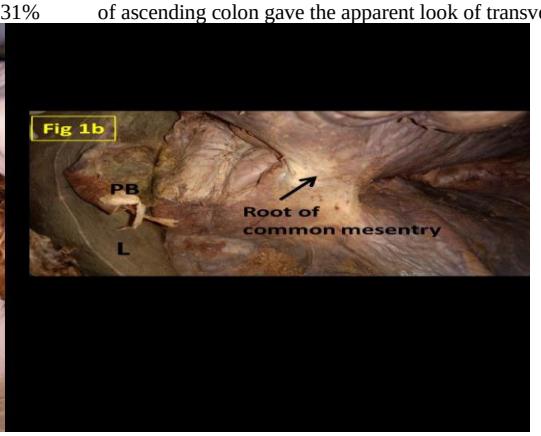


Fig 1b:Small intestine and ascending colon suspending by a common mesentery andredundant segment of ascending colon fixed by an abnormal peritoneal band to the inferior surface of liver. PB- Peritoneal Band, L- Liver

Case-2 [Fig 2a, 2b]: A long transverse colon (70cm), apex of its loop reaching the suprapubic region. This long redundant segment was fixed to the right edge of inferior border of liver by an abnormal peritoneal band. There was a compensatory decrease in length of sigmoid colon (15 cm) which was fixed to the posterior wall of pelvis due to absorption of its mesocolon.

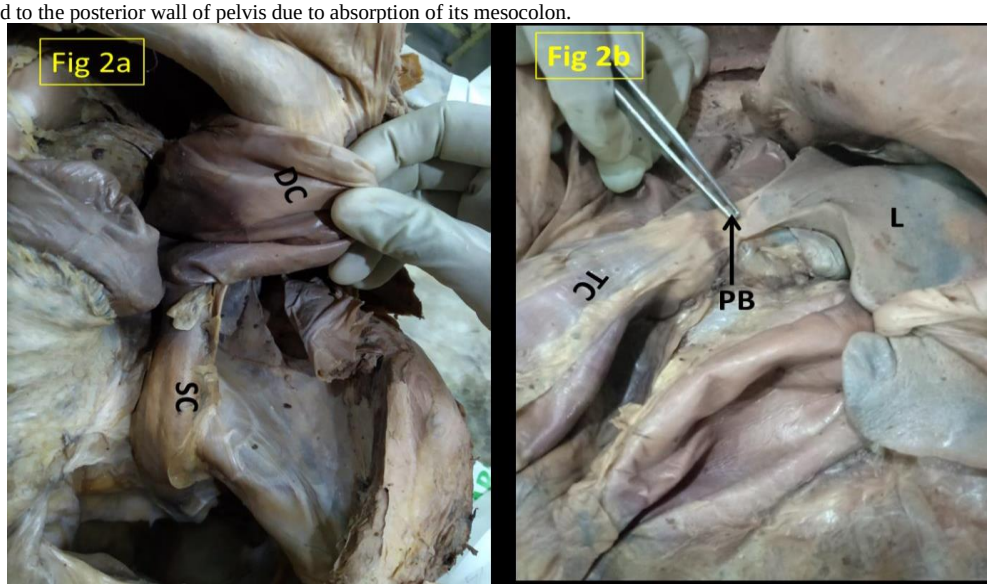


Fig 2a:Long redundant segment of transverse colonfixed to the right edge of inferior border of liver by an abnormal peritoneal band. DC- Descending Colon, SC- Sigmoid Colon

Fig 2b:Fixed sigmoid colon without sigmoid mesocolon.TC-Transverse Colon, PB- Peritoneal Band, L- Liver

Case-3 [Fig 3]: This was a case of abnormal elongation of descending colon (58cm), a large segment of which had become mobile due to persistence of descending mesocolon. Proximal and distal ends of the descending colon were retroperitoneal and intermediate part was suspended by mesocolon attached to the left lateral margin of vertebral column from L1 to L5. The upper part of descending mesocolon was adherent to the mesentery of small bowel. The Intraperitoneal segment of descending colon occupied the left hypochondrium, epigastrium and umbilical region of abdomen and its original position, the left flank was empty. The mobile segment of descending colon was kept fixed in this position by an abnormal vascular peritoneal band connecting it to the left colic flexure. Another peritoneal band was found in the site, where the peritoneal relation of descending colon abruptly changed from retroperitoneal to intraperitoneal, a deep peritoneal recess under it opening to the left paracolic gutter. In this case there was a compensatory decrease in length of the sigmoid colon (20 cm) which was fixed to the pelvic wall due to absorption of sigmoid mesocolon.

