

# Endoscopy

## Comparison of Adenoma Detection Rate Between Three-dimensional and Standard Colonoscopy: A Multicenter Randomized Controlled Trial

Wei-Yuan Chang, Li-Chun Chang, Hsuan-Ho Lin, Pin-Ya Wei, Hsing-Chien Wu, Wei-Chih Liao, Han-Mo Chiu, Ming-Shiang Wu.

Affiliations below.

DOI: 10.1055/a-2510-8759

Please cite this article as: Chang W-Y, Chang L-C, Lin H-H et al. Comparison of Adenoma Detection Rate Between Three-dimensional and Standard Colonoscopy: A Multicenter Randomized Controlled Trial. *Endoscopy* 2024. doi: 10.1055/a-2510-8759

**Conflict of Interest:** The authors declare that they have no conflict of interest.

**This study was supported by** MedicalTek Co. Ltd, Taiwan.

**Trial registration:** NCT05153746, ClinicalTrials.gov (<http://www.clinicaltrials.gov/>), Randomized, Multi-Center Study

### Abstract:

#### Background and study aim:

Improvement of adenoma detection rate (ADR) effectively reduces the subsequent incidence of colorectal cancer (CRC). Three-dimensional (3D) colonoscopy provided more anatomical details than standard two-dimensional (2D) colonoscopy and improved ADR in a simulation study. We aimed to compare the ADR between 2D and 3D colonoscopy.

#### Patients and methods:

In this multicenter randomized controlled trial, subjects aged  $\geq 40$  years who underwent colonoscopy for screening, surveillance, or symptoms were consecutively enrolled between February 2022 and June 2023 and randomized into 2D or 3D groups with a 1:1 ratio. The primary outcome was ADR. The secondary outcomes included the detection rates of flat adenoma, right-sided adenoma, proximal adenoma, sessile serrated lesion and advanced adenoma.

#### Results:

Of the 348 participants recruited, 158 and 160 were allocated to 2D and 3D colonoscopy, respectively. The mucosa inspection time was comparable between the 3D ( $9.8 \pm 2.6$  minutes) and 2D ( $9.4 \pm 3.1$  minutes) groups ( $p = .21$ ). The 3D group had significantly higher ADR (53.1% vs. 38.6%, difference (95% confidence interval, CI): 14.5% (3.7-25.4),  $p = .0094$ ), as well as higher detection rates for flat adenoma (35.0% vs. 21.5%, difference: 13.5% (3.7-23.3),  $p = .0076$ ), right-sided adenoma (26.3% vs. 15.2%, difference: 11.1% (2.2-19.9),  $p = .015$ ), proximal adenoma (38.1% vs. 23.4%, difference: 14.7% (4.7-24.7),  $p = .0045$ ) and adenoma sized 5-9mm (45.0% vs. 31.0%, difference: 14.0% (3.4-24.5),  $p = .010$ ). However, there was no difference in the detection rate of sessile serrated lesion and advanced adenoma.

#### Conclusions:

3D colonoscopy improved the detection of adenomas without significantly increasing the mucosa inspection time. (ClinicalTrials.gov: NCT05153746)

### Corresponding Author:

Dr. Wei-Chih Liao, National Taiwan University Hospital, Internal Medicine, No.7, Chung Shan S. Rd. Zhongshan S. Rd., Zhongzheng Dist., Taipei City 10002, Taiwan (R.O.C.), 100 Taipei, Taiwan, david.ntuh@gmail.com

**Affiliations:**

Wei-Yuan Chang, National Taiwan University Hospital, Internal medicine, Taipei, Taiwan

Li-Chun Chang, National Taiwan University Hospital, Internal Medicine, Taipei, Taiwan

Hsuan-Ho Lin, National Taiwan University Hospital Hsin-Chu Branch Hsin-Chu Hospital, Internal Medicine, Hsinchu, Taiwan  
[...]

Ming-Shiang Wu, National Taiwan University Hospital, Internal Medicine, Taipei, Taiwan



1

1 **Comparison of Adenoma Detection Rate Between Three-dimensional and**  
2 **Standard Colonoscopy: A Multicenter Randomized Controlled Trial**

3 **Short title:** Adenoma Detection Rate with 3D colonoscopy

4

5 Wei-Yuan Chang, MD, MSc<sup>1,2</sup>, Li-Chun Chang, MD, PhD<sup>1,2\*</sup>, Hsuan-Ho Lin, MD,  
6 MSc<sup>3</sup>, Pin-Ya Wei, MD<sup>3</sup>, Hsing-Chien Wu, MD<sup>4</sup>, Wei-Chih Liao, MD,  
7 PhD<sup>1,5\*</sup>, Han-Mo Chiu, MD, PhD<sup>1,2</sup>, Ming-Shiang Wu, MD, PhD<sup>1,5</sup>

8 \*The two authors contributed equally to this work

9 <sup>1</sup>Department of Internal Medicine, National Taiwan University Hospital, Taipei,  
10 Taiwan

11 <sup>2</sup>Health Management Center, National Taiwan University Hospital, Taipei,  
12 Taiwan.

13 <sup>3</sup>Department of Internal Medicine, National Taiwan University Hsinchu Branch,  
14 Hsinchu, Taiwan

15 <sup>4</sup>Department of Internal Medicine, National Taiwan University Cancer Center,  
16 Taipei, Taiwan

17 <sup>5</sup>Internal Medicine, National Taiwan University College of Medicine, Taipei,  
18 Taiwan.

19 **Corresponding authors:**

20 Li-Chun Chang, M.D, Ph.D.

2

1

3

21 Clinical Associate Professor,  
22 Department of Internal Medicine, National Taiwan University Hospital  
23 No. 7, Chung-Shan South Road, Taipei, Taiwan.

24 Fax: +886- 2-23947899

25 Telephone: +886-2-23123456 ext: 263188

26 Email: lichunchang@ntu.edu.tw

27

28 **Author contributions:**

29 Corresponding author: Li-Chun Chang

30 First author: Wei-Yuan Chang

31 Senior authors - Wei-Chih Liao and Li-Chun Chang

32 Conception and design of the study: Wei-Chih Liao, Li-Chun Chang, Ming-  
33 Shiang Wu

34 Generation, collection, assembly, analysis and/or interpretation of data: Li-  
35 Chun Chang, Wei-Yuan Chang, Hsuan-Ho Lin, Pin-Ya Wei, Hsing-Chien Wu,

36 Drafting and revision of the manuscript: Wei-Yuan Chang, Li-Chun Chang, Wei-  
37 Chih Liao, Han-Mo Chiu

38 Approval of the final version of the manuscript: All authors

39

40 **Funding support:**

41 This trial was supported by MedicalTek Co. Ltd, Taiwan. The funding source  
42 had no role in the study design, data collection and analysis, interpretation,  
43 manuscript preparation, or the decision to submit this paper for publication.

44

45 **Disclosures:**

46 The authors declared no conflict of interest relevant to this article.

47

48 **Data Transparency Statement:**

49 Appropriate academic parties may contact Li-Chun Chang  
50 (lichunchang@ntu.edu.tw) for the statistical code, and de-identified participant  
51 dataset that underlies the results reported in this article, per the data sharing  
52 policies of the National Taiwan University Hospital and the Ministry of Health  
53 and Welfare of the Taiwanese Government, with input from the investigator  
54 group where applicable after receipt of the research proposal.

55

56

## Abstract

### 57 **Background and study aim:**

58 Improvement of adenoma detection rate (ADR) effectively reduces the  
59 subsequent incidence of colorectal cancer (CRC). Three-dimensional (3D)  
60 colonoscopy provided more anatomical details than standard two-dimensional  
61 (2D) colonoscopy and improved ADR in a simulation study. We aimed to  
62 compare the ADR between 2D and 3D colonoscopy.

### 63 **Patients and methods:**

64 In this multicenter randomized controlled trial, subjects aged  $\geq 40$  years who  
65 underwent colonoscopy for screening, surveillance, or symptoms were  
66 consecutively enrolled between February 2022 and June 2023 and randomized  
67 into 2D or 3D groups with a 1:1 ratio. The primary outcome was ADR. The  
68 secondary outcomes included the detection rates of flat adenoma, right-sided  
69 adenoma, proximal adenoma, sessile serrated lesion and advanced adenoma.

