REVIEW

Endocuff-assisted versus standard colonoscopy for improving adenoma detection rate: meta-analysis of randomized controlled trials

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Abstract

Background The effect of Endocuff-assisted colonoscopy compared with standard colonoscopy is conflicting in terms of the adenoma detection rate. The aim of this meta-analysis was to compare the efficacy of Endocuff-assisted colonoscopy for adenoma detection.

Methods PubMed, Embase, Google Scholar and Cochrane Library were searched up to the end of June 8, 2021. All randomized controlled trials (RCTs) comparing Endocuff-assisted colonoscopy with standard colonoscopy were included. Dichotomous data were pooled to obtain the relative risk with a 95% CI, whereas continuous data were pooled using a mean difference with 95% CI.

Results A total of 23 RCTs involving 17,999 patients were included. Compared with standard colonoscopy, use of the Endocuff was associated with a significant improvement in the adenoma detection rate (RR = 1.16, 95% CI 1.08–1.24), polyp detection rate (RR = 1.17, 95% CI 1.09–1.25), sessile serrated lesion detection rate (RR = 1.23, 95% CI 1.05–1.43), left-side lesion detection rate (RR = 1.24, 95% CI 1.08–1.43), and mean number of adenomas per patient (MD = 0.17, 95% CI 0.08–0.26). There were no significant differences between the and groups in detection of advanced adenomas, mean number of polyps per patient, right-side lesion detection rate, cecal intubation rate, cecal intubation time and withdrawal time.

Conclusions The pooled evidence suggests a significant improvement in the adenoma detection rate, and polyp detection rate using the Endocuff. On the other hand, no significant effect on the detection of advanced adenomas and mean number of polyps per patient was noted.

Introduction

Globally, colorectal cancer (CRC) is the third most commonly diagnosed malignancy and the second leading cause of cancer death [1]. Morbidity and mortality associated with CRC can be mitigated through appropriate screening and surveillance. Colonoscopy, as a screening procedure, is a gold standard in detecting tumors at an earlier and more treatable stage and also facilitates the timely removal of precancerous lesions or adenomas [2]. The adenoma detection rate (ADR) is now the main quality indicator of colonoscopy because of its inverse correlation with interval cancer rate [3, 4]. ADR can be improved by technique or devices that improve mucosal exposure or by tools that highlight flat colonic lesions.

A number of distal attachments have been tested to improve ADR, including a transparent cap, cuff, or rings [5]. The cuff is attached to the tip of the colonoscope, and the fingers are used to flatten colonic folds, leading to increased mucosal visualization [6]. Endocuff (Arc Medical, Leeds, UK), which was granted United States Food and Drug Administration approval in 2012, is a soft plastic cap with rows of finger-like projections attached onto the colonoscope tip. In 2014, the next-generation Endocuff (Endocuff Vision) was released, consisting of a single row of finger-like projections which were 3 mm longer [7].

A number of studies have been published comparing the efficacy of Endocuff-assisted colonoscopy (EAC) to that of

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standard colonoscopy, but so far, the impact of EAC on ADR is conflicting with data suggesting equivocal benefit from its use. Aside from individual studies, several meta-analyses have been performed to assess the effect of Endocuff [8–12]. Fewer randomized controlled trials (RCTs) were included in the early meta-analyses, and the high heterogeneity noted called for careful interpretation of the results. The most recent meta-analysis [12], including 8 RCTs, found a significant improvement in ADR and mean number of adenomas per colonoscopy with shorter withdrawal times using the second-generation cuff device compared with standard colonoscopy. Six RCTs comparing Endocuff-assisted and standard colonoscopy have recently been published [13–18]. Therefore, we conducted a meta-analysis of published data to evaluate the efficacy and safety of EAC.

Materials and methods

This systematic review and meta-analysis have been registered at NIHR PROSPERO (CRD42021231865). It is reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [19].

Search strategy

A literature search was conducted using PubMed, Embase, Google Scholar and Cochrane Library up to June 8, 2021 without language restrictions. Relevant studies were identified using the following terms: "Endocuff", "Endocuff vision", "distal attachment" and "adenoma detection rate or ADR". The search was restricted to human subjects. Additional studies were identified using a hand search of references of original or review articles and international conferences on this topic, primarily including United European Gastroenterology Week (UEGW) and Digestive Disease Week (DDW).

Inclusion and exclusion criteria

Studies were included if they met the following criteria: (1) RCTs that compared Endocuff-assisted and standard colonoscopy for adenoma detection, (2) presenting the detailed outcomes of Endocuff-assisted and standard colonoscopy or including such data for calculation in the article. Nonrandomized prospective, retrospective, feasibility or pilot studies, meta-analysis, editorials, reviews, case reports/series, studies not reporting on ADR and duplicate publications were excluded.

Data extraction

Two investigators (Wang J, Ye C) independently extracted the data and reached a consensus for all items. If the investigators generated different results, they checked the data again and had a discussion to reach an agreement. If they were unable to reach an agreement, an expert (Fei S) was invited to join the discussion. Data extracted from the selected articles included the first author's name, year of publication, country of origin, study period, device type, indications for colonoscopy, baseline characteristic of the patients, and primary outcomes.