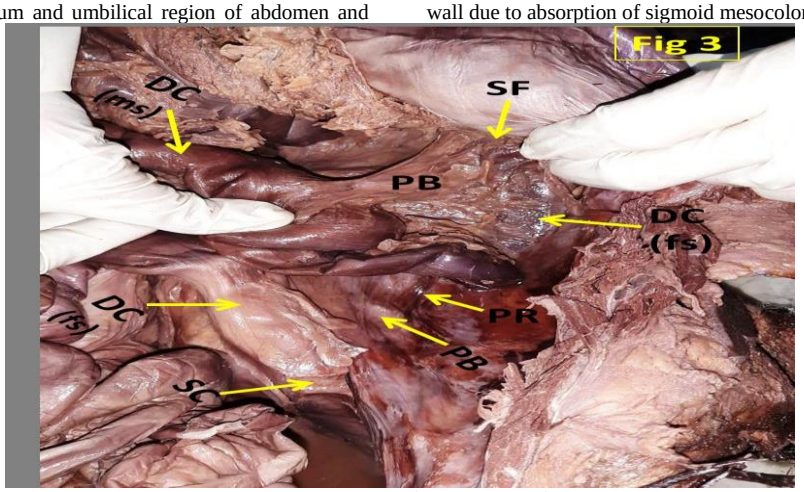
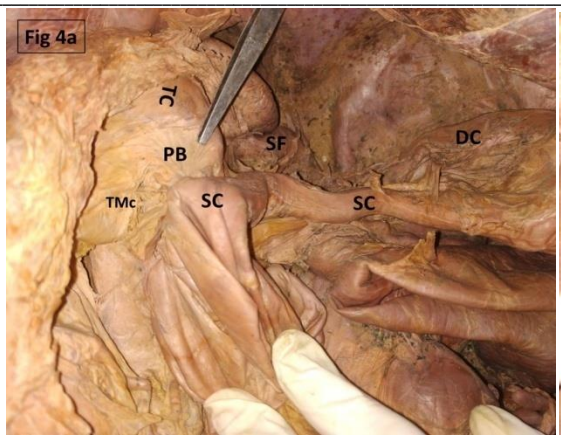


Fig 3: Persistent descending mesocolon, redundant descending colon folded on itself, abnormal peritoneal band connecting it to the left colic flexure, fixed sigmoid colon, deep peritoneal recess opening to the left paraduodenal gutter.DC(ms)- Descending Colon mobile segment, DC(fs)- Descending Colon fixed segment,SC- Sigmoid Colon,PB- Peritoneal Band,PR- Peritoneal Recess, SF- Splenic Flexure

Case-4 [Fig 4a,4b]: This was a case of long sigmoid colon (68cm) forming a suprapelvic loop. The sigmoid colon ascended medial to the descending colon into the left hypochondrium and coursed through the epigastrium and umbilical region of abdomen to the pelvis. The sigmoid mesocolon was attached to the left lateral margin of vertebral column extending from the level of 1st lumbar to sacral promontory. Sigmoid colon was fixed in this position by an abnormal peritoneal band connecting it to the transverse colon. Another peritoneal band reflected from the upper part of descending colon to the adjacent part of sigmoid colon producing a deep peritoneal recess underneath it opening to the left paracolic gutter.



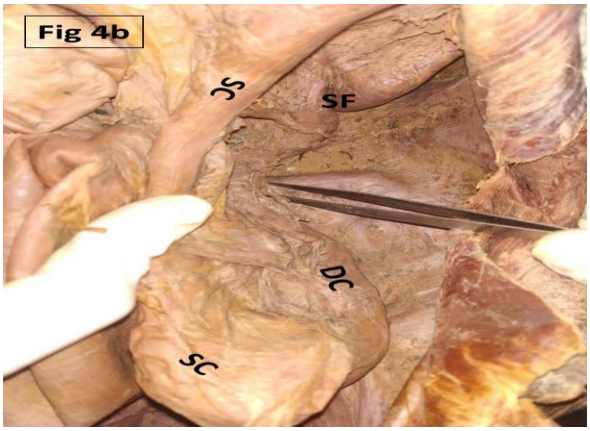


Fig 4a: Upper part of sigmoid colon is reflected to show the peritoneal band connecting it to the transverse colon. Sigmoid colon descending back into the pelvis.TC- Transverse Colon, TMc- Transverse Mesocolon, SF- Splenic Flexure, PB- Peritoneal Band