### 70 **Results:**

71 Of the 348 participants recruited, 158 and 160 were allocated to 2D and 3D  
72 colonoscopy, respectively. The mucosa inspection time was comparable  
73 between the 3D ( $9.8 \pm 2.6$  minutes) and 2D ( $9.4 \pm 3.1$  minutes) groups ( $p=.21$ ).  
74 The 3D group had significantly higher ADR (53.1% vs. 38.6%, difference (95%  
75 confidence interval, CI): 14.5% (3.7-25.4),  $p=.0094$ ), as well as higher detection  
76 rates for flat adenoma (35.0% vs. 21.5%, difference: 13.5% (3.7-23.3),  
77  $p=.0076$ ), right-sided adenoma (26.3% vs. 15.2%, difference: 11.1% (2.2-19.9),  
78  $p=.015$ ), proximal adenoma (38.1% vs. 23.4%, difference: 14.7% (4.7-24.7),  
79  $p=.0045$ ) and adenoma sized 5-9mm (45.0% vs. 31.0%, difference: 14.0% (3.4-

11

4

12

80 24.5),  $p=.010$ ). However, there was no difference in the detection rate of sessile  
81 serrated lesion and advanced adenoma.

82 **Conclusions:**

83 3D colonoscopy improved the detection of adenomas without significantly  
84 increasing the mucosa inspection time. (ClinicalTrials.gov: NCT05153746)

85



86

## INTRODUCTION

87 Colorectal cancer (CRC) is the third most common cancer and the second  
88 leading cause of cancer-related deaths worldwide[1]. Most sporadic CRCs  
89 arise from pre-existing adenomas[2], and removal of these precancerous  
90 lesions has been shown to effectively reduce both the incidence and mortality of  
91 CRC[3,4]. Therefore, the effectiveness of colonoscopy in protecting against  
92 CRC hinges on the detection and removal of adenomas, and adenoma  
93 detection rate (ADR) is the most important quality indicator of colonoscopy.  
94 Previous research showed that a 1% increase in ADR can reduce CRC  
95 incidence and mortality by 3% and 5%, respectively[5]. Therefore, various  
96 modalities have been developed to improve ADR, including image-enhancing  
97 technologies[6], chromoendoscopy[7], and devices enhancing exploration of  
98 the mucosa[8,9].

99 Despite improvements in ADR conferred by those modalities, post-  
100 colonoscopy colorectal cancer (PCCRC) remains a concern[10]. The incidence  
101 of PCCRC has been reported at 8.6% within three years[11], with more than  
102 80% of PCCRCs being attributed to missed adenomas[12,13]. Notably, flat and  
103 proximal adenomas are independently associated with the development of  
104 PCCRC and particularly difficult to detect, posing significant challenges in  
105 improving ADR[12,14,15].

106 Three-dimensional (3D) endoscopy provides 3D visualization with superior  
107 depth perception over conventional two-dimensional (2D) endoscopy and may  
108 thereby enhance detection of flat/superficial lesions and subtle mucosal  
109 changes. 3D endoscopy has shown promise in enhancing the detection of

17

6

18



110 superficial gastric neoplasms and accuracy in assessing morphology[16]. 3D  
111 endoscopy had also been proposed to enhance the detection of colonic  
112 adenomas, showing a 25% increase in adenoma detection in a study using  
113 simulated 3D colonoscopy in a synthetic colon model[17,18]. However, whether  
114 3D colonoscopy could improve ADR and facilitate detection of flat polyps  
115 compared with standard 2D colonoscopy in clinical colonoscopic practice  
116 remains to be studied.

117 MonoStereo 3D endoscopic visualization system (MedicalTek Co. Ltd,  
118 Taichung, Taiwan) is a novel 3D endoscopy system which performs real-time  
119 conversion of standard 2D images to realistic 3D visualization during  
120 endoscopy and has been approved for clinical use[19,20]. We hypothesized  
121 that the 3D endoscopic visualization system could enhance polyp detection  
122 during colonoscopy, especially for flat/superficial polyps. Therefore, we  
123 conducted a randomized controlled trial (RCT) to investigate whether 3D  
124 colonoscopy improved adenoma detection over standard 2D colonoscopy.

## 125 MATERIAL AND METHODS

### 126 Study design

127 This was a prospective multicenter randomized, open-label, single-blind  
128 trial conducted in one referral center and two regional hospitals in Taiwan.  
129 Complying with the principles of the Declaration of Helsinki and Good Clinical  
130 Practice guidelines, this trial was approved by the institutional review board of  
131 National Taiwan University Hospital (No.202109112DIPB) and registered at  
132 ClinicalTrials.gov (NCT05153746). An independent data and safety monitoring

133 committee monitored the progress of the trial, with regular assessment of safety  
134 outcomes, overall trial integrity, and trial performance.

### 135 **Participants**

136 Subjects aged 40 or older who were scheduled for colonoscopy for  
137 screening, surveillance, or symptoms at outpatient clinics in the participating  
138 institutions were consecutively assessed for eligibility. Subjects with a  
139 contraindication to colonoscopy or polypectomy or with a history of  
140 inflammatory bowel disease and hereditary polyposis syndrome were excluded.

### 141 **Randomization and masking**

142 The participants were randomized centrally by research assistants at the  
143 endoscopy units before the start of colonoscopic examinations in a 1:1 ratio  
144 without stratification using a computer-generated randomization sequence with  
145 a block size of twenty. Allocation concealment was ensured by storing the group  
146 allocation in ordered, sealed, and opaque envelopes. The patients and  
147 research assistants who assessed the outcomes were blinded to the group  
148 allocation to avoid bias.

### 149 **Procedures**

#### 150 ***Three-dimensional colonoscopy***

151 **Figure 1a** illustrates the MonoStereo 3D endoscopic visualization system  
152 (MedicalTek Co. Ltd, Taichung, Taiwan). 2D images (**Figure 1b**, right screen in  
153 **Figure 1d**) are converted in 80 milliseconds to images (**Figure 1c**, left screen in  
154 **Figure 1d**) which yield immersive 3D images through polarized glasses,  
155 providing real-time 3D imagery without perceptible time lag (**Figure 1d**)  
156 (**Video**). The system offers three pupillary distance selections to mitigate

157 eyestrain, and endoscopists are recommended to identify the optimal personal  
158 selection before first use by finding the selection yielding the most vivid 3D  
159 imagery. The system does not require calibration before examination;  
160 endoscopists are advised to place the 3D screen at eye-level and stand in front  
161 of the screen at a distance tailored to individual preference (generally 100 cm to  
162 150cm for a 31"/32" screen). Instantaneous switch between 3D and standard  
163 2D displays is achieved by pressing a button. As the polarized glasses do not  
164 change the visual perception of the surrounding environment or standard 2D  
165 endoscopic images, the endoscopist do not need to remove the glasses when  
166 not using the 3D display.

### 167 ***Intervention and colonoscopy***

168 Study colonoscopies were performed by three junior (colonoscopy  
169 experience < 5000) and one senior colonoscopist (colonoscopy experience ≥  
170 5000). Before the commencement of the study, the participating colonoscopists  
171 received an introduction on the 3D technology and equipment and performed  
172 3D colonoscopy using a colonoscopy simulator. Each colonoscopist was then  
173 requested to use 3D colonoscopy in conjunction with standard 2D colonoscopy  
174 for mucosa inspection during colonoscope withdrawal in at least ten  
175 colonoscopic procedures (**Figure 1d**).

176 For the RCT, high definition colonoscopes (290 series, Olympus, Tokyo,  
177 Japan) and video processors (EVIS Lucera Elite, Olympus, Tokyo, Japan) were  
178 used for colonoscopy. Bowel preparation and image-enhanced endoscopy  
179 were performed in the same way in both groups. Standard 2D colonoscopy was  
180 used for colonoscope insertion as in routine clinical practice in both groups. The

181 use of distal attachment devices, such as cap or cuff, was prohibited. After the  
182 cecum was intubated, colonoscope withdrawal was performed exclusively with  
183 2D or 3D images as per allocation. A standardized protocol for photo  
184 documentation of individual colonic segments and a withdrawal time of 6  
185 minutes or longer were required during colonoscope withdrawal. During  
186 withdrawal, image-enhanced endoscopy (narrow-band imaging or  
187 chromoendoscopy with indigo carmine) was routinely used for suspicious  
188 lesions, and adenomas were removed/resected. The size, morphology, and  
189 location of each polyp were recorded, and specimens were sent for histological  
190 examination. The time for optic diagnosis and polyp removal was defined as  
191 therapeutic time. Mucosa inspection time was defined as withdrawal time minus  
192 therapeutic time. Participants were excluded for analysis if the colonoscopic  
193 examination was incomplete, defined as a failure of cecal intubation or poor  
194 bowel preparation. In line with the established clinical workflow of the  
195 participating institutions, bowel preparation was assessed with the modified  
196 Aronchick bowel preparation scale[21,22].

