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# Use of robotic colonoscopy in patients with previous incomplete colonoscopy

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**Abstract. – OBJECTIVE: Conventional colonoscopy (CC) is the gold standard to diagnostic and therapeutic approach to colon. However, in few cases, cecal intubation could fail due to colon anatomy, patient compliance and physician expertise. Endotics robotic colonoscopy is a novel, safe, mini-invasive modality to explore the entire colon. Our aim was to assess, in a retrospective study, Endotics ability of cecal intubation in all cases in which CC failed.**

**PATIENTS AND METHODS: Between January 2008 and December 2012, 276 Endotics robotic colonscopy examinations were performed at the Gastroenterology and Metabolic Diseases Unit of Pisa University Hospital, Pisa, Italy, in a series of consecutive patients who had undergone CC and failed cecal intubation.**

**RESULTS: We assessed the cecal intubation rate in 102 patients addressed to Endotics after previous incomplete CC. Overall, endotics system was successful in 93.1% of the incomplete conventional colonoscopy cases (95% performance).**

**CONCLUSIONS: Whenever the intended exploration of the entire colon with CC failed, the endotics robotic endoscopy represented a useful tool as it helped examine the entire colon in almost all cases.**

Key Words
Colonscopy, Endotics, Robotic colonscopy.

## Introduction

Colorectal cancer is the third most common malignancy worldwide and is the second cause of all cancer-related deaths in the United States[1], even though it could be easily prevented with appropriate screening techniques[2].

Conventional colonoscopy is the gold standard for colorectal cancer screening methods, thanks to its ability in exploring the entire colon and in detecting/removing small or mid-size polyps during the same procedure[3,4]. However, it is an invasive procedure and may cause pain and discomfort to patients: as matter of fact, the main reason for subjects to refuse a screening colonoscopy is the fear of pain associated with the examination.

Cecal intubation is one of the main goals of colonoscopy and, at the same time, represents an indicator of colonoscopy quality[5]. International guidelines recommend cecal intubation rates ≥90% for all colonoscopies in daily clinical practice and ≥95% in screening programs[6]. Nevertheless, cecal intubation fails in 5-10% of cases, even when performed by experienced endoscopists[7].

Most authors refer to difficult colonoscopy when reaching of the cecum proves challenging or impossible to gain[8]. In addition to poor bowel cleanliness, there are several factors – including narrow-angle loopings, obstructive pathologies and patient discomfort – that may contribute to the inability to intubate the caecum[6,9-11]. These studies reveal that a redundant colon and evoked pain represent the main causes of colonoscopy failure.

A number of studies examining patient discomfort and colon anatomical difficulties documented a correlation between pain and anatomical colon configuration. In particular, 90% of all pain episodes in colonoscopy coincided with looping colon[12-14], whereas 9% matched with presumed over-insufflation of air[12].

Actually, abdominal pain is mainly due to the traction on the mesenteries exerted by the colonoscope with the intent to solve eventual loops. Moreover, such maneuvers enhance the risk of colon perforation, discomfort, undue pain and longer recovery time[13].

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In the event of incomplete colonoscopy, colon inspection could be completed either by radiological examination – as barium enema, virtual colonoscopy and magnetic resonance imaging[9] – or by a subsequent pediatric colonoscope or a gastroscope[5,15].

Endotics (Era Endoscopy S.r.l, Peccioli, Pisa, Italy) is a new alternative diagnostic instrument which combines high quality performance with an extremely high level of patient acceptance[16].

The aim of this study was to evaluate the performance of the endotics system in achieving total colonic examination in cases of failed cecal intubation by standard, conventional colonoscopy.

## Patients and Methods

### The Endotics System

Endotics (Era Endoscopy S.r.l, Peccioli, Pisa, Italy) is a new self-propelled robotic colonoscope, consisting of a workstation, a disposable probe and a console.

The disposable device has an active part, with a head, a steerable tip, a flexible body and a passive part, including a thin tail and a special tank with an electro-pneumatic connector. The head hosts a vision system, consisting of a camera with Light Emitting Device (LED) light sources, a channel for water jet and one for air streaming, in order to provide rinsing and suction/insufflation, respectively.

The workstation gives the operator a full control of the probe by means of a hand-held console, and allows the visualization of real-time images on a screen. The endoscopist can steer 180 degrees the head of the colonoscope in any direction, can elongate the central body of the probe – allowing it to move forward following the shape of the colon – and can control rinsing, air insufflation and suction.