Fig 4b: An abnormally long sigmoid colon ascending from the distal end of descending colon into the left hypochondrium.DC- Descending Colon, SC- Sigmoid Colon,SF- Splenic Flexure

Case 5 [Fig 5]: This was a case of long transverse colon(65cm) suspended by an abnormal peritoneal band like a sling which extended from the gallbladder to the hepatic flexure. In this case the ascending colon was excessively fixed to the posterior abdominal wall by an extraperitoneal membrane called Jackson's membrane with disappearance of the right paracolic gutter.

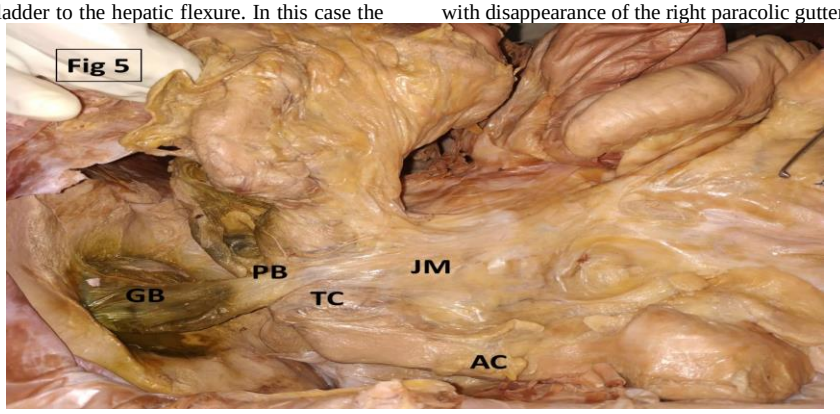


Fig 5:Abnormally long transverse colon suspended by peritoneal band (cystocolic ligament) and jackson's membrane extending from ascending colon to posterior abdominal wall. GB- Gall Bladder,TC- Tranverse colon, AC- Ascending Colon, JM- Jackson's membrane

Embryogenesis

During the development of gut, at first all parts of small and large intestines have a mesentery, by which they are suspended from posterior abdominal wall. The mesentery of the primary intestinal loop undergoes profound changes with rotation and coiling of the bowel. The dorsal mesentery twists around the origin of superior mesenteric artery. Despite the changes in position, mesentery to the midgut and hindgut remains continuous as a single entity from duodenojejunal flexure to the mesorectal level. In some regions, it is retained as a free mesentery. These regions include the mesentery proper to the jejunum and ilium, the transverse mesocolon, meso-appendix, mesosigmoid and mesorectum. In other regions, such as ascending and descending segments of colon, the mesentery becomes attached to the peritoneum on the posterior abdominal wall, with a layer of fascia (Toldt fascia) intervening between the two peritoneal layers.[12]During the course of development, errors of fixation may sometimes occur, resulting in persistence of mesentery in parts of intestine which normally becomes retroperitoneal or parts of intestine, that normally have mesentery, may be fixed by abnormal absorption of peritoneum. Abnormal fixation also alters the normal disposition of different parts of intestine.[1]Incomplete absorption of peritoneum, the most common defect may involve various lengths of either the ascending or descending mesocolon or both. When fusion has been so incomplete that it would invariably be regarded as a case of anomalous fixation, the mesentery is relatively long and therefore allows abnormal movement. The extreme of incomplete fixation of colon is the failure of the common mesentery of small intestine and ascending colon to fuse at all to the posterior body wall, so that the root of the common mesentery is limited to a small area about the origin of superior mesenteric artery. At the other extreme of fixation ascending colon may not only have lost its mesentery but also be abnormally fixed to the posterior body wall so that there is no paracolic recess. A band of connective tissue may pass across the front of the colon covering a small portion or the entire length of ascending colon. A particularly broad band of membrane across the right paracolic recess, usually attaching to almost the whole length of ascending colon but not to cecum, is often referred to as Jackson's membrane or veil.[13]

In the present study a wide range of abnormal fixation of colon has been observed ranging from no fixation at all to extremes of fixation with obliteration of paracolic gutter due to presence of Jackson's membrane. The incidence of mobile ascending and descending colon

is low in comparison to other studies because only those cases with considerable length of mesentery were considered as mobile colon and not just mobility due to laxity of underlying tissue.