### 197 **Outcomes**

198 The primary outcome was ADR, defined as the proportion of patients with  
199 at least one adenoma detected during colonoscopy. Secondary outcomes were  
200 flat (Paris classification 0-IIa, 0-IIb, or 0-IIc) ADR (fADR), sessile (Paris  
201 classification 0-Is) ADR, right-sided (cecum and ascending colon) ADR (rADR),  
202 left-sided (transverse colon to rectum) ADR (lADR), proximal (cecum to splenic  
203 flexure) ADR (pADR), distal (descending colon to rectum) ADR (dADR), sessile  
204 serrated lesion detection rate (SSLDR), advanced adenoma detection rate

205 (AADR), ADR stratified by size (<5 mm, 5-9 mm,  $\geq 10$  mm), polyp detection rate  
206 (PDR), mean adenoma number per patient and mean polyp number per patient.

207 AA was defined as adenomas with size  $\geq 10$  mm, villous component, or high-  
208 grade dysplasia according to World Health Organization classification[23].

### 209 **Statistical analysis**

210 A simulation study suggested that 3D colonoscopy could increase the ADR  
211 by 60% (from 42.7% to 67.7%) compared to standard colonoscopy<sup>18</sup>. Following  
212 international guidelines, we set the ADR with standard colonoscopy at 25%<sup>24</sup>.  
213 To detect a 60% increase in ADR between 3D and standard colonoscopy (40%  
214 vs. 25%) with an 80% statistical power and a 2-sided significance level of 0.05,  
215 a minimum of 150 participants per group was needed. Accounting for potential  
216 exclusions or dropouts of approximately 10%, the enrollment target was at least  
217 165 participants for each group. The analysis was by intention-to-treat.  
218 Categorical variables were summarized using frequencies and percentages,  
219 and continuous variables as means and standard deviations (SDs). Statistical  
220 significance for categorical variables was tested using the Pearson chi-square  
221 test, and differences between groups for continuous variables were tested  
222 using the independent sample t-test. Univariable and multivariable logistic  
223 regression analyses were conducted to identify factors predictive of adenoma  
224 detection. Variables with a *p* value less than 0.05 in the univariable analysis  
225 were included in the multivariable analysis, and variance inflation factor was  
226 used to detect multicollinearity. Post-hoc analysis of the temporal changes in  
227 ADR and mucosa inspection time was conducted to explore the learning curve  
228 of 3D colonoscopy. All analyses were performed using STATA software

229 (StataCorp, College Station, TX, USA). All tests were 2-tailed, and differences  
230 were considered significant if  $p < .05$ .

231

## RESULTS

### 232 Patients

233 From February 2022 through June 2023, a total of 348 subjects were  
234 screened for eligibility (**Figure 2**), and 339 consented to participate. 334  
235 subjects underwent colonoscopy and were randomly allocated to either the 2D  
236 or 3D group (each  $n=167$ ). After excluding cases with incomplete colonoscopy  
237 and inadequate bowel preparation, 158 and 160 subjects in the 2D and 3D  
238 groups were analyzed, respectively. There was no crossover between the two  
239 groups.

### 240 Baseline characteristics

241 The baseline characteristics and clinical information are summarized in  
242 **Table 1**. Among the 318 enrolled participants, 150 (47.2%) were men and the  
243 mean age was  $61.9 \pm 10.6$  years. Most (69.8%) of the recruited subjects were  
244 asymptomatic, and the major indication for colonoscopy among the  
245 asymptomatic patients was positive fecal immunochemical test (FIT) or  
246 surveillance colonoscopy. The groups were comparable in age, sex, family  
247 history of CRC, cigarette and alcohol consumption, antithrombotic agent use,  
248 underlying diseases, colonoscopy indications, and bowel preparation status.  
249 There was no significant difference between the two groups in mucosa  
250 inspection time among the entire cohort (2D vs. 3D:  $9.4 \pm 3.1$  vs.  $9.8 \pm 2.6$   
251 minutes,  $p = .21$ ).

### 252 Outcomes



253 The 3D colonoscopy function was successfully implemented in all cases  
254 allocated to the 3D group without temporary equipment dysfunction during the  
255 colonoscopic procedures. For the two groups combined (n=318), PDR and  
256 ADR were 54.4% and 45.9%, respectively. ADR was significantly higher in the  
257 3D group compared with the 2D group (53.1% vs. 38.6%, difference (95%  
258 confidence interval [CI]: 14.5% (3.7-25.4), odds ratio (OR) (95%CI): 1.80 (95%  
259 CI:1.15-2.82),  $p = .0094$  (**Table 2**). Regarding the secondary outcomes, the 3D  
260 group had higher detection rates of flat adenomas (3D vs. 2D: 35.0%, vs.  
261 21.5%, difference (95% CI): 13.5% (3.7-23.3), OR (95% CI): 1.96 (1.19-3.24),  
262  $p = .0076$ ), right-sided adenomas (3D vs. 2D: 26.3% vs. 15.2%, difference (95%  
263 CI): 11.1% (2.2-19.9), OR (95% CI): 1.98 (1.14-3.48),  $p = .015$ ), proximal  
264 adenomas (3D vs. 2D: 38.1% vs. 23.4%, difference (95% CI): 14.7% (4.7-24.7),  
265 OR (95% CI): 2.02 (1.24-3.28),  $p = .0045$ ), and small-sized adenomas (5-9mm)  
266 (3D vs. 2D: 45.0% vs. 31.0%, difference (95% CI): 14.0% (3.4-24.5), OR (95%  
267 CI): 1.82 (1.15-2.88),  $p = .010$ ) compared with the 2D group. The number of  
268 adenoma per patient was also higher in the 3D group (median (interquartile  
269 range, IQR), 2D vs. 3D: 0 (0-1) vs. 1 (1-2),  $p = .028$ ). As all individuals with  
270 adenomas had at least one left-sided adenoma (adenomas at transverse,  
271 descending, sigmoid colon, or rectum), the left-sided ADR was equivalent to  
272 overall ADR in both groups. There was no significant difference in the detection  
273 rate of sessile adenoma, distal adenoma, AA and SSL.

#### 274 **Factors associated with adenoma detection**

275 In the univariable logistic regression analysis, age, hypertension, FIT  
276 positivity, bowel preparation (excellent/good vs fair), mucosa inspection time,

277 and 3D colonoscopy were significantly associated with adenoma detection  
278 (**Table 3**). The multivariable analysis showed that 3D colonoscopy was  
279 independently associated with adenoma detection (adjusted OR (aOR)  
280 (95%CI): 1.76 (1.09-2.83)) after adjusting for FIT positivity, mucosa inspection  
281 time, and other confounders. Age (aOR: 1.03 (1.01–1.06)) and mucosa  
282 inspection time (aOR: 1.16 (1.06–1.28)) were also independently associated  
283 with adenoma detection.

#### 284 **Temporal changes in ADR and mucosa inspection time**

285 Compared with the 2D group, the mean mucosa inspection time in the 3D  
286 group was significantly longer in the first 40 exams (11.1±2.6 vs. 9.6±2.6  
287 minutes,  $p=.012$ ) but became comparable afterward (**Table 1 & Figure 3a**).  
288 Similar trends were observed in each endoscopist with inter-endoscopist  
289 variations. The learning curve, as inferred by the difference in mucosa  
290 inspection time between 3D and 2D colonoscopy, seemed shortest for the  
291 senior colonoscopist, with the time difference reduced from 2.8 minutes for  
292 procedure 1~10 to 0.5 minute for procedure 11~ 20. By contrast, one junior  
293 endoscopist appeared to have the longest learning curve (time difference: 1.9,  
294 0.9, and 0.5 minutes for procedure 1~10, 11~20, and 21~30, respectively). On  
295 the other hand, ADR in the 3D group was consistently higher than that in the 2D  
296 group by approximately 15% throughout the study, even among the first 40  
297 exams (**Figure 3b**). All endoscopists achieved numerically higher ADR with 3D  
298 colonoscopy (difference in ADR, 3D minus 2D: senior endoscopist: 12%; junior  
299 endoscopists: 12.5%, 21.6%, and 50%, respectively). However, per-  
300 endoscopist analyses on differences in mucosa inspection time and ADR were



301 post-hoc and had limited sample size and thus should be interpreted as  
302 exploratory.