The system is highly flexible, as the probe adapts its shape to the complex curves of the colon, thereby exerting low straightening forces during its movement. A semi-automatic sequence of actions allows the probe to advance like an inchworm. This particular locomotion is achieved by means of two clampers located in the proximal and in the distal part of the probe, respectively. They adhere to the intestinal mucosa by means of a vacuum technique and a mechanical grasping action. The semi-automatic sequence can be described as follows:

1. The clamper located in the proximal part of the probe adheres to the mucosa (automatic phase);
2. The central part of the probe body is elongated by the endoscopist under visual control (manual phase);
3. The distal clamper adheres to the mucosa (automatic phase);
4. The proximal clamper is released (automatic phase);
5. The central part of the body is shortened (automatic phase);
6. The proximal clamper adheres to the mucosa (automatic phase);
7. The distal clamper is released (automatic phase);

Such sequence is repeated several times in order to advance the probe through the colonic lumen.

Recent reports[17-19]. have confirmed that Endotics system proves high diagnostic accuracy in absence of evoked pain.

### Study Protocol

This is a retrospective study. 276 Endotics examination were performed between January 2008 and December 2012 at the Gastroenterology Department of Pisa University Hospital, Pisa, Italy. Patients underwent endotics system after they had undergone a complete or an incomplete conventional colonoscopy. The study mainly describes the technical success of Endotics in patients who failed conventional colonoscopy. Thus, there is no direct comparison between these two techniques and there are no data that require ROC curve analysis.

Senior gastroenterologists performed both traditional colonoscopy and endotics system colonoscopy without use of sedative agents.

Bowel preparation was the same for both procedures: a fiber-free diet in the seven days preceding the examination and oral administration of phosphate sodium lavage solution (80 mL in 2000 mL of water until evacuation of clear yellowish fluid) on the day before the examination.

All conventional colonoscopies were performed with a standard colonoscope (Olympus, Tokyo, Japan).

From this initial population the following exclusion criteria were applied:

1. Procedures performed in patients who underwent endotics system after they had undergone a complete conventional colonoscopy (81 procedures);

2. Procedures performed in patients who had undergone incomplete conventional colonoscopy and incomplete endotics system due to poor bowel preparation (20 conventional colonoscopic procedures and 49 endotics system procedures);
3. Incomplete endotics colonoscopies due to stenosis (5 procedures);
4. Incomplete endotics colonoscopies due to device malfunctioning (11 procedures);
5. Incomplete endotics colonoscopies with missing data (8 procedures).

After applying such exclusion criteria, 102 endotics procedures were compared with their respective previous incomplete conventional colonoscopy.

## Results

102 out of 276 endotic examination were considered in patients who failed to inspect the entire colon with standard colonoscopy. In these 102 patients, we assessed the cecal intubation rate.

Patient's characteristics and standard colonoscopy results are shown in Table I. Colon segment at which standard colonoscopy stopped were sigmoid in 28.43%, splenic flexure in 58.82% and hepatic flexure in 12.74%.

Colonoscopy was defined as complete, therefore successful, when the operator succeeded in visualizing and recognizing the caecum. The colonoscopy performed with endotics system was successful in 95 (93.1%) patients.

**Table I.** Patients' baseline characteristic and results of incomplete conventional colonoscopy.

| | |
|---|---|
| ***Patients baseline characteristics*** | |
| Gender M/F no. | 42/60 (41.2%/58.8%) |
| Mean Age (± SD) | 51 ±12.49 |
| History of abdominal surgery M/F N° | 13/9 |
| ***Colon segment at which colonoscopy stopped n°*** | |
| Sigmoid | 29 (28.43%) |
| Splenic flexure | 60 (58.82%) |
| Hepatic flexure | 13 (12.74%) |
| ***Reasons colonoscopy was stopped n°*** | |
| Extensive loop and or colon angulation | 68 (66.7%) |
| Patient discomfort | 34 (33.3%) |

SD: Standard Deviation

In 16 cases (Table II), polyps were detected during endotics system procedure and in 7 cases these polyps were removed in a subsequent conventional colonoscopy. Conventional colonoscopy performed after endotics system procedures confirmed number and size of the polyps visualized during endotics procedures. Complete results are shown in Table II.

