Anthem

Clinical UM Guideline

Subject: Wireless Capsule Endoscopy for Gastrointestinal Imaging and the Patency Capsule
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Description

This document addresses the use of wireless capsule endoscopy (WCE or video capsule endoscopy [VCE]) devices which have been developed for imaging portions of the gastrointestinal tract and the patency capsule which is intended to ensure that there are no strictures in the digestive tract to impede passage of the wireless endoscopy capsule.

WCE is accomplished by encasing video, illumination and transmission modules inside a capsule the size of a large vitamin pill. When swallowed, peristalsis moves the capsule along the esophagus and gastrointestinal tract. The encapsulated camera records images and then transmits the data to an external receiver worn by the person being tested. The receiver can download the data to a computer workstation for interpretation.

Magnetically controlled WCE is being explored as a means to visualize the upper gastrointestinal tract (esophagus, stomach, and duodenum). With magnetically controlled WCE, magnets are used to control and maneuver the wireless capsule as it moves through the gastrointestinal tract.

Note: Please see the following related document for additional information:

- MED.00090 Wireless Capsule for the Evaluation of Suspected Gastric and Intestinal Motility Disorders

Clinical Indications

Medically Necessary:

A. Wireless capsule endoscopy of the small bowel is considered **medically necessary** as a diagnostic imaging tool, in adults or children 2 years of age and older, in the following clinical circumstances:
   1. To investigate obscure gastrointestinal bleeding, suspected to be of small bowel origin, after appropriate evaluation (at a minimum upper and lower endoscopy) has excluded a source of bleeding in the upper gastrointestinal tract or colon; **or**
   2. For the initial evaluation of individuals with suspected Crohn's disease when small bowel follow-through (SBFT) or enteroclysis, including CT enteroclysis and upper and lower endoscopy are non-diagnostic AND there is no suspected or confirmed gastrointestinal obstruction, stricture, or fistulae; **or**
   3. Suspected small intestinal tumors; **or**
   4. For individuals beginning at age 35 or greater with Lynch syndrome or polyposis syndromes; **or**
   5. For diagnostic re-evaluation of individuals with known Crohn's disease who remain symptomatic afterappropriate treatment has occurred and there is no suspected or confirmed gastrointestinal obstruction, stricture, or fistulae; **or**
   6. Refractory undiagnosed malabsorptive syndromes with prior history of negative small bowel biopsy(for example, suspected celiac disease with prior negative biopsy); **or**
   7. To investigate anemia with concomitant iron deficiency, suspected to be of small bowel origin, after appropriate evaluation (at a minimum upper and lower endoscopy) has excluded a source of anemia from the upper GI tract and colon.

Not Medically Necessary:

A. Wireless capsule endoscopy is considered **not medically necessary** for all other indications, including but not limited to:
   1. The evaluation of small bowel disease in individuals with abdominal pain in the absence of gastrointestinal bleeding;
   2. The evaluation of esophageal disease;
   3. Colorectal cancer screening or as a means to identify colon disease;
   4. Individuals with known or suspected gastrointestinal obstruction, stricture, or fistulae.

B. Use of a patency capsule is considered **not medically necessary.**
C. Use of a magnetically controlled wireless capsule is considered **not medically necessary.**

Coding

The following codes for treatments and procedures applicable to this document are included below for informational purposes. Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement policy. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

When services may be Medically Necessary when criteria are met:

CPT	
91110	Gastrointestinal tract imaging, intraluminal (eg, capsule endoscopy), esophagus through ileum, with interpretation and report

ICD-10 Diagnosis	
C17.0-C17.9	Malignant neoplasm of small intestine
C18.0-C18.9	Malignant neoplasm of colon
C19	Malignant neoplasm of rectosigmoid junction
C20	Malignant neoplasm of rectum
C7A.010-C7A.019	Malignant carcinoid tumors of the small intestine
D12.6	Benign neoplasm of colon, unspecified
D13.2	Benign neoplasm of duodenum

D13.30-D13.39	Benign neoplasm of other and unspecified parts of small intestine
D37.2	Neoplasm of uncertain behavior of small intestine
D50.0-D50.9	Iron deficiency anemia
K50.00-K50.919	Crohn's disease (regional enteritis)
K90.0-K90.9	Intestinal malabsorption
K92.0	Hematemesis
K92.1	Melena
K92.2	Gastrointestinal hemorrhage, unspecified
R10.0-R10.9	Abdominal and pelvic pain
R19.5	Other fecal abnormalities
Z15.09	Genetic susceptibility to other malignant neoplasm [Lynch syndrome, polyposis syndromes]
Z80.0	Family history of malignant neoplasm of digestive organs
Z83.710-Z83.719	Family history of colonic polyps
Z86.010	Personal history of colonic polyps

When services are Not Medically Necessary:
For the procedure and diagnosis codes listed above when criteria are not met, for all other diagnoses not listed, or for situations designated in the Clinical Indications section as not medically necessary.

When services are also Not Medically Necessary:
For the following procedure codes; or when the code describes a procedure designated in the Clinical Indications section as not medically necessary.

CPT	
91111	Gastrointestinal tract imaging, intraluminal (eg, capsule endoscopy), esophagus, with interpretation and report
91113	Gastrointestinal tract imaging, intraluminal (eg, capsule endoscopy), colon, with interpretation and report
91299	Unlisted diagnostic gastroenterology procedure [when specified as use of patency capsule]
0651T	Magnetically controlled capsule endoscopy, esophagus through stomach, including intraprocedural positioning of capsule, with interpretation and report

ICD-10 Diagnosis	
	All diagnoses

Discussion/General Information

Wireless Capsule Endoscopy for Obscure GI Bleeding

The following are examples of two small bowel WCE devices with 510k clearance. The PillCam SB® (Given Imaging, Inc., Duluth, GA) received U.S. Food and Drug Administration (FDA) 510k clearance in 2004. The EndoCapsule® (Olympus America Inc., Center Valley, PA) received 510k clearance in 2007.

Two published studies compared the results of WCE and push enteroscopy (PE) in individuals with obscure gastrointestinal bleeding. Both reported that capsule endoscopy revealed additional information not provided by PE and rarely missed lesions detected by PE. The results were consistent across these two studies reporting additional diagnostic yield from WCE in 25 to 50% of the cases. For example, in one study of 20 individuals with obscure digestive tract bleeding, WCE found a bleeding site in 11 out of 20 (55%) of those studied and provided additional information not detected by PE in 5 out of 20 cases (25%). All of the lesions detected by WCE were distal to the region examined during PE (Lewis, 2002).

The second comparative study was conducted on 32 subjects in Germany (Ell, 2002). Overall, this study found that WCE identified a definite source of bleeding in 21 out of 32 subjects (66%) studied and provided additional information not detected by PE in 16 of 32 cases (50%). No significant complications from WCE were reported in these studies.

A meta-analysis compared WCE with other approaches (including small bowel barium radiography and PE) in identifying small bowel pathology in individuals with obscure gastrointestinal bleeding (Triester, 2005). The researchers extracted their findings from pooled data from studies which involved more than 500 participants. When WCE was compared with PE for obscure gastrointestinal bleeding, WCE resulted in a yield of 63% and enteroscopy 28%. With regards to clinically significant findings, WCE accounted for 56% and PE 26%. When WCE was compared with small bowel barium radiography, the yield for any findings was 67% and 8%, respectively. Clinically significant findings accounted for 42% and 6%, respectively.

Mylonaki and colleagues (2003) investigated the clinical efficacy and technical performance of capsule endoscopy and PE in a series of 50 subjects with colonoscopy and gastroscopy negative gastrointestinal bleeding. The source of bleeding was discovered in the small intestine in 34 of 50 subjects. The yield of WCE was superior to PE in evaluating the source of obscure bleeding in the small intestine (68% vs. 32% respectively). No complications were encountered with PE; however, several technical difficulties were encountered with WCE. The capsule was retained in the esophagus of 1 individual, and in 7 subjects the capsule passed into the pylorus and returned to the stomach. The battery stopped working in 16 (28%) and in 3 there was a temporary loss of images due to an electrical disconnection. A total of 49 of the 50 subjects preferred capsule endoscopy to PE while 2 found the capsule difficult to swallow.

Practice guidelines on the diagnosis and management of small bowel bleeding, published by the American College of Gastroenterology (ACG) support the use of WCE "as a first-line procedure for small bowel (SB) evaluation after upper and lower GI sources have been excluded, including second-look endoscopy when indicated". The ACG guidelines also indicate that in the diagnosis of small bowel bleeding, provided that the VCE in not contraindicated, "VCE should be performed before deep enteroscopy to increase diagnostic yield" (Gerson, 2015).

In its guidelines on Quality Indicators for Capsule Endoscopy and Deep Enteroscopy, the American Society of Gastrointestinal Endoscopy (ASGE) indicates that "substantial evidence and expert consensus exist" to support the use of capsule endoscopy as a diagnostic tool in individuals with "overt and occult suspected small bowel bleeding including iron-deficiency anemia"(Leighton, 2022).

Wireless Capsule Endoscopy for Crohn's Disease
Dionisio and colleagues (2010) used a meta-analysis to evaluate the diagnostic yield of WCE compared with other modalities in individuals with suspected and established Crohn's disease (CD). The other modalities included PE, colonoscopy with ileoscopy (C+IL), small bowel radiography (SBR), computed tomography enterography (CTE), and magnetic resonance enterography (MRE). Data on the diagnostic yield of the various modalities were extracted, pooled, and analyzed. Data on individuals with suspected and

established CD were analyzed separately. Weighted incremental yield (diagnostic yield of WCE-diagnostic yield of comparative modality) and 95% confidence intervals (CIs) of WCE over comparative modalities were calculated. A total of 12 trials (n=428) compared the yield of WCE with SBR in individuals with CD. Eight trials (n=236) compared WCE with C+IL; four trials (n=119) compared WCE with CTE; two trials (n=102) compared WCE with PE; and four trials (n=123) compared WCE with MRE. For the suspected CD subgroup, several comparisons met statistical significance. The researchers concluded that WCE is superior to SBR, CTE, and C+IL in the evaluation of individuals with suspected CD. The researchers also concluded that WCE is also a more effective diagnostic tool in established CD individuals compared with SBR, CTE, and PE.