303

## DISCUSSION

304 This RCT conducted in individuals aged 40 or older showed that 3D  
305 colonoscopy resulted in a significant 15% increase in ADR, as well as in the  
306 detection rates of small, flat, right-sided and proximal neoplasms which are  
307 commonly overlooked by standard 2D colonoscopy. Notably, 3D colonoscopy  
308 enhanced polyp detection without increasing the mucosa inspection time and  
309 could be used in conjunction with other image-enhancing modalities such as  
310 narrow-band imaging and chromoendoscopy.

311 Enhancing the ADR is crucial for reducing the incidence of PCCRC and  
312 associated mortality[5]. Despite the multitude of advanced image processing  
313 technologies that have been developed to improve adenoma detection<sup>6</sup>, the  
314 incidence of PCCRC remains as high as 8% in Asia and Europe and is mainly  
315 attributed to missed neoplasms during colonoscopy[11,25,26]. Neoplasms with  
316 flat morphology, particularly those located in the proximal colon, are more likely  
317 to be overlooked[27]. The larger colonic folds in the proximal colon where  
318 neoplasms are more often flat further compound adenoma detection[28]. This  
319 study corroborated the notion that 3D colonoscopy enhances anatomical  
320 details and depth perception and thereby facilitates identification of those hard-  
321 to-detect neoplasms. Our finding that 3D colonoscopy improved ADR and  
322 detection for flat, right-sided or proximal adenomas supported for its potential to  
323 reduce PCCRCs, warranting further long-term follow-up research. Multicenter  
324 clinical trials and real-world studies, advocacy by gastroenterology societies

325 and opinion leaders, regulatory approval, and education/training are crucial for  
326 the dissemination of 3D colonoscopy.

327 The finding that 3D colonoscopy mainly enhanced the detection of polyps  
328 5-9 mm in size might be attributed to that such polyps were on the verge of  
329 being missed or detected (i.e., near the threshold of detection) on 2D  
330 colonoscopy; therefore, enhanced depth perception conferred by 3D  
331 colonoscopy significantly increased the ability to detect those polyps. By  
332 contrast, polyps 1-5 mm might remain difficult to detect despite enhanced depth  
333 perception and thus 3D colonoscopy did not significantly improve detection. In  
334 line with this notion, studies on chromoendoscopy using indigo carmine found  
335 no or minimal improvement in detecting adenomas 1-5mm [29,30]. On the other  
336 hand, polyps >10 mm could be easily detected on 2D colonoscopy, with limited  
337 room for further improvement by 3D colonoscopy.

338 It is worth noting that while high ADRs (ADR 38.6%, rADR 15.2%, pADR  
339 23.4%, fADR 21.5%) were achieved by standard 2D colonoscopy with a mean  
340 mucosa inspection time of approximately 9 minutes, 3D colonoscopy could  
341 further increase the ADRs by approximately 15% (ADR 53.1%, rADR 26.3%,  
342 pADR 38.1%, fADR 35.0%). The ADRs of the 2D group in our study was in line  
343 with a recent RCT by Zhao et al. which showed that 2D white light colonoscopy  
344 with a mucosa inspection time of 9 minutes achieved ADR, pADR, and fADR of  
345 36.6%, 21.4%, and 27.4%, respectively[31]. An odds ratio of 1.76 for detecting  
346 adenomas after adjusting for mucosa inspection time and other confounders  
347 firmly supported that 3D colonoscopy provided distinctive advantage over 2D  
348 colonoscopy in adenoma detection that cannot be provided by alternative

349 means such as increasing the mucosa inspection time. Whether 3D  
350 colonoscopy could provide greater benefit over standard 2D colonoscopy in real  
351 clinical settings where the mucosa inspection time is shorter than 9 minutes  
352 warrants further study.

353 Our exploratory analysis supported that 3D colonoscopy has a short  
354 learning curve and consistently confers an improvement in ADR even during the  
355 learning phase. The finding suggested a learning curve between 10 and 20  
356 procedures for 3D colonoscopy with inter-endoscopist variation. Taken  
357 together, the consistent benefit in ADR and short learning curve supported that  
358 3D colonoscopy could be easily adopted by endoscopists in routine  
359 colonoscopy practice.

360 A recent cross-over RCT including patients younger than 40 years  
361 compared 2D then 3D vs. 3D then 2D colonoscopy (i.e., tandem colonoscopy)  
362 and showed that ADR in the first exam was comparable between 3D and 2D  
363 colonoscopy (24.7% vs. 23.8%), whereas in the second exam ADR was  
364 significantly higher with 3D compared with 2D (13.8% vs. 9.9%)[32]. However,  
365 the tandem colonoscopy design could introduce bias, because the diagnostic  
366 performance of the latter exam was influenced by the findings of the first one. In  
367 contrast, the parallel design of this study minimized bias, better reflected clinical  
368 reality, and used ADR, the surrogate for PCCRC, as the primary outcome.  
369 Notably, the ADR of the first colonoscopy in the previous study did not differ  
370 between 2D and 3D and seemed lower than that in the current study, probably  
371 due to the shorter withdrawal time (<6 minutes) and the inclusion of younger  
372 patients (aged 18 to 40) in that study. In contrast, the current study enrolled

373 individuals aged over 40 and thus the results should be more generalizable to  
374 the examinees of clinical colonoscopy practice, and the ability to further improve  
375 ADR where colonoscopy quality assurance measures were rigorously  
376 implemented highlighted the benefit of 3D colonoscopy in enhancing adenoma  
377 detection. The use of different 3D endoscopy systems could have also  
378 contributed to the differences between the two studies, as the vividness of 3D  
379 visualization might differ between systems depending on the image  
380 reprocessing algorithms employed.

381 This study had several notable strengths. This RCT is the first to  
382 demonstrate the ability of 3D imaging in improving ADR and enhancing  
383 detection of flat and proximally located adenomas which are challenging to  
384 detect with standard 2D colonoscopy. Second, this study ensured high-quality  
385 colonoscopy thorough measures such as attention to bowel cleansing and  
386 photodocumentation and maintaining a withdrawal time exceeding 6 minutes in  
387 accordance with the international benchmarks. Third, this study enrolled  
388 individuals aged over 40 to align the study population with the examinees in  
389 general colonoscopic practice, enhancing the relevance and generalizability of  
390 the results. Last, this study conducted stratified comparisons according to polyp  
391 morphologies and location, revealing the advantage of 3D colonoscopy in  
392 enhancing detection of flat and proximal adenomas.

393 This study also had limitations. Given the apparent differences between 2D  
394 and 3D colonoscopy, it was not possible to blind the colonoscopists to group  
395 allocation. However, the quality assurance program including standardized  
396 photodocumentation in participating institutions ensured that the mucosa

397 inspection time was comparable between the two groups and >6 minutes,  
398 refuting the possibility that colonoscopists tried harder to find polyps in the 3D  
399 group. Therefore, non-blinding of endoscopists should not have introduced  
400 significant bias. While the endoscopists' ADR might have been affected by  
401 study participation (i.e., Hawthorne effect), the potential influence should occur  
402 in both 2D and 3D groups to a similar degree; therefore, the observed difference  
403 in ADR should be little influenced by the Hawthorne effect and remain valid. The  
404 comparability in other procedural factors and randomization minimized the  
405 possibility of confounding, and regression analysis adjustment for potential  
406 confounders further supported that the observed improvement in adenoma  
407 detection was attributed to 3D colonoscopy. Second, given the limited  
408 availability of the newly developed 3D colonoscopy equipment, this RCT  
409 included only a limited number of institutions and colonoscopists. A larger trial  
410 including more institutions/colonoscopists and diverse patient populations is  
411 warranted to further ascertain the potential benefit conferred by wide  
412 implementation of 3D colonoscopy. Third, this study did not evaluate the  
413 endoscopists' burden such as eye strain because of the lack of a well-  
414 established objective evaluation tool/method. However, none of the  
415 participating endoscopists reported fatigue or eye strain after performing 3D  
416 colonoscopy, probably because this 3D endoscopy system uniquely considers  
417 pupillary distance. Tailoring the 2D to 3D conversion process according to  
418 pupillary distance is crucial for mitigating visual discomfort when watching 3D  
419 imagery[33]. The finding that a significant increase in ADR with 3D colonoscopy  
420 was not accompanied by an increase in the mucosa inspection time compared

421 with 2D colonoscopy also supported that processing the 3D images did  
422 significantly increase endoscopist burden. Whether more prolonged use of this  
423 3D system for colonoscopy might increase endoscopist burden remains to be  
424 evaluated. Lastly, given the relatively low prevalence of SSL and AA, this study  
425 was not powered to detect potential differences in the rate of SSL and AA  
426 between 3D and 2D colonoscopy. The numerically higher detection rates of  
427 SSL and AA with 3D colonoscopy observed in this study warrants confirmation  
428 by further research with a larger sample size.

