Cureus
Part of SPRINGER NATURE

Open Access Review Article

Cold Versus Hot Snare Endoscopic Mucosal Resection for Colorectal Polyps: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

Review began 10/11/2026
Review ended 10/29/2026
Published 11/03/2026

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DOI: 10.7759/cureus.119035

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Abstract

Endoscopic mucosal resection (EMR) is central to colorectal cancer prevention, but the optimal snare technique, cold versus hot, for achieving complete and safe resection remains debated. This systematic review and meta-analysis compared cold snare EMR (CS-EMR) with hot snare EMR (HS-EMR) across colorectal polyp sizes. PubMed, Scopus, and Web of Science were searched from inception to September 2026 for randomized controlled trials comparing CS-EMR with HS-EMR in adults undergoing colorectal polypectomy. Efficacy outcomes included en bloc resection and recurrent or residual adenoma. Safety outcomes included immediate and delayed bleeding, perforation, postpolypectomy syndrome, and any adverse event. Procedure duration was also assessed. Risk of bias was assessed using the Cochrane Risk of Bias 2 (RoB 2) tool. Risk ratios (RRs) and standardized mean differences (SMDs) were pooled using random-effects models. Seven randomized controlled trials were included. En bloc resection rates were comparable between groups (RR: 0.91, 95% CI: 0.77-1.06, p = 0.22). CS-EMR was associated with a shorter procedure duration (SMD: −0.17, 95% CI: −0.33 to −0.02; p = 0.03) and a lower risk of perforation (RR: 0.10, 95% CI: 0.02-0.55). However, CS-EMR was associated with a higher risk of recurrent or residual adenoma (RR: 1.88, 95% CI: 1.43-2.48; p < 0.00001), an effect that appeared to be driven by trials involving large (≥20 mm) nonpedunculated polyps. No significant differences were observed in immediate bleeding (RR: 1.10, 95% CI: 0.51-2.35), delayed bleeding (RR: 0.46, 95% CI: 0.14-1.52), postpolypectomy syndrome (RR: 0.58, 95% CI: 0.23-1.47), or any adverse event (RR: 0.58, 95% CI: 0.28-1.22). CS-EMR was associated with shorter procedure duration and a lower risk of perforation, without significant differences in bleeding or overall adverse events, but was associated with a clinically significant increase in recurrent or residual adenoma, particularly in large nonpedunculated polyps. CS-EMR may therefore be a suitable option for small and intermediate-sized colorectal polyps, whereas its use in larger lesions should be accompanied by appropriate endoscopic surveillance. Further randomized trials with standardized recurrence definitions and longer follow-up are needed to clarify the optimal lesion-size thresholds for technique selection.

Categories: General Surgery, Gastroenterology
Keywords: adenoma recurrence, cold snare, colorectal polyps, endoscopic mucosal resection, hot snare

Introduction And Background

Colorectal cancer (CRC) is among the most common cancers worldwide and remains an important cause of cancer-related morbidity and mortality [1]. Most CRCs develop through the adenoma-carcinoma sequence, which provides an opportunity for prevention through the detection and removal of precursor lesions during colonoscopy. Colonoscopic polypectomy is therefore an essential component of CRC prevention, and long-term studies have shown that the removal of adenomatous polyps is associated with reductions in both CRC incidence and mortality [2,3].

Complete removal of a colorectal polyp, however, cannot always be achieved at the initial procedure. In the Complete Adenoma Resection (CARE) study, incomplete resection was identified in 6.8% of polyps measuring 5-9 mm and in 17.3% of those measuring 10-20 mm [4]. Residual neoplastic tissue may subsequently develop into recurrent or metachronous disease and has been implicated as one of the factors contributing to post-colonoscopy or interval CRC [4]. Improving the completeness of resection while maintaining procedural safety therefore remains an important consideration when selecting an endoscopic resection technique.