A meta-analysis compared the yield of WCE with other modalities in symptomatic individuals with suspected or confirmed nonstricturing CD (Triester, 2006). The researchers examined the data of 11 prospective controlled trials, involving a total of 309 participants. The results suggested that WCE is superior to small bowel barium radiography (63% and 23% respectively), colonoscopy with ileoscopy (61% and 46% respectively), CT enterography/ CT enteroclysis (69% and 30% respectively) and PE (46% and 8% respectively) for diagnosing nonstricturing small bowel CD. While diagnostic yield of WCE was higher than that of small bowel MRI (72% and 50% respectively); the analysis relied on data from only one study with 18 subjects.

In another small study (n=43), subjects with or without known CD who were suspected to have small-bowel CD were prospectively evaluated with PE, enteroclysis, and WCE. Group 1 consisted of 22 individuals known to have CD, while Group 2 consisted of 21 individuals suspected of having small bowel CD. In Group 1, WCE detected more erosions than the other two investigations ($p<0.001$). In Group 2, a new diagnosis of CD was made in 2 subjects, but there was no significant difference in yield compared with the other two investigations. The referring physicians rated the usefulness of WCE as 4.4 on a scale of 5. The findings of WCE resulted in a change in the management of 30 participants (70%). The authors concluded that WCE has a higher yield than PE and enteroclysis in individuals with known CD when small-bowel mucosal disease is suspected, and this leads to a change in management in the majority of these individuals (Chong, 2005).

Albert and colleagues (2005) compared the diagnostic accuracy of WCE with MRI and enteroclysis in 52 subjects with suspected CD or with previously established non-small bowel CD. Thirty-nine (39) females and 13 males were investigated by MRI, fluoroscopy and, if bowel obstruction could be excluded, by WCE. CD was newly suspected in 25 of the individuals while the diagnosis of CD (non-small bowel) had been previously established in 27 individuals. Small bowel CD was diagnosed in 41 of the 52 participants (79%). WCE was not accomplished in 14 individuals due to bowel strictures. Of the remaining 27 participants, WCE, MRI, and fluoroscopy detected small bowel CD in 25 (93%), 21 (78%), and 7 (33%) of 21 cases, respectively. WCE was the only diagnostic tool used in 4 individuals. WCE was slightly more sensitive than MRI (12 versus 10 of 13 individuals with suspected CD and 13 versus 11 of 14 individuals with established CD). The researchers concluded that WCE and MRI are complementary methods for diagnosing small bowel CD. WCE is capable of detecting limited mucosal lesions that may be missed by MRI, but awareness of bowel obstruction is mandatory. In contrast, MRI is helpful in identifying transmural CD and extraluminal lesions, and may exclude strictures.

Dubcenco and colleagues (2005) reported on capsule endoscopy findings in individuals with established and suspected small-bowel CD correlated with radiologic, endoscopic, and histologic findings. Symptomatic eligible individuals had ileocolonoscopy and biopsies from the terminal ileum, followed by small-bowel radiologic studies before WCE. Endoscopic, radiologic, WCE, and histologic findings were compared. Histology (terminal ileum biopsy specimens or a tissue sample after small-bowel resection) served as the gold standard. Data were analyzed for 39 individuals. All study participants had histologic evaluation of the small bowel. A final diagnosis of active small-intestine CD was made in 29/39 participants (74.4%). When calculated, WCE yielded a sensitivity and specificity of 89.6% and 100.0%, respectively, and a positive predictive value and negative predictive value of 100.0% and 76.9%, respectively, whereas small-bowel series were 27.6% and 100.0% and 100.0% and 32.3% respectively. The researchers concluded that WCE is more accurate in detecting small-bowel inflammatory changes suggestive of CD than conventional studies. WCE when combined with ileocolonoscopy may be proposed as a first-line investigation of the small intestine in cases of uncomplicated known or suspected CD.

The ASGE indicates that based on “substantial evidence and expert consensus”, WCE is an acceptable tool for the diagnosis and surveillance of Crohn’s disease. The ASGE also reports that capsule retention has been reported in 2.4% of individuals with Crohn’s disease and cautions that all individuals undergoing CE should be evaluated for risk factors for capsule retention. Additionally, the group recommends the use of a patency capsule to decrease the risk of capsule retention in individuals with Crohn’s disease (Leighton, 2017).

The European Society of Gastrointestinal Endoscopy (ESGE) recommendations on the clinical use of VCE to investigate small-bowel, esophageal and colonic diseases (Ladas, 2010) state the following:

> The main reasons for a VCE procedure in Crohn’s disease are to establish the diagnosis, to assess disease prognosis, disease activity, and mucosal healing post therapy, and to define the extent and severity of disease. VCE examination may be particularly important before medication dosage is changed, and for follow-up after immunomodulators and biologics have been given. VCE may permit confirmation of the diagnosis when Crohn’s disease is suspected on clinical grounds, without a definite diagnosis from another modality.

In a more recent publication, the ESGE indicates CE is not an appropriate first-tier test to diagnose Crohn’s disease but may be an appropriate tool in individuals with suspected Crohn’s disease and negative ileocolonoscopy findings (Pennazio, 2015).

Wireless Capsule Endoscopy for Familial Syndromes
WCE is also being investigated as a means to carry out surveillance of the small bowel in individuals with Lynch syndrome (hereditary non-polyposis colorectal cancer [HNPCC]) or inherited polyposis syndromes including familial adenomatous polyposis (FAP). These conditions have a high risk for benign small-bowel polyps and cancer.

The ESGE (Ladas, 2010) recommends that based on the available published data, VCE may replace enteroclysis for surveillance in individuals with Peutz–Jeghers syndrome. The guideline also states that VCE “is indicated in FAP patients with duodenal polyps, because these patients may develop small-bowel polyps.” The guideline acknowledges that:

> Although capsule endoscopy allows better visualization of the small intestine than other noninvasive diagnostic methods, it has low sensitivity for identifying the major papilla and does not seem accurate in distinguishing the ampullary from the periampullary region. Therefore, the use of side-view duodenoscopy for staging duodenal disease is mandatory.

The ASGE Technology Status Evaluation Report on Wireless Capsule Endoscopy (Mishkin, 2006) concluded that WCE is a relatively new technology for assessment of the digestive tract. Small intestinal applications are the most extensively studied, and it has quickly become a first-line test for visualizing the mucosa of the small intestine. The most common applications include evaluation for “suspected small intestinal tumors and surveillance in patients with polyposis syndromes.”

Wireless Capsule Endoscopy for Iron Deficiency Anemia
WCE has been proposed to investigate unexplained iron deficiency anemia (IDA) when upper and lower endoscopic gastrointestinal evaluation is negative. Apostolopoulos and colleagues (2006) studied 253 consecutive individuals diagnosed with unexplained IDA.

Of this group, 51 had negative endoscopic workups. WCE was performed on these individuals. Following the WCE, air double-contrast enteroclysis was also performed on this group. WCE identified one or more small bowel lesions considered to be a likely cause of IDA in 29 of the 51 participants while enteroclysis identified abnormalities in only 6 of the 51 participants. WCE also identified all 6 of the radiographic findings.

In a retrospective case series, Muhammad and colleagues (2009) studied 424 individuals with IDA and negative standard endoscopic evaluations with or without obscure gastrointestinal bleeding (OGIB). The groups were further divided by age: those less than 50 years (group 1); 50-64 years (group 2); 65-85 years (group 3); and greater than 85 years old (group 4). In all groups, WCE identified small bowel erosion/ulceration and angiodysplasia. The highest percentage of these findings occurred in group 3 (65-85 years) and group 4 (greater than 85 years) in the IDA individuals with and without OGIB. The authors concluded that WCE is a valuable diagnostic tool for small bowel evaluation when standard endoscopic evaluations are negative. Further, they concluded that diagnostic yield of WCE in the evaluation of IDA progressively increases as age advances.

Wireless Capsule Endoscopy for Esophageal Disease

The PillCam ESO® (Given Imaging, Inc., Duluth, GA) received 510k clearance by the FDA in 2007 for imaging the esophagus.

WCE has been proposed as a diagnostic tool in the detection of Barrett's esophagus and other esophageal disorders. Unlike the small intestine, which in many cases cannot be directly visualized with PE, the esophagus can be directly visualized with an upper gastrointestinal endoscopy (EGD). For example, an EGD with or without a biopsy, is the standard technique to evaluate Barrett's esophagus in individuals with gastroesophageal reflux disease (GERD). If WCE is used as an alternative to EGD, those with a negative study could potentially forgo a conventional endoscopy. However, individuals with findings suggestive of Barrett's esophagus would require a confirmatory EGD with biopsy. Therefore the role of WCE requires consideration of specific selection criteria to establish the most efficient imaging hierarchy for evaluating the esophagus.

At the present time, there is limited published literature addressing these issues. In 2004, Eliakim compared WCE to conventional upper endoscopy for detection of esophageal pathologies. Endoscopy identified esophageal pathology in 12 of the 17 subjects. WCE identified esophageal pathology in all 12 and an additional pathology in 1 individual that was missed during endoscopy. The positive predictive value of the WCE for esophageal pathology was 92%; the negative predictive value was 100%. WCE specificity was 80% and sensitivity 100%. The authors concluded that while this study demonstrated that WCE is an accurate, convenient, safe and well-tolerated method to screen for esophageal disorders, additional large-scale studies are necessary to more fully assess this diagnostic tool. Other studies have examined modifications of WCE, such as attaching a string to the capsule which allowed the operator to manually control the movement of the capsule through the esophagus. In the first study, 30 subjects with clinical liver cirrhosis were enrolled; 19 for surveillance and 11 for screening purposes (Pennazio, 2004). Fifty individuals with Barrett's esophagus were enrolled in the second study (Ramirez, 2003). This modified procedure proved to be safe (no capsules were lost and no strings were disrupted) in both studies.

McCarty and colleagues (2017) conducted systematic review and structured meta-analysis of all studies to evaluate the efficacy of WCE for the screening and diagnosis of esophageal varices in individuals with portal hypertension. A total of 17 studies published between 2005 and 2015 were included in the meta-analysis (n=1328). The diagnostic accuracy of WCE for identifying esophageal varices was 90% (95% CI, 0.88-0.93). The diagnostic sensitivity and specificity were 83% (95% CI, 0.76-0.89) and 85% (95% CI, 0.75-0.91), respectively. The diagnostic accuracy WCE for grading medium to large varices was 92% (95% CI, 0.90-0.94). The sensitivity and specificity were 72% (95% CI, 0.54-0.85) and 91% (95% CI, 0.86-0.94), respectively, for grading of medium to large varices. Although in the majority of the studies participants reported minor discomfort due to the process of swallowing the capsule, 2 significant adverse events were described. Both events involved episodes of nausea or vomiting secondary to capsule retention which was caused by an unsuspected esophageal stricture. Of these 2 significant adverse events, one required EGD for the retrieval of the capsule. The authors acknowledged that the sensitivity of WCE is not sufficient to replace EGD and additional studies are needed to further evaluate the role of wireless capsule endoscopy in subjects with portal hypertension.