Clinical Implications

A long colon is often associated with a failure of zygosis of its mesocolon with the parietal peritoneum. As a result of this the elongated colon is not fixed to posterior abdominal wall and can swing free on a long mesentery which makes it a potential risk for volvulus. When there is incomplete peritoneal fusion a peritoneal pocket may be formed behind the colon, opening to the right if it is on the right side or to the left if on the left side, into the paracolic gutters; such a pocket may be the locus for paracolic or retro-colic hernias.[2] In the present study, in one case of persistence descending mesocolon and one case of long suprapelvic sigmoid colon deep peritoneal recesses were found opening to the left paracolic gutter.Metcalf et al. stated that transit time is largely proportional to the length of a colonsegment.[14]Atony and a weak muscular tone may be limited to the site of the redundancy.

Wang L. et al studied the intraoperative anatomic characteristics and postoperative outcome of persistent descending mesocolon (PDM) in laparoscopic colorectal cancer resection by comparing patients with and without this anomaly.In PDM, imaging studies typically show medial movement of descending colon due to aberrant mesenteric fixation, thereby freeing left iliac fossa and left outer abdominal cavity. They have also reported that, in some case the descending mesocolon was adherent to either transverse mesocolon or to the mesentery of small bowel. In these cases identifying inferior mesenteric artery by separating the adhesions was time consuming and the chance of intraoperative bleeding was high.So they concluded that persistent descending mesocolon prolongs operative times and increases bleeding time in laparoscopic colorectal cancer surgery and should be considered a risk factor when encountered. [2]In the present study also there was medial shift of descending colon in a case persistence descending mesocolon with adhesion to the mesentery of small bowel as well as to the transverse colon and mesocolon.

Table 1: Normal range for length of each colonic segment

Colonic segments	Mean length in cm
Ascending colon	15(SD±5)
Transverse colon	50(SD±10)
Descending colon	25(SD±5)
Sigmoid colon	40(SD±10)

Table 2: Morphology of Colonic segments and their abnormal peritoneal attachments

Colonic Segments	Length		Mobility(abnormal)		Shift in Position				Peritoneal band extending to:
	Increased	Decreased	Mobile	Fixed	Rt	Lt	Up	Down	
Ascending	1(3.3%)	-	1(3.3%)	-	-	1(3.3%)	-	-	Liver
Transverse	2(6.6%)	-	-	-	-	-	-	2(6.6%)	Liver, Gall bladder
Descending	1(3.3%)	-	1(3.3%)	-	1(3.3%)	-	-	-	Lt. Colic Flexure
Sigmoid	2(6.6%)	2(3.3%)	-	2(6.6%)	2(3.3%)	-	2(6.6%)	-	Tr. Colon, Descending colon

Table 3: Length of Colonic segments

Colonic segments	Ascending	Transverse	Descending	Sigmoid
Normal range of length in cms	10-20	40-60	20-30	30-50
	<10= nil	<40=nil	<20=nil	<30=2
	10-15=11	40-50=13	20-25=12	30-40=11
	15-20=18	50-60=15	25-30=17	40-50=15
	>20=1	>60=2	>30=1	>50=2

Table 4: Comparative colonic characteristics with previous studies

Authors	Year	Place	Sample size	Results (in %)		
				Mobile ascending	Mobile descending	Fixed sigmoid
Treves[7]	1885	London	100 cadavers	26	36	-
Saunders BP et al[6]	1995	Japan	118 patients	9	8	17
Philips M et al[5]	2015	U.K	35 cadavers	66	31	-
Michael SA et al[8]	2015	India	31 cadavers	-	-	32.2
Present study	2020	India	30 cadavers	3.3	3.3	6.6

Conclusion

It is concluded from the present study that sigmoid colon is more variable in length in comparison to other segments of colon. Redundancy can affect any segment of colon but transverse colon and sigmoid colons are more often elongated than ascending and descending colon. Elongation of one segment of colon may lead to reduction in length of another segment. A wide range of abnormality in fixation of gut, starting from no fixation at all to over fixation of ascending colon by Jackson's membrane can occur. Abnormal peritoneal attachments as well as abnormal position and relations with adjacent viscera produce different anatomical pictures that may greatly influence the surgical outcome in colorectal surgery. A fundamental awareness of these variations and pre-operative diagnosis through imaging study is particularly important to avert surgical risk.

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