Hot snare endoscopic mucosal resection (HS-EMR) has long been used for the treatment of larger and nonpedunculated colorectal lesions [5]. The technique involves submucosal injection, followed by snare resection with electrocautery. Submucosal lifting separates the lesion from the deeper layers of the bowel

wall, while electrocautery allows tissue transection and provides a hemostatic effect. The use of thermal energy, however, can produce injury beyond the immediate resection site and may result in complications such as delayed bleeding, perforation, and postpolypectomy syndrome [5]. Although these events are uncommon, some patients require hospitalization, repeat endoscopy, blood transfusion, or surgical treatment.

The increasing use of cold resection has provided an alternative that avoids electrocautery. Cold snare polypectomy (CSP) is now widely used for small colorectal polyps and has been associated with a low rate of serious procedure-related complications [6-8]. Its application to larger lesions is more challenging, however, because complete capture and removal become progressively more difficult as lesion size increases. Piecemeal resection may further increase the possibility of leaving residual tissue. CS-EMR was developed in part to address these limitations. In CS-EMR, submucosal injection is performed before cold snare resection, providing tissue elevation and a clearer resection plane without the use of electrocautery.

Randomized trials have subsequently evaluated CS-EMR against HS-EMR in colorectal polyps of different sizes. For nonpedunculated lesions measuring 6-10 mm, trials have reported high rates of complete histological resection with both approaches, with no clear evidence of inferior efficacy for CS-EMR [9-11]. Studies including lesions up to 15 or 20 mm have also reported high resection rates with CS-EMR, although procedure time and bleeding outcomes have varied across studies [11-13]. These results have led to increasing interest in the use of cold EMR for lesions beyond the size range in which conventional CSP is routinely performed.

The comparison becomes more clinically relevant in larger nonpedunculated lesions. Hot EMR has traditionally been used in this setting because of the technical difficulty of achieving complete resection and concerns regarding residual or recurrent adenoma [5]. Recent randomized trials have provided direct comparisons between cold and hot EMR for these larger lesions. Across these studies, cold EMR has generally been associated with fewer thermal-related adverse events, including perforation and clinically significant bleeding, whereas hot EMR has shown lower rates of residual or recurrent adenoma during follow-up [14,15]. Thus, the choice between the two techniques involves balancing the reduction of procedure-related harm with the achievement of durable lesion eradication.

The available trials also differ in several aspects of study design and technique. Lesion size ranges vary, as do submucosal injection solutions, snare characteristics, resection methods, approaches to margin treatment, and follow-up protocols. Complete resection has also been assessed using different methods, including immediate margin biopsies and surveillance colonoscopy. These differences can make direct comparisons between individual studies difficult, particularly for uncommon outcomes such as perforation and clinically significant bleeding. For these reasons, we conducted a systematic review and meta-analysis of randomized controlled trials directly comparing CS-EMR with HS-EMR for colorectal polyps.

Review

Methods

Protocol and Registration

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [16] and the Cochrane Handbook for Systematic Reviews of Interventions [17]. The review protocol was prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO, CRD420261517789).

Eligibility Criteria

Studies were eligible for inclusion if they were randomized controlled trials (RCTs) involving adult patients with colorectal polyps or lesions undergoing endoscopic mucosal resection (EMR). Eligible trials directly compared CS-EMR, in which the lesion was resected without electrocautery, with HS-EMR, in which electrocautery was used during snare resection. Trials conducted in outpatient, endoscopy, or hospital-based settings were eligible. We excluded non-randomized and observational studies, case reports, case series, reviews, editorials, conference abstracts without sufficient outcome data, and studies comparing cold snare polypectomy with hot snare polypectomy without EMR. Studies evaluating cold snare EMR versus cold snare polypectomy, or studies in which the intervention and comparator could not be clearly classified as CS-EMR and HS-EMR, were also excluded.

Literature Search

A comprehensive systematic search was conducted across PubMed, Scopus, and Web of Science from inception to September 2026, without language restrictions. The same search strategy was applied across all three databases using the following terms: ("Colorectal polyps" OR "Colorectal adenoma" OR "Colonic polyp" OR "Colonic adenoma") AND ("Endoscopic mucosal resection" OR "cold EMR" OR "hot EMR" OR "C-EMR" OR

"H-EMR" OR "cold snare" OR "hot snare" OR "cold-snare" OR "hot-snare" OR "cold snare EMR" OR "hot snare EMR").