WCE for esophageal disorders is an emerging technology with diagnostic potential. However, the limited data currently available are too preliminary to establish its role in the evaluation of the esophagus.

Wireless Capsule Endoscopy for Colonic Disease

Obtaining images of the colon is another application being explored for WCE. WCE of the colon is particularly appealing when compared to the conventional means of bowel exploration (colonoscopy) because it is non-invasive, does not require sedation, intubation, insufflation, or radiation and no serious adverse effects have been reported. Researchers are exploring the use of WCE as an alternative method of colorectal cancer screening and as a substitute to conventional colonoscopy in the diagnosis of colonic diseases. Several studies have assessed the accuracy of WCE for the detection of colorectal disease.

Schoofs and colleagues (2006) reported the results of a pilot evaluation in humans of the safety, feasibility, and performance of colon capsule endoscopy compared with conventional colonoscopy. The study included 36 participants who were referred for screening colonoscopy or for suspicion of polyps or colorectal cancer. In the detection of any polyp, the sensitivity, specificity, PPV and NPV of conventional colonoscopy compared to WCE were 76%, 64%, 83%, and 54%, respectively. For the detection of three polyps or more, the sensitivity, specificity, PPV and NPV of WCE were 63%, 68%, 36%, and 86%, respectively. The authors concluded that results of WCE were encouraging but additional larger trials are needed.

Eliakim and colleagues (2006) conducted a prospective, multicenter study which evaluated 84 individuals who were referred for colonoscopy as part of colorectal cancer screening (43%), postpolypectomy surveillance (26%), and lower gastrointestinal signs and symptoms (31%). After undergoing colon preparation, the participants ingested the capsule on the morning of the examination, followed by conventional colonoscopy on the same day. The PillCam Colon capsule (PCC) findings were reviewed by three experts in capsule endoscopy who were blinded to the findings on conventional colonoscopy. Of the 84 participants, 20 (24%) had at least one polyp of 6 mm or more in size, or three or more polyps of any size: 14/20 (70%) were identified with capsule endoscopy and 16/20 (80%) were identified by conventional colonoscopy. Polyps of any size were found in 45 participants; 34/45 (76%) were detected by capsule endoscopy and 36/45 (80%) by conventional colonoscopy. With regards to any polyp thought to be significant (any polyp larger than 6 mm), the first reading of the capsule demonstrated a sensitivity, specificity, PPV and NPV of 50%, 83%, 40%, and 88%, respectively. All of these statistics were higher when a second reading of the capsule video was performed (a practice that is not commonly performed with small-bowel capsule endoscopy). In comparison with conventional colonoscopy, false-positive findings using the PCC were recorded in 15/45 cases (33%). There were no adverse events related to the capsule endoscopy.

Sieg and colleagues (2009) evaluated the feasibility and performance of WCE in comparison with special attention to a short colon transit time. WCE was prospectively tested in ambulatory subjects enrolled for colonoscopy who presented for screening or with positive fecal occult blood test. Study participants underwent colon preparation and ingested the capsule in the morning. Colonoscopy was performed after excretion of the capsule. Colonoscopy and WCE were performed by independent physicians who were blinded to the results. A total of 38 subjects were included in the study, but results were reported for the 36 individuals who successfully completed WCE and the conventional colonoscopy examination. One participant was excluded because the capsule remained in the stomach during the entire period of examination. Another participant had limited time and the procedure had to be

stopped when the capsule was still in the transverse colon. The capsule was excreted within 6 hours in 84% of the participants (median transit time 4.5 hours). If oral sodium phosphate was excluded from the preparation, the colon transit time increased to a median of 8.25 hours. In total, 7/11 polyps less than 6 mm detected by colonoscopy were identified by WCE. One polyp (less than 6 mm) detected by WCE was not identified by colonoscopy. No large polyps were found. One case of colorectal cancer (CRC) was detected by both methods. The mean rates of colon cleanliness (range from 1=excellent to 4=poor) in the cecum (2.1), transverse colon (1.6), and in the descending colon (1.5) were significantly better than in the rectosigmoid colon (2.6), and the overall mean rate during colonoscopy was significantly better than during WCE. No adverse effects occurred. The authors concluded that WCE appears to be a promising new modality for colonic evaluation and may increase compliance with CRC screening. To achieve a short colon transit time, sodium phosphate seems to be a necessary adjunct during preparation. The short transit time is a prerequisite to avoid the delay mode of the capsule. With an undelayed PCC, a "pan-enteric" examination of the gastrointestinal tract would be feasible. The authors further concluded that additional studies are needed to improve the cleanliness, especially in the rectum and to evaluate the method as a potential screening tool.

Triantafyllou and colleagues (2009) evaluated if PCC endoscopy can complete colon examination after failure of conventional colonoscopy to visualize the cecum. The study included 12 participants who had incomplete colonoscopy – 6 cases had an obstructing tumor of the left side of the colon, and in 6 cases there were technical difficulties to complete colonoscopy. The PCC endoscopy was able to visualize the rectum in 1 case. The capsule did not reach the site where colonoscopy stopped in 6 of the 12 cases (3 left-sided tumors and 3 with technical difficulties). In 1 of the 3 cases in which the capsule passed the site where colonoscopy stopped, poor bowel preparation precluded the accurate examination of the colon. A total of 4 participants underwent a third colon examination (three barium enemas and one virtual CT colonoscopy). There were no adverse events related to PCC endoscopy. The authors concluded that in subjects with incomplete colonoscopy, PCC endoscopy did not always satisfactorily examine the colon.

Van Gossum and colleagues (2009) conducted a prospective, multicenter study comparing WCE with optical colonoscopy for the detection of colorectal polyps and cancer. In this cohort of 328 participants, the subjects underwent an adapted colon preparation, and colon cleanliness was graded from poor to excellent. The sensitivity and specificity of WCE to detect polyps greater than or equal to 6 mm in size were 64% (95% CI, 59-72) and 84% (95% CI, 81-87), respectively. The sensitivity and specificity of WCE to detect advanced adenoma were 73% (95% CI, 61-83) and 79% (95% CI, 77-81), respectively. Of 19 cancers discovered by colonoscopy, 14 were identified by WCE (sensitivity, 74%; 95% CI, 52-88). For all lesions, the sensitivity of WCE was higher in subjects with good or excellent colon cleanliness than in those with fair or poor colon cleanliness. Mild-to-moderate symptoms (abdominal discomfort, nausea, vomiting and headache) were reported in 26 (7.9%) of the 328 participants who completed the study and resolved within 48 hours. The authors concluded that the use of WCE of the colon allows visualization of the colonic mucosa in most individuals, but its sensitivity for identifying colonic lesions is low when compared with the use of optical colonoscopy.

Pilz and colleagues (2010) reported the results of a prospective study comparing WCE to conventional colonoscopy as the gold standard. A total of 59 individuals were included in the study and results were evaluable in 56 participants. Polyp detection rate for significant polyps was 11% on colonoscopy and 27% on WCE. Conventional colonoscopy detected 6/56 (11%) subjects with polyps which were not identified by WCE. For polyps of any size, the sensitivity of WCE was 79% (95% CI, 61-90), specificity was 54% (95% CI, 35-70), PPV was 63% and NPV was 71%. The authors concluded, “in comparison to the gold standard, the sensitivity of WCE for detection of relevant polyps is low; however, the high NPV supports its role as a possible screening tool.”

In a prospective study, Rex and colleagues (2015) enrolled 884 individuals at average risk for colon cancer. All participants underwent WCE followed by conventional optical colonoscopy several weeks later. The conventional colonoscopy was conducted by an endoscopist blinded to capsule results. An unblinded colonoscopy was carried out on participants found to have lesions 6 mm or larger by capsule but not conventional colonoscopy. A total of 189 (21%) individuals were excluded from analysis due to inadequate cleansing, rapid colon transit time (less than 40 minutes), site termination and individuals lost to follow-up. Capsule endoscopy detected polyps 6 mm or larger with 81% sensitivity (95% CI, 77%-84%) and 93% specificity (95% CI, 91%-95%). WCE detected polyps 10 mm or larger with 80% sensitivity (95% CI, 76%-84%) and the specificity was 97% (95% CI, 96%-98%). Capsule colonoscopy identified subjects with 1 or more conventional adenomas 6 mm or larger with 88% sensitivity (95% CI, 82%-93%) and 82% specificity (95% CI, 80%-83%), and 10 mm or larger with 92% sensitivity (95% CI, 82%-97%) and 95% specificity (95% CI, 94%-95%). Sessile serrated polyps and hyperplastic polyps accounted for 26% and 37%, respectively, of false-negative findings from capsule analyses.

Spada and colleagues (2010) performed a systematic review and meta-analysis to assess the accuracy of WCE in detecting colorectal polyps. A total of 8 studies providing data on 837 subjects demonstrated WCE sensitivity for polyps of any size and significant findings (polyps greater than or equal to 6 mm in size or more than three in number) were 71% and 68%, respectively. The specificity of WCE for polyps of any size and significant findings were 75% and 82%, respectively.

Researchers are also exploring the use of WCE as an alternative method for assessing the extent and severity of ulcerative colitis. Sung and colleagues (2012) evaluated 100 individuals with suspected or known ulcerative colitis by performing WCE and colonoscopy on the same day. The authors reported WCE sensitivity and specificity to detect active colonic inflammation was 89% (95% CI, 80-95) and 75% (95% CI, 51-90), respectively. The PPV and NPV were 93% (95% CI, 84-97) and 65% (95% CI, 43-83), respectively. The researchers concluded that while WCE is a safe procedure to monitor mucosal healing in ulcerative colitis, at this stage, it cannot be recommended to replace conventional colonoscopy in the management of this condition.

