Preference for Colonoscopy Versus Computerized Tomographic Colonography: A Systematic Review and Meta-analysis of Observational Studies

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In recent years, colorectal cancer (CRC) screening using computerized tomographic colonography (CTC) has attracted considerable attention. In order to better understand patient preferences for CTC versus colonoscopy, we performed a systematic review and meta-analysis of the available literature. Data sources included published studies, abstracts and book chapters, in any language, with publication dates from 1995 through February 2012, and with prospective or retrospective enrollment of diagnostic or screening patients who had undergone both procedures and explicit assessment of their preference for colonoscopy versus CTC. A predefined algorithm identified eligible studies using computer and hand searches performed by two independent investigators. We used a mixed effects model to pool preference differences (defined as the proportion of subjects who preferred CTC minus the proportion who preferred colonoscopy for each study). Twenty-three studies met inclusion criteria, totaling 5616 subjects. In 16 of these studies, patients preferred CTC over colonoscopy, while colonoscopy was preferred in three studies. Due to the high degree of heterogeneity, an overall pooled preference difference was not calculated. Stratified analysis revealed that studies published in radiology journals (preference difference 0.590 [95 % CI 0.485, 0.694]) seemed more likely than studies in gastroenterology (0.218 [−0.015–0.451]) or general medicine journals (−0.158 [−0.389–0.072]) to report preference for CTC ($p < 0.001$). Studies by radiology authors showed a trend towards stronger preference for CTC compared with studies by gastroenterology authors. Symptomatic patients expressed no preference, but screening patients preferred CTC. There was no difference in preferences between studies using “masked” and “unmasked” preference ascertainment methods. Three studies featuring limited bowel preparations for CTC reported marked preference for CTC. There was no

evidence of publication bias, while cumulative and exclusion analysis did not show any temporal trend or dominant study. Limitations included data heterogeneity and preference ascertainment limitations. In conclusion, most included studies reported preference for CTC. On stratified analysis, screening patients preferred CTC while diagnostic patients showed no preference. Studies published in radiology journals showed significantly stronger preference for CTC compared with studies in gastroenterology or general medicine journals.

KEY WORDS: colorectal cancer; adenoma; screening; colonoscopy; computerized tomographic colonography.

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INTRODUCTION

In recent years, colorectal cancer (CRC) screening using computerized tomographic colonography (CTC) has attracted considerable attention. With continuous technical improvements, CRC screening using CTC now exhibits accuracy rates approaching that of colonoscopy,¹ and CTC every 5 years is one of the screening approaches endorsed by some current guidelines.^{2,3} At present, the uptake of screening colonoscopy is still relatively low,⁴ partly because of suboptimal patient acceptance. One of the purported advantages of CTC over colonoscopy is superior patient acceptance due to non-invasiveness. Using the available literature, we performed a systematic review and meta-analysis on patient preference for CTC versus colonoscopy.

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METHODS

Study Identification

Since this is a systematic review and meta-analysis of published studies and publicly available data, it did not

require institutional review board approval. In conducting this study we adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.⁵ We searched the PubMed, EmBase and Cochrane databases from January 1995 to August 2011 using a pre-determined, systematic algorithm (Appendix A, available online), aiming to retrieve articles comparing patient preference for conventional colonoscopy versus CTC. In addition, we performed a hand search of citations in all included articles as well as editorials and reviews published in prominent gastroenterology, general medicine and radiology journals (Appendix B, available online).

The initial search strategy was designed to be highly sensitive (but with low specificity). At least one investigator manually reviewed the titles of all retrieved studies, and obviously irrelevant ones were excluded. We then reviewed the abstracts of the remaining studies. After eliminating further studies based on predefined exclusion criteria, the full texts of the remaining ones were independently reviewed by two specially trained investigators (OSL and MN).

Inclusion/Exclusion Criteria

Prospective, retrospective or cross-sectional studies that involved patients who had undergone both CTC and colonoscopy (crossover design) and compared their preferences were eligible. In prospective studies, subjects were consented before they had undergone either CTC or colonoscopy and their preferences were ascertained afterwards. In retrospective studies, investigators identified patients who had already experienced both colonoscopy and CTC in the past, and asked them to recall which procedure they preferred. Eligible studies had to be published as an abstract at a major scientific conference, a letter to the editor, or a full article in a peer-reviewed medical journal. Studies published in non-English languages were eligible. Case reports, unpublished material and studies with fewer than 20 subjects were excluded. Studies involving symptomatic patients or patients at increased risk for CRC were eligible, but were subject to subgroup analysis.