Bias assessment

The risk of bias in individual studies was assessed using the Cochrane Collaboration tool [20]. This particular tool evaluates different domains of potential source of bias: random sequence generation and allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias) and other bias. The analysis results were defined as low, high or unclear bias (bias-related information is not clear or bias cannot be determined). Publication bias was assessed using subjective judgment based on funnel plots as well quantitatively using Egger's regression analysis. A p value < 0.05 was indicative of substantial publication bias.

Outcome measures

The primary outcome of this study was to calculate a pooled ADR. The secondary outcomes were the polyp detection rate, detection rate of advanced adenomas, sessile serrated lesion detection rate, mean number of adenomas per patient, mean number of polyps per patient right-sided lesion detection rate, left-sided lesion detection rate, ileum intubation rate, cecal intubation rate, cecal intubation time, withdrawal time, and adverse events.

Statistical analysis

A meta-analysis was performed using the Cochrane Collaboration RevMan 5.4 and STATA package version 12.0. The analyses were performed by calculating pooled estimates of primary and secondary outcome. Relative risk (RR) with 95% confidence interval (CI) for each proportional outcome was calculated. Mean difference (MD) with 95% CI was calculated for continuous variables. The χ^2-test-based Q statistic test was performed to assess the

between-study heterogeneity. We also quantified the effect heterogeneity according to the I^2 test. When a significant Q test ($P < 0.05$) or $I^2 > 50\%$ indicated heterogeneity across studies, the random effects model was used; otherwise, the fixed effects model was used. An analysis of sensitivity was performed to evaluate the stability of the results. Additionally, we conducted subgroup analysis by the ADR for standard colonoscopy groups (baseline ADR), the device type (Endocuff or Endocuff Vision), adenoma size (≤ 5 mm, 6–9 mm, ≥ 10 mm) and indications for endoscopy (screening or mixed population). A p value of < 0.05 was regarded as being statistically significant.

Results

Study characteristics

Following the searching strategy, a total of 546 citations were identified. According to the inclusion criteria, 25 studies were selected and subjected to further examination [13–18, 21–39]. We excluded 2 studies [38, 39] because they are randomized tandem studies. Therefore, 23 RCTs with 17,999 patients were included in the meta-analysis [13–18, 21–37]. (Fig. 1). The characteristics of the selected studies are summarized in Table 1. Of the 23 eligible studies, 5 were from the United States [14, 23, 24, 28, 33], 3 each from United Kingdom [15, 21, 31] and Germany [22, 26, 36], 2 from mixed countries [13, 32], 2 from Thailand [17, 35], and 1 each from Spain [16], Italy [18], Portugal [25], Mexico [27], Australia [29], France [30], Netherlands [34], and Japan [37]; Nine studies were multicenter [15, 16, 18, 23, 24, 26, 31, 32, 34], 4 were two-center [13, 22, 33, 37] and 10 were single-center experiences [14, 17, 21, 25, 27–30, 35, 36]. All studies were published in English (18 full-text articles [13–18, 21, 22, 26, 27, 29–34, 36, 37] and 5 abstracts [23–25, 28, 35]). Eleven studies used the first-generation Endocuff [13, 14, 22–24, 26–28, 32, 34, 37], and 12 studies used the second-generation device (Endocuff Vision) [15–18, 21, 25, 29–31, 33, 35, 36].

Risk of bias assessment using the Cochrane Collaboration tool is provided in supplementary table 1 and supplementary Fig. 1 (Fig.S1). The shape of the funnel plots did not reveal any evidence of asymmetry (Fig. S2). Egger's test also showed no statistical significance in evaluation of publication bias ($p = 0.427$).