Oliva and colleagues (2014) assessed the diagnostic accuracy of a second-generation WCE (WCE-2) device in evaluating the disease activity of ulcerative colitis in a pediatric cohort. Colonoscopy was used as a gold standard and disease extent, tolerability, interobserver agreement and safety were measured. The 30 consecutive pediatric participants with ulcerative colitis who were prospectively enrolled in the study initially underwent WCE-2 which was followed by colonoscopy later on the same or the following day. The blinded procedures were performed and the diagnostic accuracy of WCE-2 to identify disease activity was determined using a modified Matts score, which classified the participants as either normal (Matts score ≤ 6) or with active inflammation (Matts score > 6). Interobserver agreement was determined using the kappa statistic. One participant, who was unable to swallow the capsule was excluded, leaving 29 subjects available for analysis. The sensitivity of WCE-2 for disease activity was 96% (95% CI, 79-99) and the specificity was 100% (95% CI, 61-100). The positive and negative predictive values of WCE-2 were 100% (95% CI, 85-100) and 85% (95% CI, 49-97), respectively. The authors reported no serious adverse events. Overall, the WCE-2 had a higher tolerability than colonoscopy ($p<0.05$). In all cases, the interobserver agreement was excellent ($\kappa>0.86$). The investigators concluded using a modified Matts score, CCE-2 was accurate in evaluating significant mucosal inflammation in pediatric subjects with ulcerative colitis.

The report of the Canadian Agency for Drugs and Technologies in Health (CADTH) on capsule colonoscopy/PillCam Colon concluded that there is limited evidence on WCE in imaging the colon. Larger, multi-center trials that compare WCE with colonoscopy are needed. The evidence to support the use of WCE in screening for colorectal cancer is also lacking (Tran, 2007).

The ASGE emerging technology report (2008), which provides scientific reviews solely for educational and informational purposes, highlights several areas in which additional research is needed for colonic WCE, including but not limited to the following:

- Large prospective studies to assess its efficacy and limitations in colorectal cancer screening, as well as the investigation of signs and symptoms suggestive of large-bowel pathology, are required.
- Capsule retention rates, complications, and patient tolerability relative to other colorectal cancer screening strategies need to be defined.
- The value of this device in patients with less than optimal bowel preparation needs to be addressed, particularly given the inability to further cleanse an inadequately prepared colon.
- Cost analyses of this technology compared with conventional colonoscopy are warranted, because positive findings will require a conventional colonoscopy for confirmation and therapy. In addition, the time required to read a capsule endoscopy is likely longer than that required to perform a traditional endoscopic examination.
- Further investigation of optimal bowel preparation and timing of colon imaging is needed.

The European guidelines for quality assurance in colorectal cancer screening and diagnosis indicate WCE is not recommended for colorectal cancer screening and provide the following conclusions with regards to the diagnostic performance of WCE:

> Capsule endoscopy bears promise as an alternative to colonoscopy, because the examination can be realised without intubation, insufflation, pain, sedation or radiation; no serious adverse effects have been reported. However, accuracy data show inferior performance compared to colonoscopy (III). Better diagnostic performance results from large multicentre prospective trials in the average-risk population are required before capsule endoscopy can be recommended for screening (VI - A). (Lansdorp-Vogelaar, 2012).

In 2014, the FDA approved the PillCam® COLON 2 (Given Imaging Ltd. [Yoqneam, Israel]) as a *de novo* Class II device that may be marketed and used as predicates for future 510(k) submissions. The FDA *de novo* approval letter indicates the PillCam COLON 2 is a new modality "intended to be used for detection of colon polyps in patients after an incomplete optical colonoscopy with adequate preparation, and a complete evaluation of the colon was not technically possible." According to information in the FDA Decision Summary, clearance was based on a clinical trial comparing WCE with optical colonoscopy based on the presence or absence of at least one finding of a polyp ranging in size from 6 mm to 10 mm on optical colonoscopy. Candidates for the study were individuals between the age of 50 and 75 years, at average risk for colorectal cancer. At the time of this review, the results of this study were not found in the peer-reviewed, scientific literature. Information on the manufacturer's web site indicates that contraindications to the PillCam COLON 2 device include individuals with: (1) known or suspected GI obstruction, strictures or fistulas based on the clinical picture or pre-procedure testing and profile; (2) cardiac pacemakers or other implanted electro-medical devices; (3) swallowing disorders and (4) allergies or known contraindications to the medications and preparation agents used in the procedure as described in the relevant instructions for use.

Baltes and colleagues (2018) conducted a prospective, multi-center study to examine the ability of PillCamColon2 to visualize colonic segments missed by incomplete conventional colonoscopy and evaluate the diagnostic yield. This trial included a total of 81 participants from 9 centers who underwent 2nd-generation WCE following incomplete conventional colonoscopy performed by an experienced gastroenterologist (more than 1,000 colonoscopies); subjects with stenosis were excluded from the study. Based on participant preferences, WCE was performed the following day (protocol A) after staying on clear liquids and 0.75 L Moviprep in the morning or within 30 days after new split-dose Moviprep (protocol B). If the capsule was not excreted after 7 hours, boosts of 0.75 L and 0.25 L Moviprep, and phospho-soda was administered as a rescue. A total of 74 participants were evaluated (51% in cohort A; 49% in cohort B). Adequate bowel cleansing was achieved in 67% of cases, and WCE could visualize colonic segments missed by incomplete colonoscopy in 90 % of participants under protocol A and 97% of participants under protocol B (p=0.35, n.s.). Significant polyps including adenocarcinoma were identified in 24% of cases. Detection rates for all polyps and significant polyps per participant were similar in both protocols. Polyps were discovered predominantly in the right colon (86%) in segments that were not reached by conventional colonoscopy. Extra-colonic findings such as suspected BE, upper GI-bleeding, reflux esophagitis, gastric polyps, gastric erosions and angiectasia were identified in 8 subjects. PillCamColon2 capsule was retained in the ileum of 1 subject (1.4%) without symptoms and removed during an uneventful resection for unknown CD that was diagnosed as the cause of anemia. Overall, WCE was well-tolerated; 1 individual suffered from self-limiting vomiting after consuming the phospho-soda. The authors concluded that PillCam Colon 2 using a low-volume preparation was useful after incomplete conventional colonoscopy, and it allowed for the identification of additional relevant findings, however, bowel cleansing efficiency could be improved.

In an observational, prospective, single-center study, Hussey and associates (2018) examined the efficacy of same-day WCE after incomplete conventional colonoscopy in an unselected patient cohort. Researchers recruited individuals with an incomplete conventional colonoscopy for any reason other than obstruction or inadequate bowel preparation. WCE was performed after a minimum of a 1-hour fast. Once the subject was fully alert, intravenous metoclopramide was administered after capsule ingestion when possible, and a standard WCE booster protocol was then followed. Relevant clinical information as well as WCE completion rates, findings and their impact, and adverse events were recorded. A total of 50 subjects were recruited; mean age of 57 years and 66% (n=32) were women; 76% (n=38) of WCEs were complete; however, complete colonic views were obtained in 84% (n=42) of cases. The researchers found that participants older than 50 years of age were 5 times more likely to have an incomplete WCE and there was also a trend towards known co-morbidities associated with hypomobility resulting in reduced excretion rates. The diagnostic yield for WCE in the unexplored segments was 74% (n=37), with 26% (n=13) of subjects requiring significant changes in management based on WCE findings. The overall incremental yield was 38 %; WCE findings were normal in 26% (n=13), identified polyps in 38% (n=19), inflammation in 22% (n=11), diverticular disease in 25% (n=12), angiodysplasia in 3% (n=1) and cancer in 3% (n=1). Significant small bowel findings were identified in 3 (6%) cases, including a neuroendocrine tumor and CD. One individual (2%) experienced a major adverse event related to capsule retention. The authors concluded that same-day WCE was a feasible alternative means to evaluate unexplored segments of the colon after incomplete conventional colonoscopy in selected subjects.

Kobaek-Larsen et al (2018) conducted a study to determine the polyp detection rate and per-patient sensitivity for polyps greater than 9 mm of WCE compared with conventional colonoscopy as well as the diagnostic accuracy of WCE. Participants who had a positive immunochemical fecal occult blood test during screening underwent investigator blinded WCE and conventional colonoscopy. Participants underwent repeat endoscopy if significant lesions detected by WCE were considered to have been missed by colonoscopy. Of the 253 participants, the polyp detection rate was significantly higher in WCE compared with colonoscopy (p=0.02). The per-subject sensitivity for greater than 9 mm polyps for WCE and colonoscopy was 87% (95 % CI: 83%-91%) and 88% (95% CI: 84%-92%) respectively. In individuals with complete WCE and conventional colonoscopy examinations (n=126), per-subject sensitivity of greater than 9 mm polyps in CCE (97%; 95% CI: 94%-100%) was superior to conventional colonoscopy (89%; 95% CI: 84%-94%). A complete WCE examination (n=134) could detect individuals with intermediate or greater risk (according to the European guidelines) with an accuracy, sensitivity, specificity and positivity rate of 79%, 93%, 69% and 58% respectively, using a cut-off of at least 1 polyp of larger than 10 mm or more than 2 polyps. The authors concluded that WCE was superior to conventional colonoscopy in polyp detection rate and per-patient sensitivity to greater than 9 mm polyps, but only in complete WCE examinations. The authors also acknowledged that the rate of incomplete WCE examinations must be improved.

Most of the studies evaluating the effectiveness of WCE to detect colonic lesions have been done on individuals with a clinical indication for colonoscopy rather than for use as a screening tool for the general population. Based on the available literature, studies

evaluating the efficacy of WCE compared with conventional colonoscopy for the detection of colonic diseases have demonstrated variable results. There is also insufficient evidence at this time demonstrating that WCE results in improved clinical utility in identifying colonic diseases when compared to conventional colonoscopy. Larger, randomized studies demonstrating WCE is of equal or greater value than conventional colonoscopy as a tool to detect colonic diseases are needed.

Current limitations of WCE are its requirement for highly effective bowel preparation because the colon is not well visualized with WCE when stool obscures observation of the colonic mucosa. Visualization of the colonic mucosa is also more difficult in the colon versus the small intestines because the colon is larger in diameter and transit time is slower in the colon. It is possible that WCE may miss suspicious areas of the colon because the camera is pointed in the wrong direction as it passes the suspect area. Additionally, WCE does not allow for polyp removal or biopsy, so any lesions identified during the wireless capsule examination typically require subsequent colonoscopy for further evaluation and/or treatment.