In only 7 (6.9%) patients, endotics system procedure resulted incomplete: in 5 cases Endotics system overcame the colon segment at which conventional colonoscopy was halted whereas in 2 cases the same colonic segment as traditional colonoscopy was reached by endotics system procedure. The mean cecal intubation time was 51 min (±22.5). The reasons for incomplete endotics system colonoscopy were patient panic attack (2 cases), discomfort caused by strong abdominal adhesions (1 case), and 4 abnormal peristalsis with many prolonged spasms (4 cases).

Overall, endotics system visualized the caecum in 93.1% of the incomplete conventional colonoscopy cases (95% performance).

## Discussion

Conventional colonoscopy success depends mainly on bowel characteristics of individual patients. Maneuvers to "reduce" or to "solve" the loops, together with excessive air insufflation to straighten the colon, may cause severe distress or pain during the examination. Looping of the colon also decreases the chance of cecal intubation.

Whenever a conventional colonoscopy fails, colonic examination should be completed with other procedures: to date, the most commonly-used alternative devices are barium enema, colon-Computed Tomography (TC) (e.g. virtual colonoscopy) and capsule endoscopy (Pillcam colon).

Radiological examination (Virtual colonoscopy and Barium Enema) is less painful then traditional colonoscopy, but does not allow a direct visualization of colon. The main potential drawback of a Computed Tomography Colonography (CTC) screening is the exposure to ionizing radiation. However, this is not a major issue, since low-dose protocols are now routinely implemented[20]. As regarding to the diagnostic capability in the identification of polyps ≥10 mm, CTC has a sensitivity of 90%, and a specificity of 86%, while for polyps ≥6 mm the corresponding values are in the range of 78%-84%, with a negative predictive value (NPV) close to 100%, (results attainable by radiologists trained in the method)[21,22].

**Table II.** Patients' characteristics, results of conventional colonoscopy and Endotics system colonoscopy, findings of endotics system endoscopy and further evaluation.

| No. | Age | Gender | Conventional colonoscopy reached | Reasons for incomplete conventional colonoscopy | Endotics system reached | Findings in endotics system endoscopy | Further evaluation |
|---|---|---|---|---|---|---|---|
| 1 | 50 | F | Splenic flexure | Extensive loop | Caecum | | |
| 2 | 58 | F | Sigmoid | Patient discomfort | Splenic flexure | | |
| 3 | 47 | M | Splenic flexure | Extensive loop | Caecum | | |
| 4 | 55 | M | Sigmoid | Extensive loop | Caecum | | |
| 5 | 36 | M | Splenic flexure | Extensive loop | Caecum | | |
| 6 | 47 | F | Sigmoid | Extensive loop | Splenic flexure | | |
| 7 | 48 | M | Splenic flexure | Patient discomfort | Caecum | | |
| 8 | 40 | M | Hepatic flexure | Extensive loop | Caecum | | |
| 9 | 68 | M | Splenic flexure | Extensive loop | Caecum | | |
| 10 | 47 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 11 | 77 | M | Splenic flexure | Extensive loop | Caecum | | |
| 12 | 61 | F | Splenic flexure | Extensive loop | Caecum | | |
| 13 | 56 | F | Hepatic flexure | Patient discomfort | Caecum | | |
| 14 | 57 | M | Splenic flexure | Extensive loop | Caecum | | |
| 15 | 81 | F | Splenic flexure | Extensive loop | Caecum | 1 polyp in descending colon (size 1 cm); diverticula | Conventional colonoscopy to remove the polyp |
| 16 | 47 | F | Hepatic flexure | Extensive loop | Caecum | | |
| 17 | 49 | F | Splenic flexure | Extensive loop | Caecum | | |
| 18 | 40 | F | Splenic flexure | Extensive loop | Caecum | | |
| 19 | 41 | M | Splenic flexure | Extensive loop | Caecum | | |
| 20 | 38 | F | Sigmoid | Extensive loop | Caecum | | |
| 21 | 45 | M | Splenic flexure | Patient discomfort | Caecum | | |
| 22 | 32 | F | Hepatic flexure | Patient discomfort | Caecum | 1 Polyp in rectal ampulla (size 3 mm); | |
| 23 | 37 | M | Sigmoid | Extensive loop | Caecum | | |
| 24 | 58 | F | Splenic flexure | Extensive loop | Caecum | | |
| 25 | 56 | F | Splenic flexure | Extensive loop | Caecum | | |
| 26 | 76 | M | Splenic flexure | Extensive loop | Caecum | | |
| 27 | 34 | F | Sigmoid | Extensive loop | Caecum | | |
| 28 | 40 | F | Hepatic flexure | Extensive loop | Caecum | | |
| 29 | 43 | F | Sigmoid | Extensive loop | Caecum | | |
| 30 | 42 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 31 | 42 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 32 | 45 | F | Splenic flexure | Extensive loop | Caecum | | |
| 33 | 55 | F | Splenic flexure | Extensive loop | Caecum | 1 polyp in sigmoid colon (size 1 cm); hemorroid | Conventional colonoscopy to remove the poly |
| 34 | 57 | M | Hepatic flexure | Extensive loop | Caecum | | |
| 35 | 50 | F | Hepatic flexure | Extensive loop | Caecum | | |
| 36 | 84 | F | Hepatic flexure | Extensive loop | Caecum | | |
| 37 | 56 | M | Sigmoid | Extensive loop | Caecum | | |