Fig. 1 PRISMA flow chart showing study selection procedure. *PRISMA* preferred reporting items for systematic reviews and meta-analyses, *EAC* endocuff-assisted colonoscopy, *RCT* randomized controlled trial
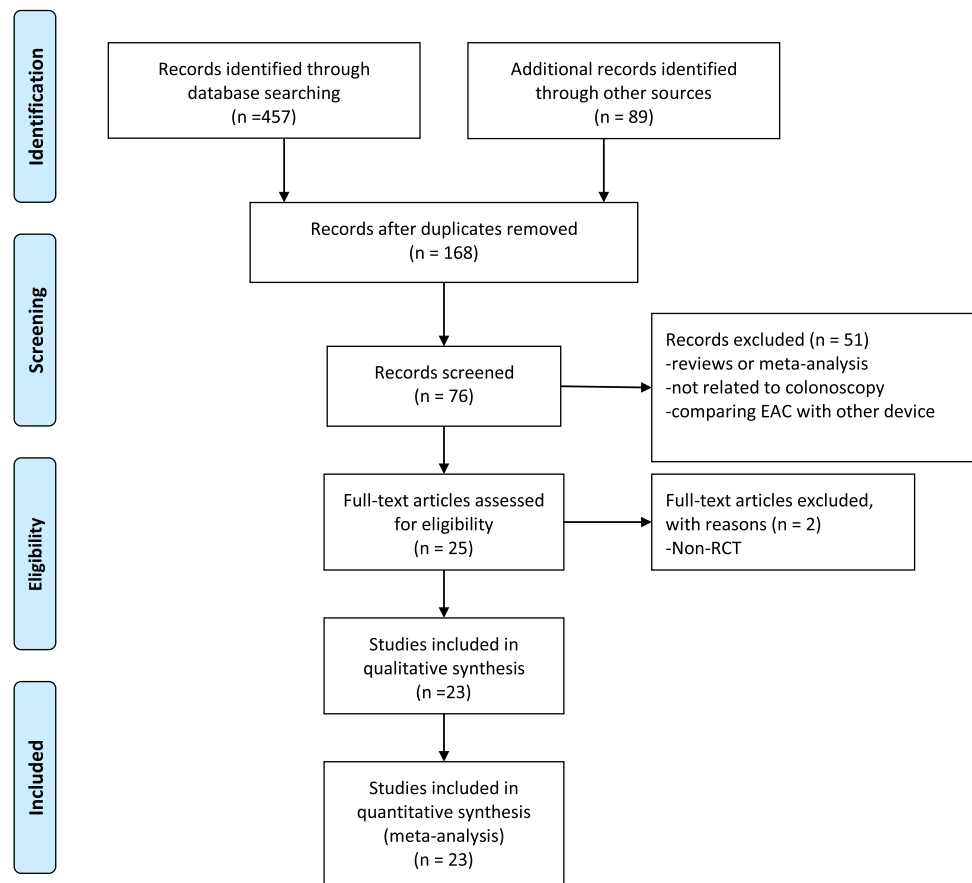
Table 1 Characteristics of the included studies

Study	Country	Year	Study period	Device	Indications	Center	Number patients		Age, years		Gender (men %)		Primary outcome
							EAC	SC	EAC	SC	EAC	SC	
Aniwan et al. [17]	Thailand	2021	2019–2020	Endocuff Vision	Screening	1	250	250	61.1	61.1	34.4	33.2	ADR
Bhattacharyya et al. [21]	UK	2017	2015–2016	Endocuff Vision	Positive FOBT, Polyp surveillance	1	266	265	68	67	60.9	67.9	MPP
Biecker et al. [22]	Germany	2014	2013.2–2013.8	Endocuff	Colorectal cancer screening, follow-up examination, evaluation for anemia, or abdominal pain	2	245	253	65	68	48.2	51.8	Number of polyps per colonoscopy
Catalano et al. [23]	USA	2017	NA	Endocuff	Screening	Multi-center	809	764	NA	NA	NA		ADR
Cattau et al. [24]	USA	2015	2015.1–2015.5	Endocuff	Screening	3	329	329	58*	67	48.2*	49	ADR
Costa Santos et al. [25]	Portugal	2019	2018–2019	Endocuff Vision	NA	1	81	89	62.4*	63	57.4*		Mean sessile serrated lesion per colonpscopy
Floer et al. [26]	Germany	2014	2014.2–2014.7	Endocuff	Screening, surveillance or diagnostic colonoscopy (anemia or abdominal discomfort)	4	249	243	64	63	49	44.9	ADR
Floer et al. [13]	Germany/Poland	2020	2015.1–2017.12	Endocuff	Screening, diagnostic colonoscopy and follow-up examination	2	189	195	62	63	49.7	45.6	ADR
González-Fernández et al. [27]	Mexico	2017	2014–2015	Endocuff	Screening	1	174	163	60	62	29	24	ADR
Hass et al. [28]	USA	2016	NA	Endocuff	Screening, surveillance, bright red blood per rectum, constipation and abdominal pain	1	281	281	NA	NA	NA	NA	NA
Jacob et al. [29]	Australia	2019	2016–2017	Endocuff Vision	NA	1	182	138	NA	NA	56.7	59.3	ADR
Karsenti et al. [30]	France	2020	2017–2018	Endocuff Vision	Screening, history of polyp/cancer, FIT+, digestive symptoms	1	1026	1032	59.25	57.4	47.4	49	ADR
Marsano et al. [14]	USA	2019	2016.3–2017.1	Endocuff	Screening, surveillance	1	42	42	60	59.3	54.8	54.8	ADR
Ngu et al. [31]	UK	2019	2014–2016	Endocuff Vision	BCSP, BCSP surveillance, colonoscopy conversion from bowel scope, symptomatic diagnostic, symptomatic surveillance	7	888	884	61.7	62.1	57.1	56.8	ADR

Table 1 (continued)