429 In conclusion, this RCT demonstrated that for individuals aged 40 and  
430 above, 3D colonoscopy significantly increased the detection rates of  
431 adenomas, particularly small, flat, and proximal adenomas, compared with  
432 standard 2D colonoscopy. The sizable increases in ADR suggested that  
433 implementing 3D colonoscopy in clinical practice might deliver significant  
434 improvement in patient outcomes.



435

**REFERENCES**

- 436 [1] Keum N, Giovannucci E. Global burden of colorectal cancer: emerging trends,  
437 risk factors and prevention strategies. *Nat Rev Gastroenterol Hepatol.*  
438 2019;16:713-732.
- 439 [2] Nguyen LH, Goel A, Chung DC. Pathways of Colorectal Carcinogenesis.  
440 *Gastroenterology.* 2020;158:291-302.
- 441 [3] Zauber AG, Winawer SJ, O'Brien MJ, et al. Colonoscopic polypectomy and  
442 long-term prevention of colorectal-cancer deaths. *N Engl J Med.* 2012;366:687-  
443 696.
- 444 [4] Nishihara R, Wu K, Lochhead P, et al. Long-term colorectal-cancer incidence  
445 and mortality after lower endoscopy. *N Engl J Med.* 2013;369:1095-1105.
- 446 [5] Corley DA, Jensen CD, Marks AR, et al. Adenoma detection rate and risk of  
447 colorectal cancer and death. *N Engl J Med.* 2014;370:1298-1306.
- 448 [6] Chang WY, Chiu HM. Can image-enhanced endoscopy improve adenoma  
449 detection rate?. *Dig Endosc.* 2022;34:284-296.
- 450 [7] Antonelli G, Correale L, Repici A, Hassan C, et al. Dye-based chromoendoscopy  
451 for the detection of colorectal neoplasia: meta-analysis of randomized  
452 controlled trials. *Gastrointest Endosc.* 2022;96:411-422.
- 453 [8] Kim SY, Park HJ, Kim HS, et al. Cap-Assisted Chromoendoscopy Using a  
454 Mounted Cap Versus Standard Colonoscopy for Adenoma Detection. *Am J*  
455 *Gastroenterol.* 2020;115:465-472.
- 456 [9] Karsenti D, Tharsis G, Perrot B, et al. Adenoma detection by Endocuff-assisted  
457 versus standard colonoscopy in routine practice: a cluster-randomised  
458 crossover trial. *Gut.* 2020;69:2159-2164.

62

21

63

- 459 [10] Rutter MD, Beintaris I, Valori R, et al. World Endoscopy Organization  
460 Consensus Statements on Post-Colonoscopy and Post-Imaging Colorectal  
461 Cancer. *Gastroenterology*. 2018;155:909-925.
- 462 [11] Morris EJ, Rutter MD, Finan PJ, et al. Post-colonoscopy colorectal cancer  
463 (PCCRC) rates vary considerably depending on the method used to calculate  
464 them: a retrospective observational population-based study of PCCRC in the  
465 English National Health Service. *Gut*. 2015;64:1248-1256.
- 466 [12] le Clercq CM, Bouwens MW, Rondagh EJ, et al. Postcolonoscopy colorectal  
467 cancers are preventable: a population-based study. *Gut*. 2014;63:957-963.
- 468 [13] Anderson R, Burr NE, Valori R. Causes of Post-Colonoscopy Colorectal  
469 Cancers Based on World Endoscopy Organization System of Analysis.  
470 *Gastroenterology*. 2020;158:1287-1299.e2.
- 471 [14] Lee J, Park SW, Kim YS, et al. Risk factors of missed colorectal lesions after  
472 colonoscopy. *Medicine (Baltimore)*. 2017;96:e7468.
- 473 [15] Zhao S, Wang S, Pan P, et al. Magnitude, Risk Factors, and Factors Associated  
474 With Adenoma Miss Rate of Tandem Colonoscopy: A Systematic Review and  
475 Meta-analysis. *Gastroenterology*. 2019;156:1661-1674.e11.
- 476 [16] Higuchi K, Kaise M, Noda H, et al. Three-dimensional visualization improves  
477 the endoscopic diagnosis of superficial gastric neoplasia. *BMC Gastroenterol*.  
478 2021;21:242.
- 479 [17] Durr NJ, González G, Parot V. 3D imaging techniques for improved  
480 colonoscopy. *Expert Rev Med Devices*. 2014;11:105-107.
- 481 [18] Sakata S, Grove PM, Stevenson AR, et al. The impact of three-dimensional  
482 imaging on polyp detection during colonoscopy: a proof of concept study. *Gut*.  
483 2016;65:730-731.



- 484 [19] Moynihan A, Boland P, Cahill RA. Twenty First Century Technological Toolbox  
485 Innovation for Transanal Minimally Invasive Surgery (TAMIS). *Surg Technol Int.*  
486 2024;44:91-98.
- 487 [20] Afonso, M.; Soares, R.; Ramos, R. et al. Three-dimensional (3D) endoscopic  
488 sleeve gastropasty: single center case series. *Endoscopy*; DOI: 10.1055/s-  
489 0042-1745406.
- 490 [21] Chang LC, Wu MS, Tu CH, et al. Metabolic syndrome and smoking may justify  
491 earlier colorectal cancer screening in men. *Gastrointest Endosc.* 2014;79:961-  
492 969.
- 493 [22] Aronchick CA, Lipshutz WH, Wright SH et al. A novel tableted purgative for  
494 colonoscopic preparation: efficacy and safety comparisons with Colyte and  
495 Fleet Phospho-Soda. *Gastrointest Endosc* 2000;52:346–352.
- 496 [23] Nagtegaal ID, Odze RD, Klimstra D, et al. The 2019 WHO classification of  
497 tumours of the digestive system. *Histopathology.* 2020;76:182-188.
- 498 [24] Rex DK, Schoenfeld PS, Cohen J, et al. Quality indicators for colonoscopy.  
499 *Gastrointest Endosc.* 2015;81:31-53.
- 500 [25] Cheung KS, Chen L, Seto WK, et al. Epidemiology, characteristics, and survival  
501 of post-colonoscopy colorectal cancer in Asia: A population-based study. *J*  
502 *Gastroenterol Hepatol.* 2019;34:1545-1553.
- 503 [26] Pedersen L, Valori R, Bernstein I, et al. Risk of post-colonoscopy colorectal  
504 cancer in Denmark: time trends and comparison with Sweden and the English  
505 National Health Service. *Endoscopy.* 2019;51:733-741.
- 506 [27] Xiang L, Zhan Q, Zhao XH, et al. Risk factors associated with missed colorectal  
507 flat adenoma: a multicenter retrospective tandem colonoscopy study. *World J*  
508 *Gastroenterol.* 2014;20:10927-10937.

- 509 [28] Soetikno RM, Kaltenbach T, Rouse RV, et al. Prevalence of nonpolypoid (flat  
510 and depressed) colorectal neoplasms in asymptomatic and symptomatic  
511 adults. *JAMA*. 2008;299:1027-1035.
- 512 [29] Pohl J, Schneider A, Vogell H, et al. Pancolonoscopic chromoendoscopy with indigo  
513 carmine versus standard colonoscopy for detection of neoplastic lesions: a  
514 randomised two-centre trial. *Gut*. 2011;60:485-490.
- 515 [30] Kahi CJ, Anderson JC, Waxman I, et al. High-definition chromocolonoscopy vs.  
516 high-definition white light colonoscopy for average-risk colorectal cancer  
517 screening. *Am J Gastroenterol*. 2010;105:1301-1307.
- 518 [31] Zhao S, Yang X, Wang S, et al. Impact of 9-Minute Withdrawal Time on the  
519 Adenoma Detection Rate: A Multicenter Randomized Controlled Trial. *Clin  
520 Gastroenterol Hepatol*. 2022;20:e168-e181.
- 521 [32] Sun X, Zhang Q, Wu S, et al. Effect of 3-Dimensional Imaging Device on Polyp  
522 and Adenoma Detection During Colonoscopy: A Randomized Controlled Trial.  
523 *Am J Gastroenterol*. 2023;118:1812-1820.
- 524 [33] Hibbard, P and Scarfe, LV. 2020. The implications of interpupillary distance  
525 variability for virtual reality. Central Archive at the University of Reading. DOI:  
526 10.1109/IC3D51119.2020.9376369.