Wireless Capsule Endoscopy for Other Applications
At this time there are inadequate data regarding other applications of WCE including, but not limited to, evaluation of irritable bowel syndrome, celiac disease, small intestinal diverticula and intussusception. Culliford and colleagues (2005) describe 47 individuals in whom capsule endoscopy was used to evaluate complicated celiac disease. The study results were consistent with celiac disease in 87% of the cases, but also resulted in some unexpected findings, including one case of intussusception. In another study by Anato and colleagues (2007), an unsuspected case of intussusception was diagnosed as researchers evaluated the efficacy and clinical impact of WCE in 37 children (over 3 years [2002-2005]). Thomson and colleagues (2007) had a similar experience when they investigated 28 consecutive children with suspected small bowel disease and inadvertently discovered a case of an intussusception of the upper jejunum. Xue and colleagues (2015) reported the results of a systematic review evaluating WCE for unexplained chronic abdominal pain. A total of 1520 participants from 21 studies were included. The pooled diagnostic yield of small bowel WCE was 20.9% (95% CI, 15.9%-25.9%). Inflammatory lesions were identified most often (78.3%), followed by tumors (9.0%). The authors acknowledge that limitations of the study included its retrospective design, the various types of examinations prior to small bowel capsule endoscopy and the dissimilar durations of abdominal pain.

Magnetically Controlled Capsule Endoscopy
WCE continues to be explored as a means to visualize the upper gastrointestinal tract. However, due to some of the anatomical and functional features of the upper gastrointestinal tract (for example, peristaltic waves and the irregular and capacious anatomy of the stomach), wireless capsules endoscopy has not been suitable for a thorough examination of the mucosal walls of the gastric cavity. Magnetically controlled capsule endoscopy, also referred to as magnetically assisted capsule endoscopy (MACE), is being investigated as a means to improve the diagnostic yield of WCE by utilizing external magnets to steer and direct the wireless capsule endoscope through at least a portion of the GI tract. It is theorized that this method will allow practitioners to manually direct the capsule to different areas of the esophagus and stomach and allow complete gastric mucosal examination. Because this is a minimally invasive procedure, researchers are hopeful that magnetically controlled capsule endoscopy may provide an alternative to conventional upper gastrointestinal endoscopy without the need for anesthesia. Limitations of magnetically controlled capsule endoscopy include the inability to obtain histology samples. Also, the performance of magnetically controlled capsule endoscopy requires adequate gastric preparation, gastric distention, and a standardized methodology for its use (Ching, 2016; Rahman, 2016).

In general, magnetically controlled capsule endoscopy systems are composed of some basic components: an ingestible (wireless) capsule endoscope that contains magnetic material, an external guidance magnet, a data recorder, and a computer workstation with software for real-time viewing. As the wireless capsule transits the upper gastrointestinal tract, the external magnetic field is exploited to steer and drive the capsule for a more controlled examination of the gastrointestinal cavity.

Swain and colleagues (2010) conducted the first in-human study using a magnetically controlled capsule to visualize the esophagus and stomach. In this case study a wireless capsule endoscope was modified to include neodymium-iron-boron magnets. The capsule's magnetic switch was substituted for a thermal one and activated by placing it in hot water. One imager was removed from the PillCam colon-based capsule and the available space was used to house the magnets. A handheld external magnet was used to maneuver the capsule in the esophagus and stomach. The capsule was swallowed by the participant and observed in the esophagus and stomach by using a gastroscope. Researchers were able to view images captured by the capsule on a real-time viewer and move the capsule to any designated location by moving a handheld external magnet around the torso of the volunteer.

Keller and colleagues (2010) reported the results of a study that demonstrated the feasibility of a magnetically controlled capsule endoscope to visualize the esophagus. Researchers compared the PillCam ESO2® (Given Imaging Ltd. Duluth GA), designed to examine the esophagus, with a modified version of the PillCam COLON (Given Imaging, Ltd. Duluth GA) which was customized to allow manipulation of the capsule by an external magnet paddle. A total of 10 healthy volunteers swallowed a conventional capsule (ESO2; Given Imaging) and a capsule endoscope with magnetic material which was activated by a thermal switch, in random order (1 week apart). The external magnetic paddle was removed when the magnetic maneuverable capsule had entered the stomach. Responsiveness of the magnetically controlled capsule endoscope was evaluated on a screen showing the capsule film in real time. Although external manipulation of the capsule proved to be achievable, the authors were unable to consistently reproduce tumbling (somersault) movements of the capsule within the esophagus. Additionally, the magnetic forces were not strong enough to hold the magnetically controlled capsule endoscope against peristalsis when the capsule approached the gastroesophageal junction.

In another study, researchers explored the feasibility and safety of magnetically controlled capsule endoscopy for examination of the human stomach (Liao, 2012). In this pilot study, 34 healthy participants ingested the magnetically controlled capsule endoscope and gas-producing powder to produce gastric distention. An external robot was used to manipulate the magnetically controlled capsule inside the stomach. The primary measurements included safety, gastric preparation, maneuverability, and gastric mucosa visualization. Gastric preparation and examination were well accepted by participants and no adverse events were reported. Gastric cleanliness was evaluated as good in 30 (88.2%) participants and as moderate in 4 (11.8%) participants. The distention of the gastric cavity was rated as good in 29 (85.3%) individuals and moderate in 5 (14.7%) subjects. Maneuverability of the capsule using magnetic guidance was graded as good in 29 (85.3%) subjects and moderate in 5 (14.7%) subjects. More than 75% of the gastric mucosa was visualized in 27 (79.4%) participants and 50% to 75% in 7 (20.6%) participants. Visualization of the gastric cardia, fundus, body, angulus, antrum and pylorus was subjectively judged as complete in 82.4%, 85.3%, 100.0%, 100.0%, 100.0% and 100.0%, respectively. Erosive lesions and polyps were found in 7 participants. The authors concluded that magnetically controlled capsule endoscopy is a feasible and safe method to examine the human stomach.

Rey and colleagues (2012) conducted a blinded capsule and gastroscopy comparative study. A total of 61 individuals with gastric pain participated in the study. Magnetically controlled capsule endoscope examination was performed 24 hours after participants had undergone upper gastrointestinal endoscopy. To remove food residue or mucus, subjects consumed 900 mL of water in 2 portions. Then to provide the air-water interface required by the guidance system, the participants consumed 400 mL of water at 35°C. Complete visualization of the gastric pylorus, antrum, body, fundus, and cardia was evaluated in 88.5%, 86.9%, 93.4%, 85.2%, and 88.5% of subjects, respectively. With regards to gastric lesions, 58.3% were detected by both upper gastrointestinal endoscopy and magnetically controlled capsule endoscopy. Capsule examination missed 14 findings that were identified by upper gastrointestinal endoscopy and upper gastrointestinal endoscopy failed to identify 31 findings detected with magnetically controlled capsule

endoscopy. However, of the lesions that were identified only by the capsule, all were determined to be clinically insignificant in that they were multiple benign gastric polyps or angiomas. Limitations of the study include but are not limited to its nonrandomized design. Additionally, because in accordance with the study protocol upper gastrointestinal endoscopy was always performed prior to visualization with the capsule, it is possible that some of the minute erosions identified by the magnetically controlled capsule endoscope were caused by the upper gastrointestinal endoscopy that had been performed the previous day. The authors also thought it important to emphasize the following:

> Capsule findings were not only diagnosed immediately but also by review of the recorded data by using reading software; this could explain the high number of hyperplastic polyps or minute erosions detected by the capsule, given that the overall time for diagnosis was much longer than for conventional gastroscopy. Further clinical studies should also include high-definition gastroscopy with new technological enhancements such as narrow-band imaging.

Denzer and colleagues (2015) investigated the accuracy of magnetically controlled capsule endoscopy versus conventional upper gastrointestinal endoscopy in individuals with routine indications for upper gastrointestinal endoscopy. Main outcome was accuracy (sensitivity/specificity) of magnetically controlled capsule endoscopy for diagnosis of major gastric lesions, defined as those lesions requiring conventional upper gastrointestinal endoscopy for biopsy or removal. Evaluation of the esophagus and duodenum was not included in this study. A total of 189 symptomatic participants (105 male; mean age 53 y) from two medical centers subsequently and blindly underwent capsule and conventional gastroscopy by nine and six examiners, respectively. Examiners received a standard indication list but were blinded to previous findings, suspected diagnoses, and participant history. Magnetically controlled capsule endoscopies and conventional upper gastrointestinal endoscopies were always performed by different examiners who were blinded to the results of the other test. Magnetically controlled capsule endoscopy was always performed prior to conventional upper gastrointestinal endoscopy. Twenty-three major lesions were found in 21 participants. The accuracy of magnetically controlled capsule endoscopy was 90.5% (95% CI, 85.4%-94.3%) with a specificity of 94.1% (95% CI, 89.3%-97.1%) and a sensitivity of 61.9% (95% CI, 38%-82%). Accuracy did not correlate with the location of the lesion, gastric luminal visibility, examiner case volume, or examination time. Of the remaining 168 participants, 94% had minor and mostly multiple lesions; the magnetically controlled capsule made a correct diagnosis in 88.1% (95% CI, 82.2%-92.6%), with gastric visibility and lesion location in the proximal stomach having significant influence. The magnetically controlled capsule gastroscopy was preferred by the participants.

In 2016, Rahman and colleagues evaluated the maneuverability and the ability of a magnetically controlled capsule system to completely visualize and maintain views in the upper gastrointestinal tract. A total of 26 volunteers were recruited to participate in the study. The hand-held magnet was placed at specific points on the body surface and rotated to hold and move the capsule. The ability to view the upper GI tract landmarks (esophagogastric junction [EGJ]), cardia, fundus, body, incisura, antrum, and pylorus) were documented. Control was measured by the ability to hold the capsule for 1 minute at 5 positions: the lower esophagus and 4 designated positions in the distal and proximal stomach as well as being able to transverse the stomach and through the pylorus. Study participants subsequently underwent a standard upper gastrointestinal endoscopy. The researchers found that magnetically controlled wireless capsule was able to successfully visualize landmarks: EGJ, 92%; cardia, 88%; fundus, 96%; body, 100%; incisura, 96%; antrum, 96%; and pylorus, 100%. Difficulties were encountered near the esophagogastric junction, where peristaltic forces overcame the magnetic hold. An age of 40 years or greater was associated with successful pyloric traversing (p=0.04). There was positive concordance for 8 of 9 minor pathological findings identified on standard upper gastrointestinal endoscopy.