Study	Country	Year	Study period	Device	Indications	Center	Number patients		Age, years		Gender (men %)		Primary outcome
							EAC	SC	EAC	SC	EAC	SC	
Rees et al. [15]	UK	2020	2017–2018	Endocuff Vision	Screening	16	1610	1612	55	55	53	53	ADR
Rex et al. [32]	USA/Italy	2018	NA	Endocuff	Screening, surveillance, diagnostic	3	299	295	63.2	62.6	53	53	APC
Rex et al. [33]	USA	2020	2017–2018	Endocuff Vision	Screening, surveillance	2	101	99	62.7	61.7	56.4	42.4	Withdrawal time
Rivero-Sánchez et al. [16]	Spain	2019	2015–2017	Endocuff Vision	Surveillance after the complete removal of all serrated lesions 4 mm and adenomas	4	62	60	61.2	60.2	68	52	Mean number of serrated lesions per patient
van Doorn et al. [34]	Netherlands	2015	2013–2014	Endocuff	Polyp surveillance, symotons, positive family history, FIT+ screening	5	530	533	65	65	50	54	MAP
Vanduangden et al. [35]	Thailand	2020	NA	Endocuff Vision	Screening	1	200	204	NA	NA	NA	NA	ADR
von Figura et al. [36]	Germany	2019	NA	Endocuff Vision	Screening, grounds to suspect tumor, abdominal complaints, Surveillance after colorectal cancer, gastrointestinal bleeding or anemia, history of colorectal polyps, suspected inflammatory process	1	118	122	63.6	65.3	51.7	62.3	The average duration of polypectomy
Wada et al. [37]	Japan	2018	2015.4–2015.9	Endocuff	Screening, polyp surveillance, symptoms, gastrointestinal bleeding, positive fecal occult blood test result	2	239	238	61.2	62.2	51	48.3	ADR, MAP
Zorzi et al. [18]	Italy	2021		Endocuff Vision	FIT+ screening	13	908	905	60.2	60.1	53.7	53.8	ADR

FIT fecal immunochemical testing, *BCSP* Bowel Cancer Screening Programme, *ADR* adenoma detection rate, *MAP* mean number of adenomas per patient, *MPP* mean polyp per patient, *APC* adenomas per colonoscopy, *NA* not available

Quantitative data synthesis

Primary outcome

Adenoma detection rate All 23 studies reported ADR in the Endocuff and standard colonoscopy groups. The pooled ADR was 44.9% (95% CI 37.6–52.1) for EAC and 39.1% (95% CI 32.3–45.9) for standard colonoscopy. The pooled RR was 1.16 (95% CI 1.08–1.24, $p < 0.00001$) (Fig. 2; Table 2).

In subgroup analyses based on the ADR in the standard colonoscopy group, a significant difference was observed between Endocuff and standard colonoscopy groups (baseline ADR < 25%: RR = 1.47, 95% CI 1.13–1.93, $p = 0.004$; baseline ADR < 30%: RR = 1.39, 95% CI 1.21–1.58, $p < 0.00001$; baseline ADR < 35%: RR = 1.40, 95% CI 1.25–1.58, $p = 0.03$; baseline ADR < 40%: RR = 1.37, 95% CI 1.23–1.52, $p = 0.004$; baseline ADR < 45%: RR = 1.28, 95% CI 1.15–1.41, $p < 0.0001$; baseline ADR < 50%: RR = 1.24, 95% CI 1.13–1.36, $p < 0.0001$). In contrast, no statistical difference was found in the subgroup of baseline ADR > 50% (RR = 1.04, 95% CI 0.97–1.11, $p = 0.50$) (Table 2).

Eight studies reported adenoma size. The pooled results showed ADR did not differ between Endocuff and standard colonoscopy (size ≥ 10 mm: RR = 1.02, 95% CI 0.91–1.15, $p = 0.47$; 6–9 mm: RR = 1.10, 95% CI 0.96–1.27, $p = 0.29$; size ≤ 5 mm: RR = 1.03, 95% CI 0.95–1.11, $p = 0.05$) (Table 2).

In the subgroup analysis of device type, a significant difference was found in both subgroups (Endocuff: RR = 1.22, 95% CI 1.07–1.40, $p < 0.00001$; Endocuff Vision: RR = 1.12, 95% CI 1.05–1.20, $p = 0.11$) (Table 2).

When grouping by indications for colonoscopy (pure screening or mixed populations), a significant difference was found in both subgroups (pure screening: RR = 1.20, 95% CI 1.06–1.37, $p = 0.001$; mixed population: RR = 1.14, 95% CI 1.05–1.23, $p = 0.0007$) (Table 2).

Secondary outcome

Polyp detection rate 13 studies with 11,421 patients reported polyp detection rates. The pooled polyp detection rate in the Endocuff group was 54.5% (95% CI 44.6–64.4) and in the standard colonoscopy group was 46.5% (95% CI 37.2–55.9). The pooled RR was 1.17 (95% CI 1.09–1.25, $p = 0.0008$) (Fig. 3; Table 2).

Sessile serrated lesion detection rate Ten studies with 9914 patients reported Serrated polyp detection rates. The pooled serrated detection rate was 8.4% (95% CI 5.8–11.1) for Endocuff and 5.9% (95% CI 4.0–7.8) for standard colonoscopy. The pooled RR was 1.23 (95% CI 1.05–1.43, $p = 0.46$) (Fig. 3; Table 2).