527

**FIGURE LEGENDS**

528 **Figure 1.** Schematic representation of the MonoStereo 3D endoscopic  
529 visualization system (a) (provided by MedicalTek Co. Ltd). The endoscopic  
530 display can be switched from standard 2D images (b) to reconstructed images  
531 (c) which transform into real-time fully immersive 3D images when viewed with  
532 polarized 3D glasses. Employing 3D colonoscopy during routine colonoscopic  
533 examinations (d).

534 **Figure 2.** Screening, recruitment, randomization, and analysis of the study  
535 participants.

536 **Figure 3.** Temporal changes between 2D and 3D colonoscopy in mean mucosa  
537 inspection time (a) and adenoma detection rate (b).

74

25

75

538

**VIDEO LEGENDS**

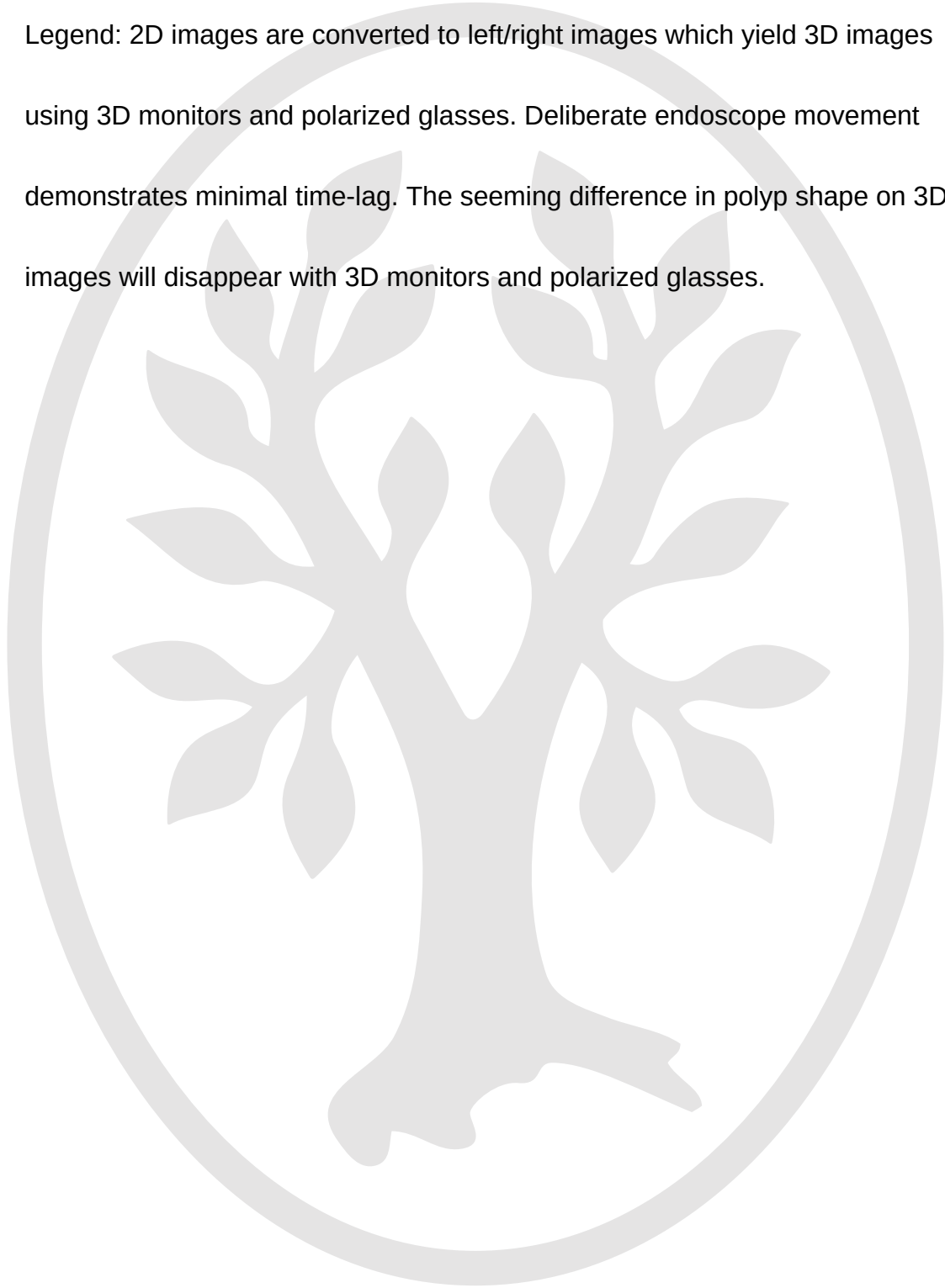
539 **Video title:** Demonstrative video: 2D and 3D colonoscopy.

540 Legend: 2D images are converted to left/right images which yield 3D images

541 using 3D monitors and polarized glasses. Deliberate endoscope movement

542 demonstrates minimal time-lag. The seeming difference in polyp shape on 3D

543 images will disappear with 3D monitors and polarized glasses.



77

26

78

**Table 1. Demographics and clinical characteristics of study subjects**

	2D colonoscopy n=158	3D colonoscopy n=160	<i>p</i>
Age - years, mean (SD)	62.4 (11.2)	61.4 (9.9)	.40
Male, n (%)	79 (50.0)	71 (44.4)	.32
Body weight – kg, mean (SD)	65.4 (12.2)	66.4 (13.2)	.48
Body height – cm, mean (SD)	164.2 (9.7)	162.9 (7.8)	.19
Body mass index, kg/m <sup>2</sup> , mean (SD)	24.2 (4.2)	24.9 (4.1)	.13
Family history with CRC, n (%)	17 (10.8)	27 (16.9)	.11
Ever smoking, n (%)	39 (24.7)	32 (20.0)	.32
Alcohol consumption, n (%)	14 (8.9)	11 (6.9)	.51
Anti-thrombotic agent use, n (%)	21 (13.3)	27 (16.9)	.37
Diabetes mellitus, n (%)	24 (15.2)	25 (15.6)	.91
Hypertension, n (%)	52 (32.9)	64 (40.0)	.19
Indication, n (%)			.35
FIT positivity	44 (27.8)	50 (31.3)	
Post-polypectomy surveillance	59 (37.3)	45 (28.1)	
Symptoms	43 (27.2)	53 (33.1)	
Others	12 (7.6)	12 (7.5)	

(To be continued)

**Table 1. Demographics and clinical characteristics of study subjects (continued)**

	2D colonoscopy n=158	3D colonoscopy n=160	<i>p</i>
Modified Aronchick bowel preparation scale*, n (%)			.085
Excellent/Good	100 (63.3)	87 (54.4)	
Fair	58 (36.7)	73 (45.6)	
Withdrawal time (min)**, mean (SD)			.0092
Mucosa inspection time (min)***, mean (SD), Entire cohort	9.4 (3.1)	9.8 (2.6)	.21
	9.6 (2.6)	11.1 (2.6)	.012

---

Case number 1-40	10.0 (3.6)	10.1 (2.5)	.89
Case number 41-80	9.5 (3.4)	9.9 (2.1)	.53
Case number 81-120	8.3 (2.6)	8.0 (2.2)	.58
Case number 121-160			

---

2D/3D: 2-dimensional/3-dimensional, SD: standard deviation, CRC: colorectal cancer, FIT: Fecal immunochemical test, min.: minute

\* Subjects rating poor or inadequate bowel preparation had been excluded from the study.