*Continued*

**Table II (Cont.).** Patients' characteristics, results of conventional colonoscopy and Endotics system colonoscopy, findings of endotics system endoscopy and further evaluation.

| No. | Age | Gender | Conventional colonoscopy reached | Reasons for incomplete conventional colonoscopy | Endotics system reached | Findings in endotics system endoscopy | Further evaluation |
|---|---|---|---|---|---|---|---|
| 38 | 55 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 39 | 49 | M | Splenic flexure | Extensive loop | Caecum | | |
| 40 | 38 | F | Sigmoid | Extensive loop | Caecum | | |
| 41 | 41 | F | Sigmoid | Patient discomfort | Caecum | | |
| 42 | 50 | M | Splenic flexure | Extensive loop | Caecum | | |
| 43 | 47 | M | Splenic flexure | Extensive loop | Caecum | Diverticula and 2 polyp in sigmoid (size 3 mm) | Polyp were not been identified with successive conventional colonoscopy |
| 44 | 50 | F | Hepatic flexure | Extensive loop | Caecum | 2 polyp in sigmoid (size 3 mm) | |
| 45 | 39 | M | Splenic flexure | Extensive loop | Caecum | | |
| 46 | 46 | F | Sigmoid | Patient discomfort | Caecum | | |
| 47 | 58 | M | Splenic flexure | Extensive loop | Caecum | 1 polyp in transverse colon (3 mm); hemorroid | |
| 48 | 43 | F | Splenic flexure | Extensive loop | Caecum | | |
| 49 | 40 | M | Splenic flexure | Extensive loop | Caecum | 1 polyp in splenic flexure (size 8 mm) | Conventional colonoscopy to remove the polyp |
| 50 | 44 | M | Splenic flexure | Patient discomfort | Caecum | | |
| 51 | 63 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 52 | 46 | M | Hepatic flexure | Patient discomfort | Caecum | | |
| 53 | 35 | M | Splenic flexure | Extensive loop | Caecum | | |
| 54 | 65 | F | Sigmoid | Extensive loop | Caecum | | |
| 55 | 42 | M | Sigmoid | Extensive loop | Caecum | 1 polyp in transverse colon (size 1 cm) | Conventional colonoscopy to remove the polyp |
| 56 | 33 | F | Sigmoid | Patient discomfort | Caecum | | |
| 57 | 40 | M | Splenic flexure | Extensive loop | Caecum | 2 polyp in transverse colon (size 3 mm) | |
| 58 | 49 | F | Splenic flexure | Patient discomfort | Caecum | 1 polyp in ascending colon (size 5 mm) | Conventional colonoscopy to remove the polyp |
| 59 | 73 | F | Sigmoid | Patient discomfort | Caecum | | |
| 60 | 78 | M | Sigmoid | Extensive loop | Caecum | Polyp in the transverse colon about 5 mm. In proximity of ilececal valve there was small whitish outgrowth (3-4 mm), easily bleeding. Diverticula in the sigmoid colon and between ascending colon and caecum | |
| 61 | 35 | F | Splenic flexure | Extensive loop | Caecum | | |
| 62 | 29 | F | Splenic flexure | Extensive loop | Caecum | | |
| 63 | 56 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 64 | 47 | F | Sigmoid | Extensive loop | Hepatic flexure | | |
| 65 | 55 | F | Sigmoid | Patient discomfort | Caecum | | |
| 66 | 48 | F | Sigmoid | Extensive loop | Caecum | | |