Detection rate of advanced adenomas Seven studies with 9243 patients reported Advanced ADR. The pooled Advanced ADR was 13.7% (95% CI 8.0–19.4) for Endocuff and 12.7% (95% CI 7.3–18.1) for standard colonoscopy. The
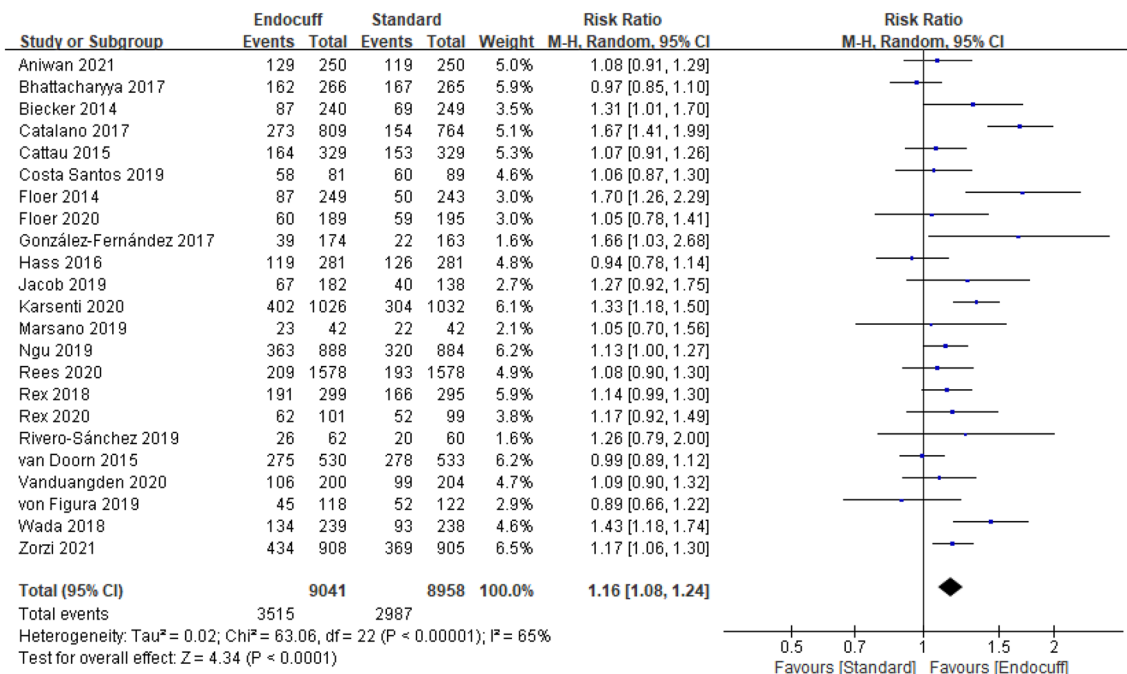

Fig. 2 Forest plots comparing endoscopic-assisted and standard colonoscopy in terms of ADR. *ADR* adenoma detection rate

Table 2 Outcomes of meta-analysis comparing EAC and SC

Outcomes	No.	EAC %	SC %	RR (95% CI)	*p*	*I²*
ADR	23	44.9 (37.6–52.1)	39.1 (32.3–45.9)	**1.16 (1.08–1.24)**	< 0.00001	65%
Device						
Endocuff	11	43.3 (35.9–50.6)	36.3 (27.1–45.6)	**1.22 (1.07–1.40)**	< 0.00001	78%
Enducuff Vision	12	46.3 (35.0–57.6)	41.7 (31.5–51.9)	**1.12 (1.05–1.20)**	0.11	35%
Indication						
Screening	7	38.7 (24.3–53.1)	32.6 (20.5–44.7)	**1.20 (1.06, 1.37)**	0.001	73%
Mixed	16	47.4 (42.1–52.8)	42 (35.6–48.4)	**1.14 (1.05, 1.23)**	0.0007	61%
Baseline ADR						
< 50%	17	39.4 (31.8–46.9)	32.9 (26.4–39.4)	**1.24 (1.13–1.36)**	< 0.0001	70%
> 50%	6	60.7 (54.7–66.8)	57.2 (52.2–62.3)	1.04 (0.97, 1.11)	0.50	0
Size						
≥ 10 mm	7	11.7 (8.2–15.1)	11.2 (7.9–14.6)	1.02 (0.91, 1.15)	0.47	0
6–9 mm	4	15 (10.9–19.1)	13.8 (8.6–18.9)	1.10 (0.96, 1.27)	0.29	20%
≤ 5 mm	5	50 (25–75)	49.9 (24.2–75.7)	1.03 (0.95, 1.11)	0.05	59%
PDR	13	54.5 (44.6–64.4)	46.5 (37.2–55.9)	**1.17 (1.09–1.25)**	0.0008	64%
AADR	7	13.7 (8.0–19.4)	12.7 (7.3–18.1)	1.11 (1.00–1.23)	0.45	0
SDR	10	8.4 (5.8–11.1)	5.9 (4.0–7.8)	**1.23 (1.05–1.43)**	0.46	0
LDR	6	30.5 (22.7–38.4)	25.5 (17.6–33.4)	**1.24 (1.08–1.43)**	0.08	43%
RDR	9	28.7 (23.3–34)	25.2 (19.7–30.7)	1.21 (1.00–1.46)	< 0.00001	83%
Ileal intubation rate	7	61 (43.6–78.5)	68 (50.9–85)	**0.89 (0.80–0.99)**	0.0001	78%
Cecal intubation rate	8	97.4 (96.7–98.2)	96.9 (95.4–98.3)	1.00 (1.00–1.01)	0.29	18%
Adverse events	16	–	–	2.6 (1.29–5.26)	0.01	51%
				MD (95% CI)	*p*	*I²*
MAP	10	–	–	**0.17 (0.08–0.26)**	< 0.00001	78%
MPP	4	–	–	0.16 (0–0.32)	< 0.00001	93%
Withdrawal time	8	–	–	– 0.29 (– 0.91, 0.33)	0.004	66%
Cecal intubation time	5	–	–	– 0.60 (– 1.45, 0.26)	0.002	77%