Endpoints and Data Abstraction

Two investigators (OSL and MN) independently abstracted data on patient preference, using the same abstraction form. Disagreements were resolved by face-to-face re-review of the study in question.

All eligible studies asked patients whether they preferred CTC or colonoscopy, using a direct dichotomous question administered after subjects had undergone both procedures. This question was usually of the form: "Which procedure (CTC or colonoscopy) did you prefer?" The mode of

preference ascertainment for each study was categorized as either "masked" or "unmasked". "Masked" ascertainment meant that patients gave their preference response either anonymously or outside the immediate presence of staff directly associated with either CTC or colonoscopy. For example, answering preferences questions by email or mail from home would be considered "masked" ascertainment, and answering such questions posed by a "neutral" research associate not associated with either the endoscopy or radiology units would also be considered "masked"; answering questions while the patient was still physically in the endoscopy or CTC unit would be considered "unmasked". The primary endpoint for our meta-analysis was the "preference difference", defined as the proportion of patients who preferred CTC minus the proportion who preferred colonoscopy; this parameter has been used in many previous meta-analyses on crossover studies involving preference ascertainment.^{6,7}

Study Quality Assessment

Two investigators (OSL and MN) independently performed quality assessment, using a scoring system analogous to one we validated for a previous meta-analysis on observational studies.⁸ We assigned each study a quality score based on study design, questionnaire type, publication mode and sample size. Studies that were published as full papers, included only asymptomatic screening patients, had patient preference as the primary study outcome, assessed preference in a "masked" manner, and had ≥ 120 subjects, received one point for each category (for a maximum score of five). Studies that were published only as abstracts or letters, included both diagnostic and screening patients, had preference as a secondary outcome, assessed preference in an "unmasked" manner, and had < 120 subjects, would receive a score of zero.

Primary Data Analysis

Using a previously validated method designed specifically for summarizing preference data in crossover trials,^{6,7} we calculated pooled preference differences and 95 % CI, using the Der Simonian and Laird method (weighted least squares solution) with stratifying variables as fixed effects, based on a mixed effects model.⁹ The degree of heterogeneity was assessed by calculating a Q statistic using the chi-squared test.

On stratified analysis, the following moderator variables were investigated: 1) Procedural indication: Some studies included only asymptomatic screening subjects, while others included both screening and symptomatic patients; 2) Bowel preparation: Standard versus "preless" or "low-prep" regimens for CTC; 3) Publication date: Studies were stratified according to whether they were published before

Table 1. Outcomes and Primary Characteristics of Studies Included in the Meta-analysis. Note: The Sample Size Includes All Subjects Who Returned Preference and Acceptance Questionnaires, Including Those Who Expressed No Preference or Equal Preference for CTC and Colonoscopy, Those Who Reported “Don’t Know”, and Those Who Did Not Answer the Preference Question. Patients Who Did Not Return the Preference Questionnaire at All Were Not Included. We Used Scores from the Earliest Questionnaire Done After the Patients Had Completed Both Colonoscopy and CTC. CTC: Computerized Tomographic Colonography; GI: Gastroenterologist; CO2: Carbon Dioxide