It has been estimated that 20-30% of individuals undergoing WCE of the small bowel may experience an incomplete small bowel examination due to the capsule not reaching the cecum within the recording time (approximately 9 hours). Delays in the capsule traveling through the gastrointestinal tract may be secondary to the capsule being unable to traverse a stricture, or both delayed gastric emptying and/or slow small bowel transit. Researchers have begun exploring if the magnetically controlled capsule system can be used to facilitate passage of the capsule through the pylorus, thereby reducing the gastric transit time (GTT) (Cotter 2013; Hale 2015; Luo2019).

Hale and colleagues (2015) investigated the feasibility of using magnetically controlled capsule endoscopy to improve capsule endoscopy completion rates. In the prospective, single-center randomized controlled trial, a total of 122 participants underwent small bowel capsule endoscopy. Participants were randomized using a computer-generated random number sequence to enter one of two protocols with 61 participants assigned to each arm. The control group involved mobilization for 30 minutes after capsule ingestion, followed by intramuscular metoclopramide 10mg (if the capsule failed to enter the small bowel) while participants in the intervention group consumed 1000mL of water prior to capsule ingestion, followed by positional change and magnetic steering. The primary outcome measure for the effect of magnetic control on transpyloric transit of the capsule was capsule endoscopy completion rate (CECR). Secondary outcome measures included gastric mucosal clarity, gastric distention, relationship of body habitus to capsule endoscopy completion rate (CECR), and patient comfort scores. The researchers observed no significant difference in CECR between the two groups (P= 0.39). Time to first pyloric image was significantly shorter in the intervention group (P= 0.03) but GTTs were similar for both groups (P= 0.12), suggesting that magnetic control accelerates capsular transit to the gastric antrum but does not affect duodenal passage. Gastric distention and clarity were better in the intervention group (P<0.0001 and P< 0.0001 respectively). In two participants, the capsule was retained in the stomach for the duration of the procedure, so only demographic data and CECR were analyzed. A subanalysis of the intervention group revealed that in 23 (37.7 %) procedures, the capsule could be manipulated into the duodenum under magnetic control within the 30-minute timeframe. No significant association between BMI and CECR (P=0.51) or waist-hip ratio and CECR (P= 0.94) was observed. Similarly, there was no significant association between BMI and gastric transit time, or waist-hip ratio and GTT. Eleven participants did not return their comfort questionnaires and thus were excluded from the patient tolerance analysis. No cases of capsule retention or significant adverse events were reported. The authors concluded that magnetically controlled capsule endoscopy provided improved gastric clarity and distention in the intervention group but did not improve the CECR or improve gastric emptying time.

Similarly, Luo and colleagues (2019) conducted a study to determine whether magnetic steering could improve the CECR compared to standard protocol. Between June 2017 and November, a total of 227 subjects referred to a single institution for magnetically controlled capsule endoscopy were enrolled in the study: 120 in the control group and 107 in the intervention group. Magnetic steering of the capsule through the pylorus was carried out after standard gastric examination. CECR, GTT, pyloric transit time, and rapid gastric transit (GTT≤30 min) rate were compared with a historical control group enrolled from January 2017 to May 2017. The intervention was considered to have failed if the capsule did not pass through the pylorus within 30 minutes. CECR was higher in the intervention group (n=107) than control group (n=120) (100% vs. 94.2%, P=0.02), with a shorter GTT (22.2 vs. 84.5 min, P<0.001) and PTT (4.4 vs. 56.7 min, P<0.001). Rapid gastric transit rate in the intervention arm was higher than the control group (58.9% vs. 15.0%, P<0.001). There were no statistical differences in the diagnostic yields between the two arms. The authors concluded that magnetically controlled capsule endoscopy improves small bowel CECR by reducing GTT. Limitations of the study include but are not necessarily limited to its small sample size and non- randomized design. The authors acknowledged that larger randomized controlled trials are warranted.

In 2020, the FDA granted de Novo classification for the Navicam®, MCE (Ankon Technologies Co., Ltd., Wuhan, Shanghai, China). The Navicam consists of a WCE, a magnetic-guidance robot, a data recorder and a computer workstation for real-time observation and capsule navigation control. According to the FDA approval letter, the Navicam magnetically controlled capsule endoscope “is

intended for visualization of the stomach of adults (≥ 22 years old) with a BMI less than 38. The system can be used in clinics and hospitals, including ER settings".

Magnetically controlled capsule endoscopy is a promising alternative for screening and diagnosing gastric diseases that offers the advantage of not requiring anesthesia. However, capsule endoscopy of the stomach does not allow for biopsy and intervention as afforded by conventional endoscopy. Most of the peer-reviewed scientific literature on magnetically controlled capsule endoscopy consists of uncontrolled, feasibility studies and small randomized trials. Currently, there is insufficient data to determine whether magnetically controlled capsule endoscopy results in an improvement in diagnostic yield or net health outcomes in individuals experiencing gastrointestinal disorders. Larger, well-designed studies are needed that demonstrate magnetically controlled capsule endoscopy is as effective as established methods for diagnosing gastrointestinal disorders (for example, upper gastrointestinal endoscopy) and results in improved clinical outcomes.

Patency Capsule

In 2006 the FDA granted 510(k) clearance for the Agile™ Patency System (Given Imaging, Inc., Duluth, GA). According to the FDA approval letter:

> The Agile™ Patency System is an accessory to the PillCam SB video capsule and is intended to verify adequate patency of the gastrointestinal tract prior to administration of the PillCam SB video capsule in patients with known or suspected strictures in adults and children from two years of age.

A few small studies have reported on the use of a patency capsule prior to WCE in individuals suspected of having intestinal strictures potentially resulting in retention of an endoscopy capsule (Boivin, 2005; Delvaux, 2005; Signorelli, 2006; Spada, 2005, 2007a, 2007b). The size of the patency capsule is similar to the WCE capsule but it is made of lactose with barium and is designed to dissolve within 30-100 hours of entering the intestinal tract. It carries a radiofrequency tag that can be detected by a scanning device. Excretion of the intact capsule within a given time period without symptoms of abdominal pain or obstruction suggests that a subsequent endoscopy capsule can be safely passed. The published studies mostly involved individuals with known CD, and asymptomatic passage of an intact patency capsule was associated with a subsequent uncomplicated WCE. The onset of symptoms or delay in passage with disintegration of the capsule resulted in the cancellation of the subsequent WCE. Nevertheless the patency capsule produced abdominal pain and obstructive symptoms in a number of individuals, with occasional need for emergency hospitalization or surgical intervention. It is also unclear whether those who were denied WCE based on the patency capsule outcome would have in fact experienced complications related to the endoscopy capsule.

Zhang and colleagues (2014) conducted a meta-analysis to estimate the diagnostic value of the patency capsule based on the existing trials. The researchers used PubMed, CENTRAL and EMBASE to search for studies that included individuals with suspected small bowel stricture who were evaluated by both the patency capsule and a reference standard (following capsule endoscopy and/or surgical pathology and/or endoscopic findings). The quality of the eligible studies was evaluated using the Quality Assessment for Diagnostic Accuracy Studies-2 criteria. Calculations were carried out to determine the sensitivity, specificity, likelihood ratios and the area under the receiver operating characteristic curve (AUROC). A total of five studies (203 subjects) met the eligibility criteria. The pooled data demonstrated a PC sensitivity of 97% (95% CI, 93-99%) and a specificity of 83% (95% CI, 65-94%). The AUROC was 0.9557. The researchers concluded the patency capsule may be of diagnostic value in confirming the patency of the GI tract prior to capsule endoscopy.

The ASGE recommends the use of the patency capsule to predict safe passage of a standard capsule endoscope in individuals at high risk of capsule retention, such as individuals with Crohn's disease (Leighton, 2022).

Larger, randomized studies are needed to validate the role of the patency capsule in preventing adverse outcomes compared to established methods of evaluation in individuals being considered for WCE.

Definitions

Anemia with iron deficiency: A condition when available iron is insufficient to support normal red blood cell production. This can be caused by overt or obscure chronic blood loss, notional deficiency or malabsorption of iron in the gastrointestinal tract.

Barrett's esophagus: A premalignant condition associated with gastroesophageal reflux disease (GERD).

Celiac disease: A genetic disorder where eating certain types of protein, called gluten, sets off an autoimmune response that causes damage to the small intestine; this, in turn, causes the small intestine to lose its ability to absorb the nutrients found in food which may lead to significant disorders of malnutrition.

Crohn's disease: Inflammation in the small intestine; Crohn's disease usually occurs in the lower part of the small intestine, called the ileum, but it can affect any part of the digestive tract, from the mouth to the anus; the inflammation extends deep into the lining of the affected organ.

Deep enteroscopy: A procedure which involves the advancement of a long endoscope into the small intestine for both diagnostic and therapeutic purposes; also known as balloon assisted enterosocopy.

Enteroclysis: A radiologic examination of the small intestine carried out by infusing radiocontrast through a tube inserted through the nose or throat to the duodenum, or jejunum. Images are taken in real time as the contrast moves through the digestive tract, aided by administration of methyl cellulose. CT enteroclysis is also now available which combines the advantages of CT and conventional enteroclysis.

Esophagogastroduodenoscopy (EGD): A diagnostic endoscopic procedure that visualizes the upper part of the gastrointestinal tract down to the duodenum; Also referred to as gastroscopy, upper endoscopy or upper gastrointestinal endoscopy.

Intussusception: A disorder in which a part of the intestine folds itself telescopically into another section of the intestine.

Obscure GI bleeding: A positive fecal occult blood test or visible GI bleeding with no bleeding source identified.

Polyposis syndromes: A group of rare hereditary multisystem disorders which support the development of multiple gastro-intestinal polyps. Conditions included in polyposis syndromes include familial adenomatous polyposis, MUTYH-associated polyposis, serrated polyposis syndrome, Peutz-Jeghers syndrome, juvenile polyposis syndrome and PTEN-hamartomatous syndromes.

Zenkers diverticulum: Herniation of the mucosa of the esophagus through a defect in the wall of the esophagus; the location is usually in the upper one-third of the esophagus.