EAC endocuff-assisted colonoscopy, *SC* standard colonoscopy, *RR* relative risk, *CI* confidence interval, *MD* mean difference, *ADR* adenoma detection rate, *PDR* polyp detection rate, *AADR* advanced ADR, *SDR* sessile serrated lesion detection rate, *RDR* right-side lesion detection rate, *LDR* left-side lesion detection rate, *MAP* mean number of adenomas per patient, *MPP* mean number of polyps per patient

Bold indicates a meaningful result

pooled RR was 1.11 (95% CI 1.00–1.23, *p* = 0.45) (Fig. S3; Table 2).

Right and left-side lesion detection rate The right- and left-sided lesion detection rates were reported in 9 and 6 studies, respectively. The pooled right-sided lesion detection rate was 28.7% (95% CI 23.3–34) for Endocuff and 25.2% (95% CI 19.7–30.7) for standard colonoscopy. The pooled RR was 1.21 (95% CI 1.00–1.46, *p* < 0.00001) (Table 2). The pooled left-sided lesion detection rate was 30.5% (95% CI 22.7–38.4) for Endocuff and 25.5% (95% CI 17.6–33.4) for standard colonoscopy. The pooled RR was 1.24 (95% CI 1.08–1.43, *p* = 0.08) (Fig. 3; Table 2).

Mean number of adenomas per patient Ten studies with 10,178 patients reported the available data between Endo-

cuff and standard colonoscopy and the pooled mean difference with a random-effect model were 0.17 (95% CI 0.08–0.26, *p* < 0.00001) (Fig. 4; Table 2). The results above indicate a significant difference between the two groups.

Adverse events

Sixteen studies reported the available data between Endocuff and standard colonoscopy. The most commonly reported complication was minor mucosal lacerations, which was reported in 66 patients in Endocuff group (4%), and in 7 patients in Endocuff Vision group (0.1%). The other complication was loss of Endocuff (0.4%), post-polypectomy bleeding (0.3%), bleeding (0.06%), and perforations (0.04%). The pooled RR with a random effects model was 2.60 (95% CI:
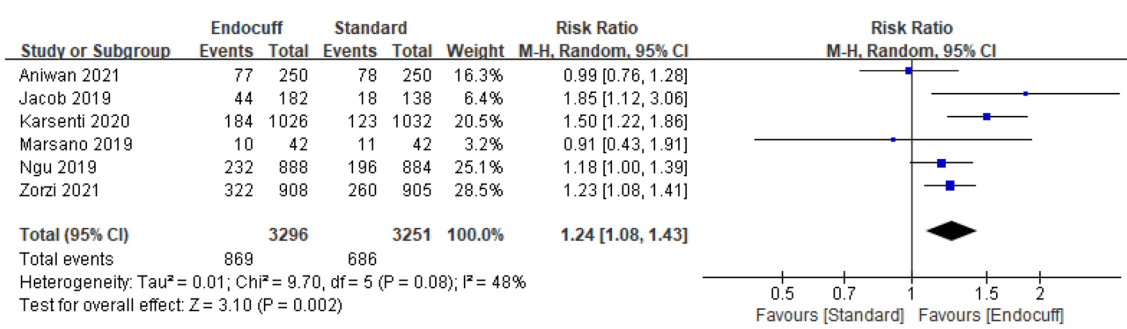
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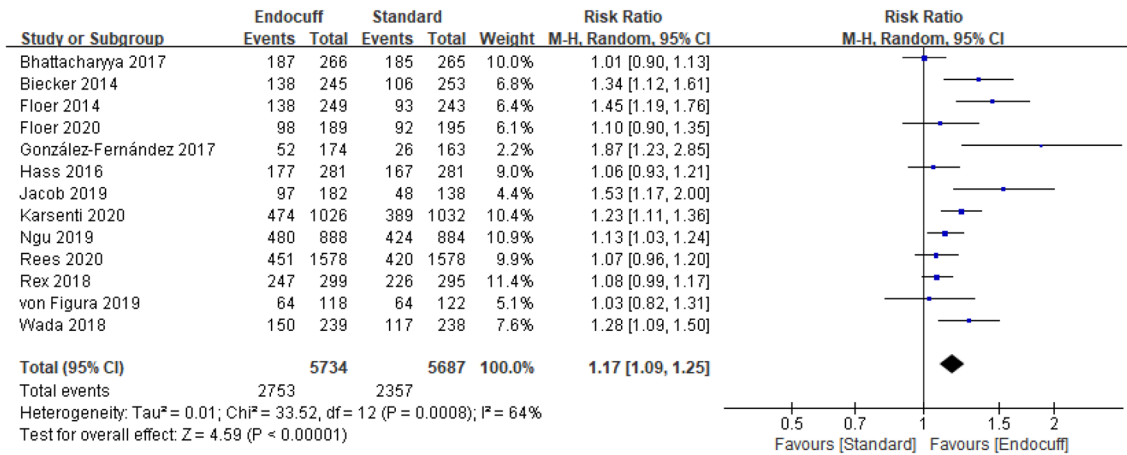
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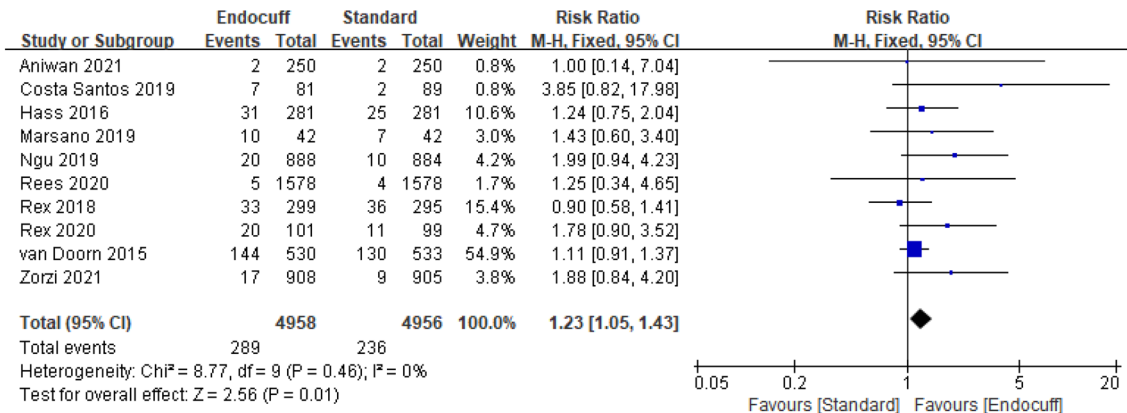
C