*Continued*

**Table II (Cont.).** Patients' characteristics, results of conventional colonoscopy and Endotics system colonoscopy, findings of endotics system endoscopy and further evaluation.

| No. | Age | Gender | Conventional colonoscopy reached | Reasons for incomplete conventional colonoscopy | Endotics system reached | Findings in endotics system endoscopy | Further evaluation |
|---|---|---|---|---|---|---|---|
| 67 | 43 | F | Hepatic flexure | Extensive loop | Caecum | | |
| 68 | 36 | F | Sigmoid | Patient discomfort | Caecum | | |
| 69 | 37 | M | Sigmoid | Extensive loop | Splenic flexure | | |
| 70 | 24 | M | Splenic flexure | Extensive loop | Caecum | | |
| 71 | 57 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 72 | 37 | M | Splenic flexure | Extensive loop | Caecum | | |
| 73 | 70 | F | Splenic flexure | Extensive loop | Caecum | | |
| 74 | 69 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 75 | 50 | M | Splenic flexure | Extensive loop | Caecum | 3 polyp in sigmoid colon (size 6 mm) | Conventional colonoscopy to remove the polyp |
| 76 | 48 | M | Splenic flexure | Extensive loop | Caecum | | |
| 77 | 36 | M | Sigmoid | Extensive loop | Caecum | | |
| 78 | 53 | F | Sigmoid | Extensive loop | Caecum | | |
| 79 | 54 | M | Splenic flexure | Patient discomfort | Caecum | | |
| 80 | 38 | F | Sigmoid | Patient discomfort | Caecum | | |
| 81 | 60 | M | Splenic flexure | Extensive loop | Caecum | 2 polyp in ceacum (size 6 mm) | Conventional colonoscopy to remove the polyp |
| 82 | 70 | M | Sigmoid | Patient discomfort | Splenic flexure | | |
| 83 | 50 | F | Sigmoid | Extensive loop | Sigmoid | | |
| 84 | 53 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 85 | 50 | F | Sigmoid | Patient discomfort | Caecum | | |
| 86 | 20 | M | Splenic flexure | Extensive loop | Caecum | | |
| 87 | 54 | F | Splenic flexure | Extensive loop | Caecum | 2 polyp (size 3 mm) in rectal ampulla | |
| 88 | 43 | M | Splenic flexure | Patient discomfort | Caecum | | |
| 89 | 71 | M | Sigmoid | Patient discomfort | Caecum | | |
| 90 | 60 | F | Splenic flexure | Patient discomfort | Caecum | 1 polyp (size 4 mm) in rectal ampulla | |
| 91 | 70 | M | Splenic flexure | Extensive loop | Caecum | | |
| 92 | 51 | F | Splenic flexure | Extensive loop | Caecum | | |
| 93 | 73 | F | Splenic flexure | Extensive loop | Caecum | | |
| 94 | 54 | F | Splenic flexure | Patient discomfort | Caecum | | |
| 95 | 38 | F | Splenic flexure | Extensive loop | Caecum | | |
| 96 | 64 | F | Sigmoid | Extensive loop | Caecum | | |
| 97 | 70 | M | Hepatic flexure | Patient discomfort | Hepatic flexure | | |
| 98 | 59 | F | Splenic flexure | Extensive loop | Caecum | | |
| 99 | 62 | M | Splenic flexure | Patient discomfort | Caecum | | |
| 100 | 39 | F | Splenic flexure | Extensive loop | Caecum | | |
| 101 | 40 | M | Splenic flexure | Extensive loop | Caecum | | |
| 102 | 58 | F | Hepatic flexure | Patient discomfort | Caecum | | |

Colon capsule endoscopy does not require sedation, air inserted in the colon, or radiation; the diet is similar to the preparation for colonoscopy, but requires a major amount of laxatives[22]. The examination lasts several hours and requires on average 1h for reporting. It has been reported with sensitivity and specificity for the diagnosis of polyps ≥6 mm of 89% (95% CI 70-97) and 76% (95% CI 72-78), respectively, while for polyps ≥10 mm were 88% (95% CI 56-98) and 89% (95% CI 86-90) respectively[21].