References

Peer Reviewed Publications:

1. Albert JG, Martiny F, Krummenerl A, et al. Diagnosis of small bowel Crohn's disease: a prospective comparison of capsule endoscopy with magnetic resonance imaging and fluoroscopic enteroclysis. Gut. 2005; 54(12):1721-1727.
2. Antao B, Bishop J, Shawis R, Thomson M. Clinical application and diagnostic yield of wireless capsule endoscopy in children. J Laparoendosc Adv Surg Tech. A. 2007; 17(3):364-370.
3. Apostolopoulos P, Liatsos C, Gralnek IM, et al. The role of wireless capsule endoscopy in investigating unexplained iron deficiency anemia after negative endoscopic evaluation of the upper and lower gastrointestinal tract. Endoscopy. 2006; 38(11):1127-1132.
4. Baltes P, Bota M, Albert J, et al. PillCamColon2 after incomplete colonoscopy - a prospective multicenter study. World J Gastroenterol. 2018; 24(31):3556-3566.
5. Boivin ML, Lochs H, Voderholzer WA. Does passage of a patency capsule indicate small-bowel patency? A prospective clinical trial? Endoscopy. 2005; 37(9):808-815.
6. Ching HL, Hale MF, McAlindon ME. Current and future role of magnetically assisted gastric capsule endoscopy in the upper gastrointestinal tract. Therap Adv Gastroenterol. 2016; 9(3):313-321.
7. Chong AK, Taylor A, Miller A, et al. Capsule endoscopy vs. push enteroscopy and enteroclysis in suspected small-bowel Crohn's disease. Gastrointest Endosc. 2005; 61(2):255-261.
8. Cohen SA, Klevens AI. Use of capsule endoscopy in diagnosis and management of pediatric patients, based on meta-analysis. Clin Gastroenterol Hepatol. 2011; 9(6):490-496.
9. Cotter J, de Castro FD, Magalhaes J, et al. Finding the solution for incomplete small bowel capsule endoscopy. World J Gastrointest Endosc. 2013; 5(12):595-599.
10. Culliford A, Daly J, Diamond B, et al. The value of wireless capsule endoscopy in patients with complicated celiac disease. Gastrointest Endosc. 2005; 62(1):55-61.
11. Delvaux M, Ben Soussan E, Laurent V, et al. Clinical evaluation of the use of the M2A patency capsule system before a capsule endoscopy procedure, in patients with known or suspected intestinal stenosis. Endoscopy. 2005; 37(9):801-807.
12. Denzer UW, Rosch T, Hoytat B, et al. Magnetically guided capsule versus conventional gastroscopy for upper abdominal complaints: a prospective blinded study. J Clin Gastroenterol. 2015; 49(2):101-107.
13. Dionisio PM, Gurudu SR, Leighton JA, et al. Capsule endoscopy has a significantly higher diagnostic yield in patients with suspected and established small-bowel Crohn's disease: a meta-analysis. Am J Gastroenterol. 2010; 105(6):1240-1248.
14. Dubcenco E, Jeejeebhoy KN, Petroniene R, et al. Capsule endoscopy findings in patients with established and suspected small-bowel Crohn's disease: correlation with radiologic, endoscopic, and histologic findings. Gastrointest Endosc. 2005; 62(4):538-544.
15. Eliakim R, Fireman Z, Gralnek IM, et al. Evaluation of the PillCam Colon capsule in the detection of colonic pathology: results of the first multicenter, prospective, comparative study. Endoscopy. 2006; 38(10):963-970.
16. Eliakim R, Yassin K, Niv Y, et al. Prospective multicenter performance evaluation of the second-generation colon capsule compared with colonoscopy. Endoscopy. 2009; 41(12):1026-1031.
17. Eliakim R, Yassin K, Shlomi I, et al. A novel diagnostic tool for detecting oesophageal pathology: the Pillcam oesophageal video capsule. Aliment Pharmacol Ther. 2004; 20(10):1083-1089.
18. Ell C, Remke S, May A, et al. The first prospective controlled trial controlling wireless capsule endoscopy with push enteroscopy in chronic gastrointestinal bleeding. Endoscopy. 2002; 34(9):685-689.
19. Hale MF, Drew K, Sidhu R, McAlindon ME. Does magnetically assisted capsule endoscopy improve small bowel capsule endoscopy completion rate? A randomised controlled trial. Endosc Int Open. 2016; 4(2):E215-221.
20. Hussey M, Holleran G, Stack R, et al. Same-day colon capsule endoscopy is a viable means to assess unexplored colonic segments after incomplete colonoscopy in selected patients. United European Gastroenterol J. 2018; 6(10):1556-1562.
21. Keller J, Fibbe C, Volke F, et al. Inspection of the human stomach using remote-controlled capsule endoscopy: a feasibility study in healthy volunteers (with videos). Gastrointest Endosc. 2011; 73:22-28.
22. Keller J, Fibbe C, Volke F, et al. Remote magnetic control of a wireless capsule endoscope in the esophagus is safe and feasible: results of a randomized, clinical trial in healthy volunteers. Gastrointest Endosc. 2010; 72(5):941-946.
23. Kobaek-Larsen M, Kroijer R, Dyrvig AK, et al. Back-to-back colon capsule endoscopy and optical colonoscopy in colorectal cancer screening individuals. Colorectal Dis. 2018; 20(6):479-485.
24. Koornstra JJ, Kleibeuker JH, Vasen HF. Small-bowel cancer in Lynch syndrome: is it time for surveillance? Lancet Oncol. 2008; 9(9):901-905.
25. Lewis BS, Swain P. Capsule endoscopy in the evaluation of patients with suspected small intestinal bleeding: Results of a pilot study. Gastrointest Endosc. 2002; 56(3):349-353.
26. Liao Z, Duan XD, Xin L, et al. Feasibility and safety of magnetic-controlled capsule endoscopy system in examination of human stomach: a pilot study in healthy volunteers. J Interv Gastroenterol. 2012; 2(4):155-160.
27. Long MD, Barnes E, Isaacs K, et al. Impact of capsule endoscopy on management of inflammatory bowel disease: A single tertiary care center experience. Inflamm Bowel Dis. 2011; 17(9):1855-1862.
28. Luo YY, Pan J, Chen YZ, et al. Magnetic steering of capsule endoscopy improves small bowel capsule endoscopy completion rate. Dig Dis Sci. 2019; 64(7):1908-1915.
29. McCarty TR, Afinogenova Y, Njei B. Use of Wireless capsule endoscopy for the diagnosis and grading of esophageal varices in patients with portal hypertension: a systematic review and meta-analysis. J Clin Gastroenterol. 2017; 51(2):174-182.
30. Muhammad A, Pitchumoni CS. Evaluation of iron deficiency anemia in older adults: the role of wireless capsule endoscopy. J Clin Gastroenterol. 2009; 43(7):627-631.
31. Mylonaki M, Fritscher-Ravens A, Swain P, et al. Wireless capsule endoscopy; a comparison with push enteroscopy in patients with gastroscopy and colonoscopy negative gastrointestinal bleeding. Gut. 2003; 52(8):1122-1126.
32. Oliva S, Di Nardo G, Hassan C, et al. Second-generation colon capsule endoscopy vs. colonoscopy in pediatric ulcerative colitis: a pilot study. Endoscopy. 2014; 46(6):485-492.
33. Parodi A, Vanbiervliet G, Hassan C, et al. Colon capsule endoscopy to screen for colorectal neoplasia in those with family histories of colorectal cancer. Gastrointest Endosc. 2018; 87(3):695-704.
34. Patel R, Hyer W. Practical management of polyposis syndromes. Frontline Gastroenterol. 2019; 10(4):379-387.
35. Pennazio M. Capsule endoscopy: Where are we after 6 years of clinical use? Dig Liver Dis. 2006; 38(12):867-878.
36. Pennazio M, Santucci R, Rondonotti E, et al. Outcome of patients with obscure gastrointestinal bleeding after capsule endoscopy: report of 100 consecutive cases. Gastroenterology. 2004; 126(3):643-653.
37. Pilz JB, Portmann S, Peter S, et al. Colon Capsule Endoscopy compared to Conventional Colonoscopy under routine screening conditions. BMC Gastroenterol. 2010; 10:66.
38. Pioche M, de Leusse A, Filoche B, et al. Prospective multicenter evaluation of colon capsule examination indicated by colonoscopy failure or anesthesia contraindication. Endoscopy. 2012; 44(10):911-916.
39. Rahman I, Pioche M, Shim C, et al. Magnet-assisted capsule endoscopy in the upper GI tract by using a novel navigation system (with video). Gastrointest Endosc. 2016; 83:889-895.
40. Ramirez FC, Shaukat MS, Young MA, et al. Feasibility and safety of string, wireless capsule endoscopy in the diagnosis of Barrett's esophagus. Gastrointest Endosc. 2003; 61(6):741-746.