\*\*Withdraw time = the total time from cecum to anus

\*\*\*Inspection time = withdraw time – time for observing and removing polyp



**Table 2. Comparison of primary and secondary outcomes between 2D and 3D colonoscopy**

	2D colonoscopy n=158	3D colonoscopy n=160	Difference in detection rate % (95%CI)	Odds ratio (95% CI)	<i>p</i>
<b>Primary outcomes</b>					
Patients with adenoma, n (%)	61 (38.6)	85 (53.1)	14.5 (3.7-25.4)	1.80 (1.15-2.82)	.0094
<b>Secondary outcomes</b>					
Patients with flat adenoma, n (%)	34 (21.5)	56 (35.0)	13.5 (3.7-23.3)	1.96 (1.19-3.24)	.0076
Patients with sessile adenoma, n (%)	44 (27.8)	47 (29.4)	1.6 (-8.4-11.5)	1.08 (0.66-1.75)	.76
Patients with right-sided adenoma, n (%)	24 (15.2)	42 (26.3)	11.1 (2.2-19.9)	1.98 (1.14-3.48)	.015
Patients with left-sided adenoma, n (%)	61 (38.6)	85 (53.1)	14.5 (3.7-25.4)	1.80 (1.15-2.82)	.0094
Patients with proximal adenoma, n (%)	37 (23.4)	61 (38.1)	14.7 (4.7-24.7)	2.02 (1.24-3.28)	.0045
Patients with distal adenoma, n (%)	48 (30.4)	53 (33.1)	2.7 (-7.5-12.8)	1.11 (0.68-1.82)	.66
(To be continued)					

**Table 2. Comparison of primary and secondary outcomes between 2D and 3D colonoscopy (continued)**

	2D colonoscopy n=158	3D colonoscopy n=160	Difference in detection rate % (95%CI)	Odds ratio (95% CI)	<i>p</i>
Patients with sessile serrated lesions, n (%)	8 (5.1)	11 (6.9)	1.8 (-3.4-7.0)	1.38 (0.54-3.54)	.50
Patients with advanced adenoma, n (%)	11 (7.0)	15 (9.4)	2.4 (-3.6-8.4)	1.38 (0.61-4.11)	.43
Patients with adenoma, n (%)					
< 5mm	14 (8.9)	13 (8.1)	0.7 (-6.9-5.4)	1.10 (0.50-2.42)	.81

5-9mm	49 (31.0)	72 (45.0)	14.0 (3.4-24.5)	1.82 (1.15-2.88)	.010
≥10mm	15 (9.5)	25 (15.6)	6.1 (-1.1-13.4)	1.77 (0.89-3.49)	.10
Patients with polyps, n (%)	73 (46.2)	100 (62.5)	16.3 (5.5-27.1)	1.94 (1.24-3.04)	.0035
No. of adenoma per patient, median (IQR)	0 (0-1)	1 (1-2)	-	-	.028
No. of polyp per patient, median (IQR)	0 (0-1)	1 (0-2)	-	-	<.0001

2D/3D: 2-dimensional/3-dimensional, OR: Odds ratio, no.: number, CI: confidence interval, SD: standard deviation, IQR: interquartile range

Right-sided adenoma: Adenoma at cecum or ascending colon; Left-sided adenoma: Adenoma at transverse colon, descending colon, sigmoid colon or rectum; Proximal adenoma: Adenoma at cecum, ascending colon, or transverse colon; Distal adenoma: Adenoma at descending colon, sigmoid colon or rectum; Flat adenoma: Paris classification 0-IIa, 0-IIb, or 0-IIc; Sessile adenoma: Paris classification 0-Is

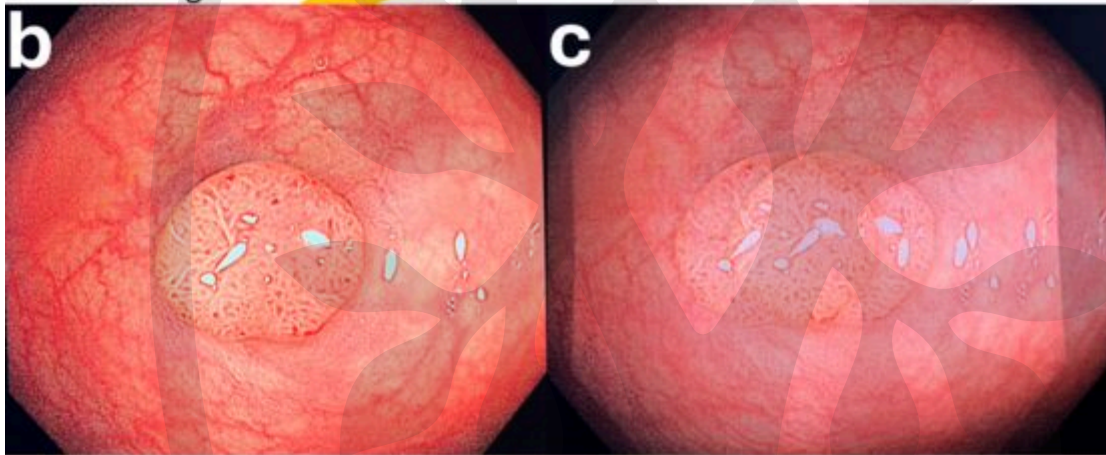
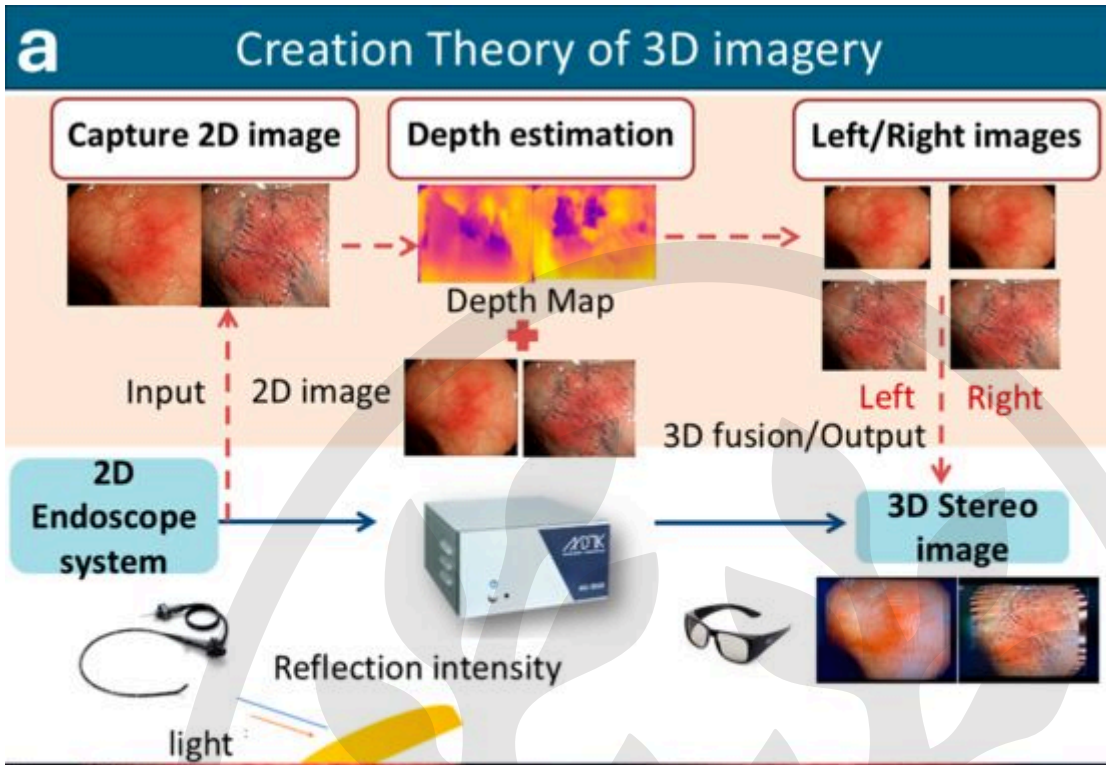