The endotics is in many ways more similar to traditional colonoscopy than the afore-mentioned techniques; it is the only system that allows a direct view of the mucosa in real time and has the advantage of being painless.

Endotics is a new emergent technology, with an unique locomotion system which allows the probe to self-propel through the intestine without any external pushing action, thus exerting low straightening forces on colon walls during its forward progression[18] (90% lower than conventional colonoscopy).

When using the endotics system, there is no need to "solve" possible loops by means of painful torsion and push/pulling maneuvers. As matter of fact, thanks to a hand-held console, the operator can elongate and steer (by bending the tip of the probe more than 180 degrees along each axis) the very soft and flexible probe in order to move it while following the shape of the intestine, also in presence of narrow-angle loops.

As shown in literature, this probe is able to adapt its shape to the configuration of the bowel, thus minimizing the pain and/or the discomfort related to unusual conformations of the colon. In fact it is reported that 70% of patients displayed a score for pain less of 1 by using a scale from 0 to 10 (30% of patients displayed a score ranging from 1 to 2.1)[18].

Endotics system is also able to remove another cause of pain evoked by conventional colonoscopy: the considerable amount of air insufflated into the colonic lumen. Indeed this device requires minimal amount of air insufflation, mainly necessary in the proximity of the head to increase the portion of bowel visualized. Moreover, during locomotion phases, clamping mechanisms remove air from the bowel in order to adhere to the colon tissue, resulting in an empty intestine at the end of the procedure.

The system requires a thorough cleaning of the bowel, greater than the conventional colonoscopy, because of the suction channel of 1 mm diameter. Previous characteristics would explain why the number of endotics exams interrupted for poor bowel preparation is higher than that of conventional colonoscopy. The size of the suction channel does not allow cleaning of the colon, therefore, the progression of the robot is more difficult in the case of poor bowel preparation. The diagnostic accuracy was equal to colonoscopy[11], with high sensitivity and specificity for polyps any size (93.3% and 100% respectively), with positive predictive value (PPV) and NPV of 100% and 97.7%[15].

This study demonstrates that such new robotic system is successful in most cases where conventional colonoscopy fails because of patient reported pain due to colonic anatomical challenges. In this report, endotics system reached the caecum in 93.1% of incomplete conventional colonoscopy cases, and in 98% of cases, a longer portion of colon was inspected These data are different from those reported in previous studies, mainly because at that time operators were still in training phase[11,14]. However, the learning curve of the product is very rapid[11] and, therefore, the same physicians can be considered as senior endoscopists.

Our data shows that in almost all cases in which conventional colonoscopy had to be halted to patients discomfort and/or looping colon, endotics system can complete the colon inspection, thus allowing a complete diagnosis by physicians.

Endotics system used for this study was exclusively a diagnostic tool, because it is not yet equipped with an operating channel, so it is not possible, like in radiological studies, to perform biopsies or remove small polyps. A new version of endotics probe is already available, equipped with a tool channel, which allows operators to sample colonic mucosa and to perform biopsies.

Nevertheless, and despite this is a retrospective, single center study, the high cecal intubation rate obtained allows us to state that endotics system is superior to conventional colonoscopy in examining "difficult" colons, thus enabling endoscopists to handle with relative ease even the most challenging colon.

## Conclusions

It has been shown that endotics system, combining high diagnostic accuracy[17] to high level of patient acceptance, is a valid option not only in colon cancer screening but also in daily clinical practice, and it can play a complementary role to conventional colonoscopy in achieving the caecum when the latter procedure fails to explore the entire colon.

**Statement of Interests**
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**Conflict of Interest**
The Authors declare that they have no conflict of interests.