Fig. 3 Forest plots comparing endoscopic-assisted and standard colonoscopy in terms of second outcomes. **A** Polyp detection rate; **B** Serrated lesion detection rate, **C** left-sided lesion detection rate

1.29–5.26, $p = 0.01$) (Table 2). Stratification based on device type, similar results were observed in the Endocuff group (77/1536, RR = 7.16, 95% CI 3.82–13.41, $p = 0.09$), but not in the Endocuff Vision group (31/5241, RR = 1.31, 95% CI 0.78–2.20, $p = 0.50$) (Fig. S4).

Other outcomes

For additional secondary outcomes, including ileum intubation rate, MPP, cecal intubation rate, cecal intubation time, and withdrawal time, there was no significant difference between the two groups except for ileum intubation rate (61% versus 68%, RR = 0.89, 95% CI 0.80–0.99, $p = 0.0001$) (Fig. S5; Table 2).
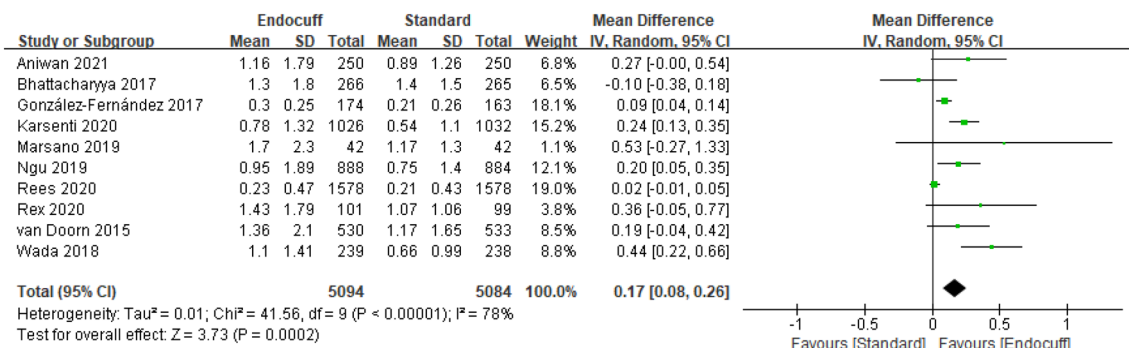
Study or Subgroup	Endocuff Mean	Endocuff SD	Endocuff Total	Standard Mean	Standard SD	Standard Total	Weight	Mean Difference IV, Random, 95% CI
Aniwan 2021	1.16	1.79	250	0.89	1.26	250	6.8%	0.27 [-0.00, 0.54]
Bhattacharyya 2017	1.3	1.8	266	1.4	1.5	265	6.5%	-0.10 [-0.38, 0.18]
González-Fernández 2017	0.3	0.25	174	0.21	0.26	163	18.1%	0.09 [0.04, 0.14]
Karsenti 2020	0.78	1.32	1026	0.54	1.1	1032	15.2%	0.24 [0.13, 0.35]
Marsano 2019	1.7	2.3	42	1.17	1.3	42	1.1%	0.53 [-0.27, 1.33]
Ngu 2019	0.95	1.89	888	0.75	1.4	884	12.1%	0.20 [0.05, 0.35]
Rees 2020	0.23	0.47	1578	0.21	0.43	1578	19.0%	0.02 [-0.01, 0.05]
Rex 2020	1.43	1.79	101	1.07	1.06	99	3.8%	0.36 [-0.05, 0.77]
van Doorn 2015	1.36	2.1	530	1.17	1.65	533	8.5%	0.19 [-0.04, 0.42]
Wada 2018	1.1	1.41	239	0.66	0.99	238	8.8%	0.44 [0.22, 0.66]
Total (95% CI)			**5094**			**5084**	**100.0%**	**0.17 [0.08, 0.26]**