Study	Type	N	Prefer CTC	Prefer Colonoscopy	Procedure Indication	Main Study Purpose	Journal Specialty	Primary Author Specialty	Preference Ascertainment Timing & Methods†	Accuracy/Referral Data Given To Patients?§	Quality Score	CTC Gas	“Low Prep” Regimen Used?
Pineau ²⁸	Abstract	55	34 (62 %)*	18 (33 %)	Not stated	Acceptance	GI	GI	Not stated	Equal	1	Not stated	Probably not
Forbes ²⁹	Letter	70	19 (27 %)	16 (23 %)	Diagnostic	Acceptance	GI	GI	Not stated	Equal	1	Room air	Probably not
Akerkar ³⁰	Paper	295	107 (36 %)	188 (64 %)*	Diagnostic & screening	Acceptance	GI	GI	Within 24 hrs, masked	No	4	Room air	No
Svensson ³¹	Paper	96	56 (58 %)*	12 (13 %)	Diagnostic	Acceptance	Radiology	Radiology	Within 24 hrs, masked	Equal	3	Room air	No
Thomeer ³²	Paper	124	88 (71 %)*	30 (24 %)	Diagnostic & screening	Acceptance	Radiology	Radiology	2-3 hrs after tests, not masked	No	2	CO2	No
Gluecker ³³	Paper	494	357 (72 %)*	25 (5 %)	High-risk screening	Acceptance	Radiology	Radiology	Return mail, masked	No	5	CO2	No
Pickhardt ³⁴	Paper	1005	500 (50 %)*	413 (41 %)	Screening	Accuracy	General	Radiology	Return mail, masked	No	4	Room air	No
Ristvedt ³⁵	Paper	120	69 (58 %)*	17 (14 %)	Diagnostic & screening	Acceptance	GI	Neither	2-3 dys after both tests, not masked	No	2	CO2 or air	No
Taylor ³⁶	Paper	91	40 (44 %)*	15 (17 %)	Diagnostic	Acceptance	Radiology	Radiology	1 week later, masked	No	3	CO2	No
Cotton ³⁷	Paper	518	238 (46 %)	212 (41 %)	Diagnostic	Accuracy	General	GI	Return mail, masked	No	3	CO2 or air	No
Iannaccone ³⁸	Paper	162	99 (61 %)*	57 (35 %)	Diagnostic & screening	Accuracy	GI	Radiology	Return mail, masked	No	3	Room air	Yes
van Gelder ³⁹	Paper	236	168 (71 %)*	45 (19 %)	High-risk screening	Acceptance	Radiology	Radiology	Right after tests, not masked	Equal, 20 % referral for colonoscopy	4	CO2	No
Juchems ⁴⁰	Paper	157	116 (74 %)*	10 (6 %)	Diagnostic	Acceptance	Radiology	Radiology	Up to 31 mths after tests, masked	No	4	Room air	No
Bosworth ⁴¹	Paper	581	145 (25 %)	303 (52 %)*	Diagnostic & screening	Accuracy†	General	Neither	Up to 3 days after tests, masked	No	4	Mostly room air	No
Floric ⁴²	Paper	54	43 (80 %)*	7 (13 %)	High-risk screening	Accuracy	Radiology	Radiology	Right after colonoscopy, not masked	Equal, 20 % referral for colonoscopy	2	CO2	Yes
Rajapaksa ⁴³	Paper	272	144 (53 %)	128 (47 %)	Diagnostic	Acceptance	GI	GI	Same day, not masked	No	3	Room air	No
Roberts-Thomson ⁴⁴	Paper	195	119 (61 %)*	76 (39 %)	Diagnostic	Accuracy	GI	GI	1 week after tests, masked	No	4	CO2	No
Jung ⁴⁵	Paper	51	5 (10 %)	33 (65 %)*	Diagnostic	Acceptance	General	Neither	24 hrs after, by phone, not masked	No	2	Room air	No
White ⁴⁶	Paper	122	72 (59 %)*	29 (24 %)	Diagnostic	Accuracy	GI/Surgery	GI/Surgery	Within 2 mths, by mail, masked	No	2	Room air	No
Graser ⁴⁷	Paper	256	118 (46 %)	95 (37 %)	Screening	Accuracy	GI	Radiology	Right after tests, not masked	No	3	Room air or CO2	No
Jensch ⁴⁸	Paper	164	124 (76 %)*	27 (16 %)	High-risk screening	Acceptance	Radiology	Radiology	Right after colonoscopy, not masked	Equal, 20 % referral for colonoscopy	3	CO2	Yes
Moawad ⁴⁹	Paper	57	54 (95 %)*	2 (3 %)	Screening	Acceptance	Radiology	GI	CTC after colonoscopy with variable lag, not masked	No	3	CO2	No
Cash ⁵⁰	Abstract	441	340 (77 %)	28 (6 %)	Screening	Acceptance	GI	GI/Radiology	CTC after colonoscopy with variable lag, masking not described	No	3	Not stated	Not stated