## References

1) Yucel C, Lev-Toaff AS, Moussa N, Durrani H. CT colonography for incomplete or contraindicated optical colonoscopy in older patients. Am J Roentgenol 2008; 190: 145-150.
2) Javeri K, Williams TR, Bonnett JW. An overview of the method, application, and various findings of computed tomographic colonography in patients after incomplete colonoscopy. Curr Probl Diagn Radiol 2010; 39: 262-274.
3) Copel L, Sosna J, Kruskal JB, Raptopoulos V, Farrell RJ, Morrin MM. CT colonography in 546 patients with incomplete colonoscopy. Radiology 2007; 244: 471-478.
4) Jung Y, Lee SH. How do I overcome difficulties in insertion? Clin Endosc 2012; 45: 278-281.
5) Morini S, Zullo A, Hassan C, Lorenzetti R, Campo SM. Endoscopic management of failed colonoscopy in clinical practice: to change endoscopist, instrument, or both? Int J Colorectal Dis 2011; 26: 103-108.
6) Neerincx M, Terhaar sive Droste JS, Mulder CJ, Räkers M, Bartelsman JF, Loffeld RJ, Tuynman HA, Brohet RM, van der Hulst RW. Colonic work-up after incomplete colonoscopy: significant new findings during follow-up. Endoscopy 2010; 42: 730-735.
7) Sato K, Shigiyama F, Ito S, Kitagawa T, Tominaga K, Suzuki T, Maetani I. Colonoscopy using a small-caliber colonoscope with passive-bending after incomplete colonoscopy due to sharp angulation or pain. Surg Endosc 2013; 27: 4171-4176.
8) Witte TN, Enns R. The difficult colonoscopy. Can J Gastroenterol 2007; 21: 487-490.
9) Kaltenbach T, Soetikno R, Friedland S. Use of a double balloon enteroscope facilitates caecal intubation after incomplete colonoscopy with a standard colonoscope. Dig Liver Dis 2006; 38: 921-925.
10) Brahmania M, Park J, Svarta S,Tong J, Kwok R, Enns R. Incomplete colonoscopy: Maximizing completion rates of gastroenterologists. Can J Gastroenterol 2012; 26: 589-592.
11) Rex DK. Achieving cecal intubation in the very difficult colon. Gastrointest Endosc 2008; 67: 938-944.
12) Shah SG, Brooker JC, Thapar C, Williams CB, Saunders BP. Patient pain during colonoscopy: an analysis using real-time magnetic endoscope imaging. Endoscopy 2002; 34: 435-440.
13) Eickhoff A, Pickhardt PJ, Hartmann D, Riemann JF. Colon anatomy based on CT colonography and fluoroscopy: Impact on looping, straightening and anc illary manoeuvres in colonoscopy. Dig Liver Dis 2010; 42: 291-296.
14) Huang RX, Xiao ZL, LI F, Ji DN, Zhou J, Xiang P, BAO ZJ. Black hood assisted colonoscopy for detection of colorectal polyps: a prospective randomized controlled study. Eur Rev Med Pharmacol Sci 2016; 20: 3266-3272.
15) Pasha SF, Harrison ME, Das A, Corrado CM, Arnell KN, Leighton JA. Utility of double-balloon colonoscopy for completion of colon examination after incomplete colonoscopy with conventional colonoscope. Gastrointest Endosc 2007; 65: 848-853.
16) Pallotta S, Tumino E, Manes G, Sacco R, Ardizzone S, Bresci G, de Franchis R. Assessment of ulcerative colitis endoscopic activity with novel robotic colonoscope: the Endotics system. Dig Liver Dis 2011; 43: S199.
17) Perri F, Iacobellis A, Gentile M, Tumino E, Andriulli A. The intelligent, painless, "germ free" colonoscopy: a Columbus' egg for increasing population adherence to colorectal cancer screening? Dig Liver Dis 2010; 42: 839-843.
18) Cosentino F, Tumino E, Passoni GR, Morandi E, Capria A. Functional evaluation of the endotics system, a new disposable self-propelled robotic colonoscope: in vitro tests and clinical trial. Int J Artificial Organs 2009; 32: 517-527.
19) Tumino E, Sacco R, Bertini M, Bertoni M, Parisi G, Capria A. Endotics system vs colonoscopy for the detection of polyps. World J Gastroenterol 2010; 16: 5452-5456.
20) Laghi A, Iafrate F, Rengo M, Hassan C. Colorectal cancer screening: The role of CT colonography. World J Gastroenterol 2010; 16: 3987-3994.
21) Eliakim R, Yassin K, Niv Y, Metzger Y, Lachter J, Gal E, Sapoznikov B, Konikoff F, Leichtmann G, Fireman Z, Kopelman Y, Adler SN. Prospective multicenter performance evaluation of the second-generation colon capsule compared with colonoscopy. Endoscopy 2009; 41: 1026-1031.
22) Johnson CD. Computed tomography colonography: a current appraisal. Gastroenterology 2009; 137: 792-794.