Heterogeneity: Tau² = 0.01; Chi² = 41.56, df = 9 (P < 0.00001); I² = 78%
Test for overall effect: Z = 3.73 (P = 0.0002)

Fig. 4 Forest plots comparing endoscopic-assisted and standard colonoscopy in terms of MAP. *MAP* mean number of adenomas per patient

Discussion

In this study, we included 23 studies involving 17,999 patients to assess the efficacy and safety of the EAC for ADR. The results showed that the EAC was superior to standard colonoscopy in terms of adenoma, polyp, sessile serrated, and left and right-sided lesion detection rates as well as mean number of adenomas per patient. No significant difference was found in advanced ADR, mean number of polyps per patient, right-sided lesion detection rates, cecal intubation rate, cecal intubation time and withdrawal time between EAC and standard colonoscopy.

Colonoscopy with adenoma detection and removal is widely considered the gold standard for the prevention of CRC. Every 1% increase in ADR is associated with a 3% reduction of interval CRC and 5% reduction of fatal interval CRC. Moreover, there is an increased risk of interval cancer when the colonoscopy is performed by an endoscopist with an ADR below 20% [3]. Recent years have seen the rapid introduction of a range of new mechanical and optical endoscopic devices aimed at improving the ADR and minimizing miss rates [40–43].

Due to the use of different devices, we further analyzed the efficacy of Endocuff or Endocuff Vision separately, and the pooled result indicated significant differences in both groups, which was in accordance with a previous study [12]. Moreover, the pooled ADR was slightly higher in the Endocuff Vision group (46.3%) compared with the Endocuff group (43.3%). However, a recent meta-analysis conducted by Aziz et al. [44], evaluated colonoscopy outcomes among Endocuff Vision, Endocuff and high-definition colonoscopy groups, and reported that the Endocuff Vision did not significantly improve ADR compared to Endocuff and high-definition colonoscopy. Because of the different expertise of endoscopists, we conducted subgroup analysis for ADR based on ADR in standard colonoscopy group (< 25%, < 30%, < 35%, < 40%, < 45%, < 50% and > 50%). The results showed that operators with baseline ADR < 50% benefit from the use of EAC, whereas the very high baseline

detectors (ADR > 50%) did not. Hence, it is clearly suggested that the expertise of the endoscopist is inversely correlated with the benefit of Endocuff in terms of ADR vs. standard colonoscopy.

In addition, we performed subgroup analysis for ADR based on indications for colonoscopy, which indicated significant differences in both groups. A higher ADR was observed in mixed population (47.4% vs 38.7% in screening group). More studies including pure screening population are needed to further confirm the effect of population on ADR. As for colorectal adenomas size, up to 15.5% of small adenomas and up to 3.4% of diminutive adenomas contain high-grade dysplasia, and the omission of those adenomas may contribute to the occurrence of interval cancers diagnosed between surveillance colonoscopies [45]. In this study, we also conducted subgroup analysis based on adenomas size and no significant difference was found. However, because only a few studies were included in the above analysis, the result should be interpreted with caution, and more studies are needed. With regard to adverse events, the results showed that the rate in the first-generation Endocuff, rather than the second-generation Endocuff Vision, was higher than in standard colonoscopy. The revised design of the Endocuff, with the removal of the distal row of arms and the creation of more rounded tips, might explain the absence of the adverse events.

Some limitations of this meta-analysis should be addressed. First, the quality of bowel preparation was reported incompletely using different scoring criteria in the included studies. Second, the endoscopists in both groups were not blinded, which is common to most endoscopic studies designed for assessment of external attachments. Third, we did not perform a comparative cost-effectiveness analysis. Ideally, adoption of interventions in clinical practice would be premised on incremental cost with each intervention per additional adenoma detected.

Conclusions

This meta-analysis showed that a significant improvement in adenoma and polyp detection rates as well as mean number of adenomas per patient using EAC compared with standard colonoscopy, especially for operators with a low ADR. Further studies are needed to confirm the value of Endocuff in improving the ADR.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10151-022-02642-9.

Declarations

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