*Statistically significantly superior preference

†Preference results are based on the percentage of patients who chose “most willing to have colonoscopy done again” versus the percentage of patients who chose “most willing to have CTC done again”

‡This refers to the timing of preference ascertainment, as well as the degree of anonymity or “masking”, e.g. patients were asked about their preference either anonymously or shielded from the presence of endoscopy or radiology staff

§Whether or not patients were informed about the estimated accuracy of CTC and colonoscopy for detecting polyps, and/or the referral rates for colonoscopy after CTC; “equal” means that patients were told that CTC and colonoscopy had equal sensitivity for detecting polyps

or after 2004 (this date was chosen because a preliminary review showed that roughly half the studies were published after 2004); 4) Sample size: Studies were stratified according to whether or not they enrolled more than 120 subjects (this number was chosen because a preliminary review showed that roughly half the studies had fewer than 120 subjects); 5) Publication format: Studies published as full papers were compared against studies published only as abstracts or letters; 6) Preference ascertainment method: Masked versus unmasked methods were compared; 7) Follow-up colonoscopy information: Studies in which subjects were told the a priori probability of needing follow-up colonoscopy after CTC were compared against studies in which subjects were not told the probability; and 8) Study quality score (scores of 0-3 versus 4-5).

Other Analysis

We also performed meta-regression, with patient preference as the dependent variable and sample size, year of publication, and quality score as independent variables.

Because our meta-analysis included only published studies and abstracts, we explored the possibility of publication bias at the study level by performing inverted

funnel plot analysis, Begg and Mazumdar rank correlation (Kendall's tau), and Egger's regression intercept testing. Finally, using Rosenthal's file drawer method, we estimated the number of studies with null results needed to overturn the conclusion of the meta-analysis.

CTC technique may change over time due to various factors, e.g. radiologist experience or technical improvements, therefore we performed temporal cumulative meta-analysis by publication date. We also looked for dominant studies by using exclusion analysis, i.e. excluding each study one at a time, to see if there was a marked change in the summary values.

Data analysis was performed using Comprehensive Meta-Analysis 2.0 (Biostat Inc., Englewood, New Jersey) and SPSS 18.0 (SPSS Inc., Chicago, Illinois) software.

RESULTS

Study Identification

The initial computer searches returned 204 titles (most recently performed on February 12th, 2012), of which 136 were obviously irrelevant based on the title, and were excluded. A further 27 were excluded after a review of the abstract. The remaining 41 studies underwent detailed evalu-

Figure 1. Forest plot showing pooled summary preference difference stratified by preference ascertainment method (masked vs. unmasked). Preference difference is defined as the proportion of patients who preferred CTC minus the proportion of patients who preferred colonoscopy. Mixed effects model comparative test $p=0.458$. CTC: Computerized tomographic colonography.

ation of the entire manuscript, and another 18 were excluded. Of the excluded studies, three assessed CTC acceptance only and there was no direct comparison against colonoscopy,^{10–12} four focused on acceptance of various bowel preparation regimens for CTC,^{13–16} four reported satisfaction or acceptability without direct preference comparison between the two modalities,^{17–20} six compared preferences for magnetic resonance colonography (MRC) versus colonoscopy,^{21–26} and lastly, one study included only 11 subjects.²⁷ Ultimately, 23 studies (comprising 5616 subjects) fulfilled all inclusion criteria and were included in this analysis (Table 1)^{28–50}; these included three studies published only in abstract or letter form.^{28,29,50} All included studies were in English.

Of the included studies, 20 were prospective, with subjects committed to undergoing CTC followed by colonoscopy, regardless of the findings on CTC. The remaining three studies were retrospective and patients could have undergone either procedure first. CTC and colonoscopy were done on the same day in 18 studies. Eleven studies utilized exclusively or mostly carbon dioxide for CTC insufflation, with the remaining 12 using room air; all studies used room air for colonoscopy insufflation. Eight studies were restricted to screening patients, while 14 involved both diagnostic and screening patients (procedure indication was not described in one abstract). Finally, three studies used “low-prep” regimens for CTC.

In six studies, patients were told the estimated accuracy of CTC and colonoscopy beforehand, while in three studies,

they were given the predicted referral rate for follow-up colonoscopy after CTC (Table 1). Eleven studies used “masked” preference ascertainment methods, nine used “unmasked” methods, while in three there was no description of ascertainment mode (Table 1).