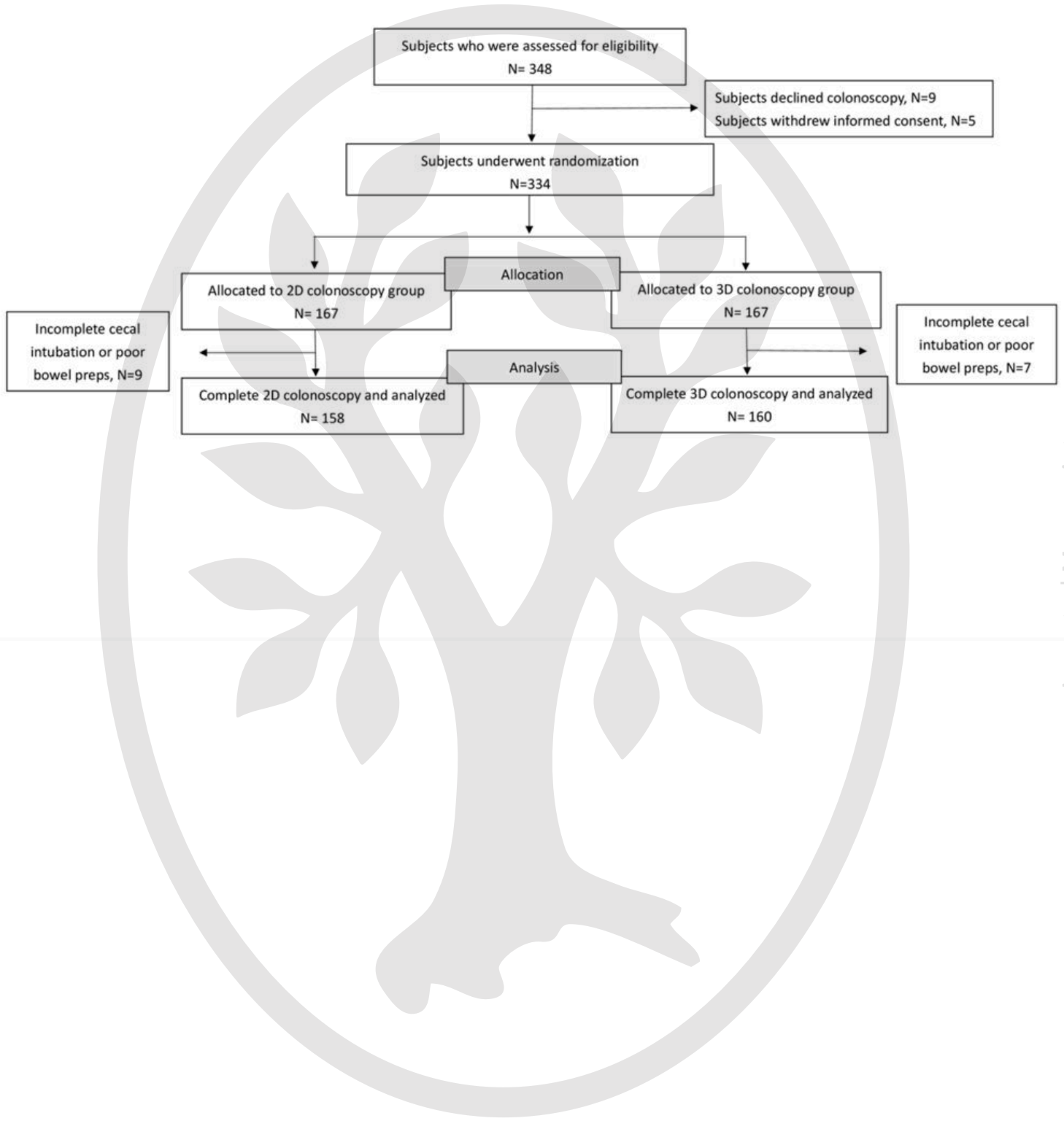
**Table 3. Factors associated with detection of adenoma**

	Univariable analysis		Multivariable analysis	
	OR (95% CI)	<i>p</i>	aOR (95% CI)	<i>p</i>
Age, per 1-year increment	1.04 (1.02-1.06)	<.0001	1.03 (1.01-1.06)	.0080
Male sex	1.44 (0.92-2.24)	.11		
BMI, per 1 kg/m <sup>2</sup> increment	1.04 (0.98-1.10)	.16		
Ever smoking	1.70 (1.00-2.90)	.050		
Alcohol consumption	1.30 (0.57-2.93)	.54		
Anti-thrombotic agent use	1.79 (0.96-3.34)	.066		
Diabetes mellitus	1.40 (0.76-2.58)	.28		
Hypertension	1.90 (1.20-3.02)	.0060	1.32 (0.79-2.20)	.29
Family history of CRC	0.63 (0.33-1.21)	.17		
FIT positivity	1.90 (1.17-3.10)	.010	1.46 (0.86-2.47)	.16
Good or excellent bowel preparation	0.60 (0.38-0.94)	.025	0.89 (0.54-1.47)	.67
Mucosa inspection time, per 1 minute increment	1.20 (1.10-1.31)	<.0001	1.16 (1.06-1.28)	.0010
3D colonoscopy use	1.80 (1.15-2.81)	.0093	1.76 (1.09-2.83)	.021

OR: odds ratio, aOR: adjusted odds ratio, CI: confidence interval; BMI: body mass index; CRC: colorectal cancer, FIT: fecal immunochemical test, 3D: 3-dimensional

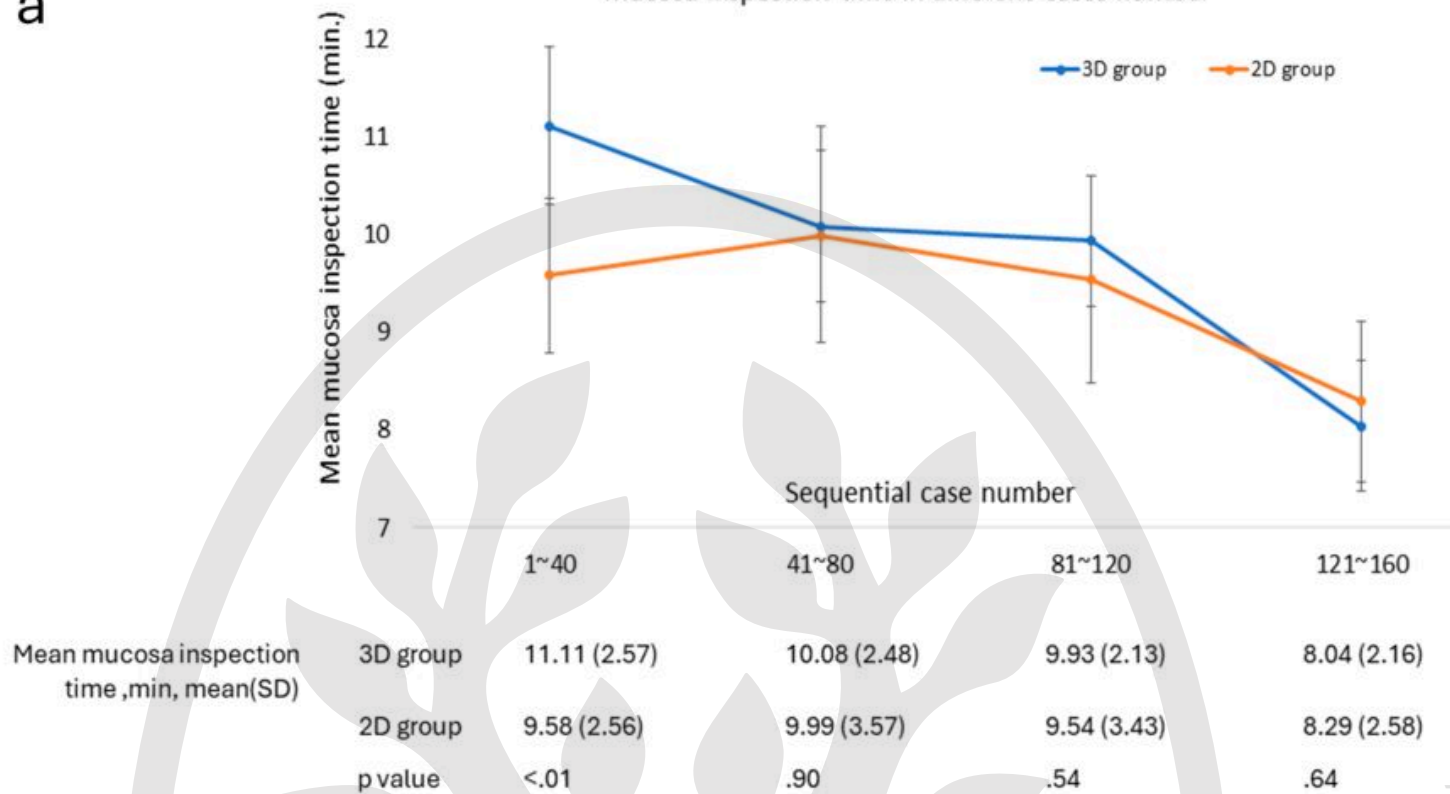






a

Mucosa inspection time in different cases number



b

ADR in different cases number