41. Rex DK, Adler SN, Aisenberg J, et al. Accuracy of capsule colonoscopy in detecting colorectal polyps in a screening population. Gastroenterology. 2015; 148(5):948-957.
42. Rey JF, Ogata H, Hosoe N, et al. Blinded nonrandomized comparative study of gastric examination with a magnetically guided capsule endoscope and standard videoendoscope. Gastrointest Endosc. 2012; 75(2):373-381.
43. Rey J, Ogata H, Hosoe N, et al. Feasibility of stomach exploration with a guided capsule endoscope. Endoscopy. 2010; 42:541-545.
44. Riccioni ME, Urgesi R, Spada C, et al. Unexplained iron deficiency anaemia: Is it worthwhile to perform capsule endoscopy? Dig Liver Dis. 2010; 42(8):560-566.
45. Schoofs N, Deviere J, Van Gossum A. PillCam colon capsule endoscopy compared with colonoscopy for colorectal tumor diagnosis: a prospective pilot study. Endoscopy. 2006; 38(10):971-977.
46. Sieg A, Friedrich K, Sieg U. Is PillCam COLON capsule endoscopy ready for colorectal cancer screening? A prospective feasibility study in a community gastroenterology practice. Am J Gastroenterol. 2009; 104(4):848-854.
47. Signorelli C, Rondonotti E, Villa F, et al. Use of the Given Patency System for the screening of patients at high risk for capsule retention. Dig Liver Dis. 2006; 38(5):326-330.
48. Singeap AM, Trifan A, Cojocariu C, Stanciu C. Colon capsule endoscopy compared to colonoscopy for colorectal neoplasms diagnosis: an initial experience and a brief review of the literature. Rev Med Chir Soc Med Nat Iasi. 2012; 116(1):145-149.
49. Spada C, Hassan C, Marmo R, et al. Meta-analysis shows colon capsule endoscopy is effective in detecting colorectal polyps. Clin Gastroenterol Hepatol. 2010; 8(6):516-522.
50. Spada C, Riccioni ME, Costamagna G. Patients with known small bowel stricture or with symptoms of small bowel obstruction secondary to Crohn's disease should not perform video capsule endoscopy without being previously tested for small bowel patency. Am J Gastroenterol. 2007b; 102(7):1542-1543.
51. Spada C, Shah SK, Riccioni ME, et al. Video capsule endoscopy in patients with known or suspected small bowel stricture previously tested with the dissolving patency capsule. J Clin Gastroenterol. 2007a; 41(6):576-582.
52. Spada C, Spera G, Riccioni M, et al. A novel diagnostic tool for detecting functional patency of the small bowel: the Given patency capsule. Endoscopy. 2005; 37(9):793-800.
53. Sung J, Ho KY, Chiu HM et al. The use of Pillcam Colon in assessing mucosal inflammation in ulcerative colitis: a multicenter study. Endoscopy. 2012; 44(8):754-758.
54. Swain P, Toor A, Volke F, et al. Remote magnetic manipulation of a wireless capsule endoscope in the esophagus and stomach of humans (with videos). Gastrointest Endosc. 2010; 71(7):1290-1293.Thomson M, Fritscher-Ravens A, Mylonaki M, et al. Wireless capsule endoscopy in children: a study to assess diagnostic yield in small bowel disease in paediatric patients. J Pediatr Gastroenterol Nutr. 2007; 44(2):192-197.
55. Triantafyllou K, Tsibouris P, Kalantzis C, et al. PillCam Colon capsule endoscopy does not always complement incomplete colonoscopy. Gastrointest Endosc. 2009; 69(3 Pt 1):572-576.
56. Triester SL, Leighton JA, Leontiadis GI, et al. A meta-analysis of the yield of capsule endoscopy compared to other diagnostic modalities in patients with non-stricturing small bowel Crohn's disease. Am J Gastroenterol. 2006; 101(5):954-964.
57. Triester SL, Leighton JA, Leontiadis GI, et al. A meta-analysis of the yield of capsule endoscopy compared to other diagnostic modalities in patients with obscure gastrointestinal bleeding. Am J Gastroenterol. 2005; 11(11):2407-2418.
58. Van Gossum A, Munoz-Navas M, Fernandez-Urien I, et al. Capsule endoscopy versus colonoscopy for the detection of polyps and cancer. N Engl J Med. 2009; 361(3):264-270.
59. Xue M, Chen X, Shi L, et al. Small-bowel capsule endoscopy in patients with unexplained chronic abdominal pain: a systematic review. Gastrointest Endosc. 2015; 81(1):186-193.
60. Zhang W, Han ZL, Cheng Y, et al. Value of the patency capsule in pre-evaluation for capsule endoscopy in cases of intestinal obstruction. J Dig Dis. 2014; 15(7):345-351.

Government Agency, Medical Society, and Other Authoritative Publications:

1. ASGE Technology Committee, Adler DG, Chand B, et al. Capsule endoscopy of the colon. Gastrointest Endosc. 2008; 68(4):621-623.
2. ASGE Technology Committee, Wang A, Banerjee S, et al. Wireless capsule endoscopy. Gastrointest Endosc. 2013; 78(6):805-815.
3. California Technology Assessment Forum (CTAF). Capsule Endoscopy in the Evaluation of Established and Suspected Crohn's Disease. October 2006.
4. Centers for Medicare and Medicaid Services. National Coverage Determination for Endoscopy. NCD #100.2. Effective date not posted. Available at: http://www.cms.hhs.gov. Accessed on April 13, 2023.
5. Gerson LB, Fidler JL, Cave DR, Leighton JA. ACG Clinical Guideline: Diagnosis and management of small bowel bleeding. Am J Gastroenterol. 2015; 110(9):1265-1288.
6. Gurudu SR, Bruining DH, Acosta RD, et al. The role of endoscopy in the management of suspected small-bowel bleeding. Gastrointest Endosc. 2017; 85(1):22-31.
7. Jiang B, Qian YY, Pan J, et al. Second-generation magnetically controlled capsule gastroscopy with improved image resolution and frame rate: a randomized controlled clinical trial (with video). Gastrointest Endosc. 2020; 91(6):1379-1387.
8. Ladas SD, Triantafyllou K, Spada C. European Society of Gastrointestinal Endoscopy (ESGE): recommendations (2009) on clinical use of video capsule endoscopy to investigate small-bowel, esophageal and colonic diseases. Endoscopy. 2010; 42(3):220-227.
9. Lansdorp-Vogelaar I, von Karsa L, International Agency for Research on Cancer. European guidelines for quality assurance in colorectal cancer screening and diagnosis. First Edition--Introduction. Endoscopy. 2012; 44 Suppl 3:SE15-E30.
10. Lee KK, Anderson MA, Baron TH, et al. Modifications in endoscopic practice for pediatric patients. Gastrointest Endosc. 2008; 67(1):1-9.
11. Leighton JA, Brock AS, Semrad CE, et al. Quality indicators for capsule endoscopy and deep enteroscopy. Am J Gastroenterol. 2022; 117(11):1780-1796.
12. Levin B, Brooks D, Smith RA, Stone A. Emerging technologies in screening for colorectal cancer: CT colonography, immunochemical fecal occult blood tests, and stool screening using molecular markers. CA Cancer J Clin. 2003; 53:44-55.
13. Lichtenstein GR, Hanauer SB, Sandborn WJ. Practice Parameters Committee of American College of Gastroenterology. Management of Crohn's disease in adults. Am J Gastroenterol. 2009; 104(2):465-483.
14. Mishkin DS, Chuttani R, Croffie J, et al. ASGE Technology Status Evaluation Report: wireless capsule endoscopy. Gastrointest Endosc. 2006; 63(4):539-545.
15. Pennazio M, Spada C, Eliakim R, et al. Small-bowel capsule endoscopy and device-assisted enteroscopy for diagnosis and treatment of small-bowel disorders: European Society of Gastrointestinal Endoscopy (ESGE) Clinical Guideline. Endoscopy. 2015; 47(4):352-386.
16. Rubin DT, Ananthakrishnan AN, Siegel CA, et al. ACG Clinical Guideline: Ulcerative colitis in adults. Am J Gastroenterol. 2019; 114(3):384-413.
17. Shamir R, Hino B, Hartman C, et al. Wireless video capsule in pediatric patients with functional abdominal pain. J Pediatr Gastroenterol Nutr. 2007; 44(1):45-50.

18. Thomson M, Fritscher-Ravens A, Mylonaki, et al. Wireless capsule endoscopy in children: a study to assess diagnostic yield in small bowel disease in paediatric patients. J Pediatr Gastroenterol Nutr. 2007; 44(2):192-197.
19. Tran K. Capsule colonoscopy: PillCam Colon. Issues Emerg Health Technol. 2007; (106):1-4.
20. U.S. Food and Drug Administration 510(k) Reclassification Order. NaviCam Capsule Endoscope System with NaviCam Stomach Capsule. DEN190037. Silver Spring, MD: FDA. May 22, 2020. Available at: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/denovo.cfm?ID=DEN190037. Accessed on April 13, 2023.
21. U.S. Food and Drug Administration 510(k) Premarket Notification Database. Olympus Capsule Endoscope System. No. K063259. Silver Spring, MD: FDA. September 14, 2007. Available at: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm?ID=K063259 Accessed April 13, 2023.
22. U.S. Food and Drug Administration 510(k) Premarket Notification Database. CapsoCam Plus (SV-3). K183192. Available at: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfpmn/pmn.cfm?ID=K183192. Accessed on April 13, 2023.
23. U.S. Food and Drug Administration 510(k) Premarket Notification Database. PillCam COLON 2 Capsule Endoscopy System. K153466. Available at: http://www.accessdata.fda.gov/cdrh_docs/pdf15/K153466.pdf. Accessed on April 13, 2023.
24. U.S. Food and Drug Administration 510(k) Summary. Given PillCam® Platform with PillCam®SB Capsules Given® AGILE Patency System. No. K090557. Silver Spring, MD: FDA. September 28, 2009. Available at: http://www.accessdata.fda.gov/cdrh_docs/pdf9/K090557.pdf. Accessed on April 13, 2023.
25. U.S. Food and Drug Administration (FDA) Center for Devices and Radiological Health. New device approval letter. January 29, 2014. PillCam COLON 2 Capsule Endoscopy System. K123666. Available at: http://www.accessdata.fda.gov/cdrh_docs/pdf12/K123666.pdf. Accessed on April 13, 2023.
26. U.S. Food and Drug Administration *de novo* Summary. PillCam COLON 2 Capsule Endoscopy System. No. K123666. Silver Spring, MD: FDA. December 12, 2012. Available at: http://www.accessdata.fda.gov/cdrh_docs/reviews/K123666.pdf. Accessed on April 13, 2023.

Index

The use of specific product names is illustrative only. It is not intended to be a recommendation of one product over another, and is not intended to represent a complete listing of all products available.

History

Status	Date	Action
	09/27/2023	Updated Coding section with 10/01/2023 ICD-10-CM changes; added Z83.710-Z83.719 replacing Z83.71.
Reviewed	05/11/2023	Medical Policy & Technology Assessment Committee (MPTAC) review. Updated the Discussion/General Information and References sections.
Reviewed	05/12/2022	Medical Policy & Technology Assessment Committee (MPTAC) review. Updated References section.
	12/29/2021	Updated Coding section with 01/01/2022 CPT changes; added 91113 effective 01/01/2022 replacing 0355T deleted 12/31/2021.
Revised	05/13/2021	MPTAC review. In Clinical Indications section, added NMN statement for magnetically controlled capsule endoscopy system and reformatted NMN indications. Updated Description, Discussion and General Information, References, Websites for Additional Information and Index sections. Updated Coding section with 07/01/2021 CPT changes; added 0651T.
Reviewed	02/11/2021	MPTAC review. Updated Rationale, Definitions, References and Index sections. Reformatted Coding section.
Reviewed	02/20/2020	MPTAC review. Updated References section.
Reviewed	03/21/2019	MPTAC review. Updated Rationale and References sections.
New	03/22/2018	MPTAC review. Initial document development. Moved content of RAD.00030 Wireless Capsule Endoscopy for Gastrointestinal Imaging and the Patency Capsule to new clinical utilization management guideline document with the same title.

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terms of frequency or in some other manner.