Primary Preference Outcomes

Amongst the included studies, 16 (comprising 3573 subjects) showed a statistically significant preference for CTC, three (927 subjects) showed a preference for colonoscopy, and four (1116 subjects) showed no difference in preference. As expected, there was a large amount of heterogeneity in the study outcomes ($Q=125$, $p<0.001$), which would be expected to seriously compromise the validity of an overall pooled estimate.⁵¹ Therefore, we did not calculate an overall pooled preference difference; instead, an extensive series of stratified analyses was done to assess the effects of important moderator variables.

Stratified Analyses

No significant differences were found when the data were stratified by main study objective (patient acceptance vs. CTC accuracy), sample size, publication date, study location, publication status, study quality score and whether

Figure 2. Pooled summary preference difference, stratified by whether or not the probability of needing follow-up colonoscopy was given to subjects. Preference difference is defined as the proportion of patients who preferred CTC minus the proportion of patients who preferred colonoscopy. Mixed effects model comparative test $p=0.001$. CTC: Computerized tomographic colonography.

or not carbon dioxide was used for CTC insufflation (data not shown). Stratified analysis comparing “masked” versus “unmasked” studies did not show any difference in outcomes (mixed effects model test $p=0.458$) (Fig. 1). Most (20) of the included studies did not tell patients the a priori probability of the need for follow-up colonoscopy after CTC; the remaining three used a probability of 20 %. Stratified analysis showed a stronger preference for CTC in the latter group ($p=0.001$) (Fig. 2).

When stratified by journal or primary author specialty, we found that studies published in radiology journals markedly favored CTC (pooled preference difference 0.590 with 95 % CI [0.485, 0.694]), but studies in gastroenterology (0.218 [-0.015, 0.451]) or general medicine journals (-0.158 [-0.389, 0.072]) showed no preference ($p<0.001$) (Fig. 3). Studies by radiology primary authors showed a trend towards stronger preference for CTC (0.434 [0.269, 0.598]) than studies by gastroenterologists (0.206 [-0.075, 0.487]) or general medicine authors (0.082 [-0.528, 0.693]) ($p=0.256$) (Fig. 4).

Figure 5 shows the data stratified by procedure indication (diagnostic/screening vs. screening only); as expected, studies

on screening patients showed a marked preference for CTC (0.530 [0.315, 0.745]), as opposed to studies that included symptomatic patients (0.158 [-0.029, 0.345]) ($p=0.011$).

Finally, studies that used “low-prep” regimens showed a trend towards more significant results than studies that used regular preparations for CTC, although both groups demonstrated preference for CTC ($p=0.109$) (Fig. 6).

Other Analyses

Testing by inverted funnel plot analysis, Begg and Mazumdar rank correlation ($p=0.632$), and Egger’s regression intercept ($p=0.407$), showed no evidence of significant publication bias. We estimated that the number of unpublished studies with null results required to change our conclusion was 454, using Rosenthal’s file drawer method.

Meta-regression using continuous variables, such as sample size, study quality score and publication year, as input variables and preference as the output variable did not show any significant relationships (data not shown).

Temporal cumulative meta-analysis by publication date showed that the preference difference became significant in

Figure 3. Pooled summary preference difference stratified by journal specialty. “Neither” refers mostly to general medicine journals. Preference difference is defined as the proportion of patients who preferred CTC minus the proportion of patients who preferred colonoscopy. Mixed effects model comparative test $p<0.001$. CTC: Computerized tomographic colonography.

Figure 4. Pooled summary preference difference stratified by primary author specialty. “Neither” refers mostly to general medicine authors. Preference difference is defined as the proportion of patients who preferred CTC minus the proportion of patients who preferred colonoscopy. Mixed effects model comparative test $p=0.256$. CTC: Computerized tomographic colonography.

favor of CTC starting in mid-2003, but no temporal trend could be discerned (eFigure A, available online).

To test whether any study had a dominant effect on the meta-analysis, we excluded each study one by one and recalculated the summary preference difference in each case (eFigure B, available online). We did not find any dominant study.

DISCUSSION

Although surveys generally show a high level of interest in CRC screening,⁵² patient acceptance of colonoscopy is limited by several factors, including embarrassment, bowel preparation and procedural discomfort.^{53,54} Even amongst screening-eligible, insured Americans with a primary care provider, the prevalence of screening colonoscopy was still relatively low (22 %) as of 2003.⁵⁵ However, in recent years, CRC screening uptake has increased from 25 % to 55 %, mostly attributed to the growth of screening colonoscopy,⁵⁶ such that now the prevalence of lifetime colonoscopy or sigmoidoscopy is about 56 % of the population aged ≥ 50 .⁵⁷

Choice of modality for evaluation of the colon can be affected by procedure-related factors such as accuracy, discomfort, invasiveness, embarrassment or inconvenience,^{52,58} as well as patient-related factors such as ethnicity or education level.⁴³ Some advantages of colonoscopy mentioned by patients include being able to watch the procedure on screen, getting immediate feedback on results, having the opportunity to “sleep through” the procedure, and being able to undergo biopsy or polypectomy during the same session.^{31,35,45} On the other hand, reported advantages of CTC include non-invasiveness, short duration, relative painlessness and novel technology.^{31,32,35,40,45} With increasing passage of time after the procedures, comfort, embarrassment and inconvenience considerations wane and outcome considerations become more prominent.³⁹

One of the purported advantages of CTC over colonoscopy is improved patient acceptance, but the data are extremely heterogeneous. A previous meta-analysis, published only in abstract form, included 11 studies, of which 9 reported that patients preferred CTC over colonoscopy (51 % of subjects preferred CTC versus 27 % who preferred colonoscopy).⁵⁹ The available studies are very heteroge-

Figure 5. Pooled summary preference difference stratified by procedure indication (screening vs. diagnostic/screening). Preference difference is defined as the proportion of patients who preferred CTC minus the proportion of patients who preferred colonoscopy. Mixed effects model comparative test $p=0.011$. CTC: Computerized tomographic colonography.

nous in design, in terms of CTC technique, procedure indication, study location, bowel preparation regimens, preference ascertainment methods and other variables. In such situations, stratified analysis can be helpful in determining the impact of various factors on outcomes.

Because acceptance and preference are “soft” measures, they are prone to bias. This is reflected by the differences seen when studies are stratified by journal type or lead author specialty. Studies published in radiology journals demonstrated a much more marked preference for CTC compared with studies in gastroenterology journals. Regarding methodological differences between the two groups, we note that radiology studies were more likely to include screening cohorts (6 out of 11 studies) compared with gastroenterology or general medicine studies (2 of 11); furthermore, all three studies using “low prep” regimens for CTC were by radiology authors. These factors may partially explain why radiology studies seem to favor CTC more; any remaining differences can be attributed to “subconscious investigator bias”, an unquantifiable element. It has been demonstrated that wording, context and ascertainment methods can significantly impact responses.^{60–62} In particular, studies employing “unmasked” ascertainment methods are prone to so-called “social desirability response bias”

(patients giving better responses than they actually believe because they feel it is more acceptable) and “ingratiating response bias” (patients giving better responses than they feel because they wish to ingratiate themselves with their providers). If accuracy data or referral rates for colonoscopy are not given or are distorted, this can further bias responses. However, it should be noted that all the included studies involved patients filling out the preference questionnaires *after* they had already undergone both procedures and knew the CTC results; in such cases, the a priori probability of needing follow-up colonoscopy may not be as influential. All these potential pitfalls underscore the importance of describing the methodology in detail when reporting patient preference studies.

Our other findings on stratified analysis are consistent with what would be expected. For example, screening patients were more likely to favor CTC, while diagnostic patients reported no difference in preference. Patients who are symptomatic or already have a known colonic condition (such as inflammatory bowel disease) are understandably less favorably disposed towards imaging tests incapable of biopsy or polypectomy.^{39,43} Nevertheless, CTC remains an important option for symptomatic patients unable or unwilling to undergo colonoscopy.

Figure 6. Pooled summary preference difference, stratified by bowel preparation type for CTC (“low-prep” vs. regular regimens). Preference difference is defined as the proportion of patients who preferred CTC minus the proportion of patients who preferred colonoscopy. Mixed effects model comparative test $p=0.109$. CTC: Computerized tomographic colonography.

Finally, as expected, studies that used “low-prep” regimens seemed to favor CTC more than studies using regular preparations. Previous studies have consistently shown that bowel preparation is the worst part of the colonoscopy experience.⁵³ However, it must be kept in mind that in clinical practice, “low-prep” regimens would necessitate a second, fuller bowel preparation for colonoscopy if pathology (e.g. polyp) is discovered; this may impact the preference of some patients.

Because of concerns about radiation exposure, MRC has been investigated. We did not include MRC in this systematic review because it is very different from CTC in terms of its developmental lifecycle, with MRC being more of an emerging technology. Compared with CTC, MRC entails a longer procedure time in a more confined environment, and insufflation of the colon is done with water rather than air. In general, most available studies have not demonstrated any preference for MRC over colonoscopy.^{21–26}

Although the proportion of subjects who prefer colonoscopy is inversely related to the proportion who prefer CTC, the “preference difference” is well established as the endpoint in meta-analyses summarizing studies comparing

preferences in a single cohort of subjects with a cross-over design, which is the type of study that is the focus of our meta-analysis. Pooling proportions is a feasible alternative approach, but is less commonly used for meta-analyses of this type, and is also affected by the same inverse relationship between those who prefer colonoscopy and those who prefer CTC.

Currently, the “STrengthening the Reporting of OBservational studies in Epidemiology” (STROBE) initiative and Newcastle-Ottawa scale are two available measures for assessing the quality of observational studies.^{63,64} STROBE consists of a checklist of features to ensure quality; however, there is no easy way to score this, making it difficult to use for stratified analysis. As for the Newcastle-Ottawa scale, its content validity and inter-rater reliability have been established, but its criterion validity and intra-rater reliability are still being validated. Furthermore, it seems geared towards case-control or prospective cohort studies, different from those in our meta-analysis. For these reasons, we elected to use the quality scale we had developed and partially validated in our previous meta-analysis for observational studies on distal polyps.⁸

Our review focuses on the preferences of patients experienced in both procedures. However, pre-procedure perception in those who have never undergone CTC or colonoscopy is perhaps even more important in predicting the behavior of patients. Only a few studies have assessed pre-procedure perception, all of which showed that subjects preferred CTC prior to being informed about the detailed technical and performance features of both procedures.^{17,28,35,58,65–67} However, once they were educated about CTC and colonoscopy (including sedation practices, accuracy data, complication rates, bowel preparation requirements and probability of referral for colonoscopy after CTC), there was a marked improvement in the perception of colonoscopy,^{28,35,66} in some cases leading to an outright reversal in preference.⁶⁵ A similar pattern was seen when primary care providers were surveyed.⁶⁶ In general, both providers and patients were concerned more about “outcome features”, such as accuracy, colonoscopy referral rates or complications, than about “process features”, such as pain, embarrassment or inconvenience.^{58,65,67}

In conclusion, amongst patients who had undergone both procedures, CTC is preferred over colonoscopy in most of the studies in this review. The use of CTC in situations where colonoscopy cannot be completed, such as tortuous colons or obstructive cancers, is already well established, and studies show that large-scale screening CTC is feasible.⁶⁸ Inadequate insurance coverage is currently a major barrier to the adoption of this technology.⁶⁹ However, even if CTC becomes widely reimbursable, whether it can improve overall compliance with CRC screening is uncertain. In some studies, offering multiple screening methods did not result in higher screening rates,^{70,71} and adding the CTC option to standard modalities (fecal occult blood testing, sigmoidoscopy and colonoscopy) would increase screening uptake by only 2 %.⁵⁸ However, a recent abstract reported that a substantial proportion of patients who had undergone CTC screening would not have undergone screening at all if the CTC option had not been available.⁷² In addition to insurance coverage, close logistical cooperation between the radiology and gastroenterology departments (to facilitate same-day colonoscopy after a positive CTC) would be necessary in order for diagnostic or screening CTC to become the standard of care. Further research should focus on CTC acceptance amongst patients who have yet to undergo either procedure, either in the form of a trial in which patients are randomized to CTC or colonoscopy and then their acceptance is assessed, or a prospective cohort study in which patients are asked to choose between CTC or colonoscopy.

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