Study Selection

All retrieved records were imported into EndNote for duplicate removal. The remaining citations were screened independently by two reviewers based on their titles and abstracts using Rayyan software (Rayyan Systems Inc., Cambridge, MA) [18]. Potentially eligible articles were then assessed independently in full text by the same reviewers. Disagreements were resolved through discussion, with consultation with a third reviewer when necessary.

Data Extraction

Data were extracted independently by two reviewers using a standardized data extraction form. The extracted variables included (1) study characteristics: first author, publication year, country, study design, sample size; (2) population and procedural characteristics: patient age, sex, details of the CS-EMR, and HS-EMR procedures; (3) efficacy outcomes: complete resection, incomplete resection, en bloc resection, residual or recurrent lesions, and technical success; (4) safety outcomes: immediate bleeding, delayed bleeding, perforation, and other procedure-related adverse events; and (5) procedural outcomes: procedure time.

Measures of Treatment Effect

The included studies evaluated the efficacy and safety of CS-EMR compared with HS-EMR using clinical, procedural, and endoscopic outcomes. Dichotomous outcomes included complete resection, en bloc resection, residual or recurrent lesions, immediate bleeding, delayed bleeding, perforation, and other adverse events. Continuous outcomes, such as procedure duration, were analyzed according to the reported measurement scale.

For dichotomous outcomes, pooled effect estimates were expressed as risk ratios (RRs) with corresponding 95% confidence intervals (CIs). For continuous outcomes measured using the same scale, mean differences (MDs) with 95% CIs were calculated. When different measurement scales were used to assess the same continuous outcome, standardized MDs (SMDs) with 95% CIs were used.

Risk of Bias Assessment

The risk of bias of each included RCT was independently assessed by two reviewers using the Cochrane Risk of Bias tool for randomized trials (RoB 2) [19]. The assessment covered five domains: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in measurement of the outcome, and bias in selection of the reported result. Any disagreements were resolved by consensus or by consultation with a third reviewer.

Data Synthesis and Analysis

Statistical analyses were performed using Review Manager software (RevMan, version 5.4.1; Cochrane Collaboration, London, UK). Dichotomous outcomes were pooled as RRs with 95% CIs, while continuous outcomes were summarized using MDs or SMDs, as appropriate. The unit of analysis followed each trial's reporting: lesions (polyps) were used where lesion-level data were available, and patients where outcomes were reported per patient.

Recurrent or residual adenoma was analysed among lesions with follow-up data (follow-up endoscopy or, in a few cases, surgical resection specimens), because recurrence can only be assessed in examined lesions. Follow-up was slightly less complete in the hot snare arms: 91.8% of cold and 89.2% of hot snare resection sites were examined at first surveillance in Pohl et al. [15], and 91.7% (177/193) and 85.7% (174/203) of lesions in Steinbrück et al. [14]. If recurrences were missed in the hot snare arms, the true difference between techniques would be slightly smaller than the pooled estimate.

Statistical heterogeneity among studies was assessed by visual inspection of forest plots, the Cochran Q test, and the I^2 statistic. A p-value <0.10 for the Cochran Q test was considered indicative of statistically significant heterogeneity, while an I^2 value >50% was considered to represent substantial heterogeneity. For pooled treatment effects, a two-sided p-value <0.05 was considered statistically significant.

Publication bias was not assessed using funnel plots or Egger's test because fewer than 10 studies were available for each meta-analysis, limiting the reliability of these methods [20].

Results

Literature Search Results

A total of 3,494 records were identified through the literature search, of which 1,147 were removed as duplicates, 2,347 records were screened by title and abstract, and 2,326 were excluded as irrelevant or ineligible publication types. Twenty-one records were eligible for full-text screening. Of these, seven articles were included in qualitative and quantitative synthesis [9-15]. The PRISMA 2020 flow diagram of the study selection process is shown in Figure *1*.

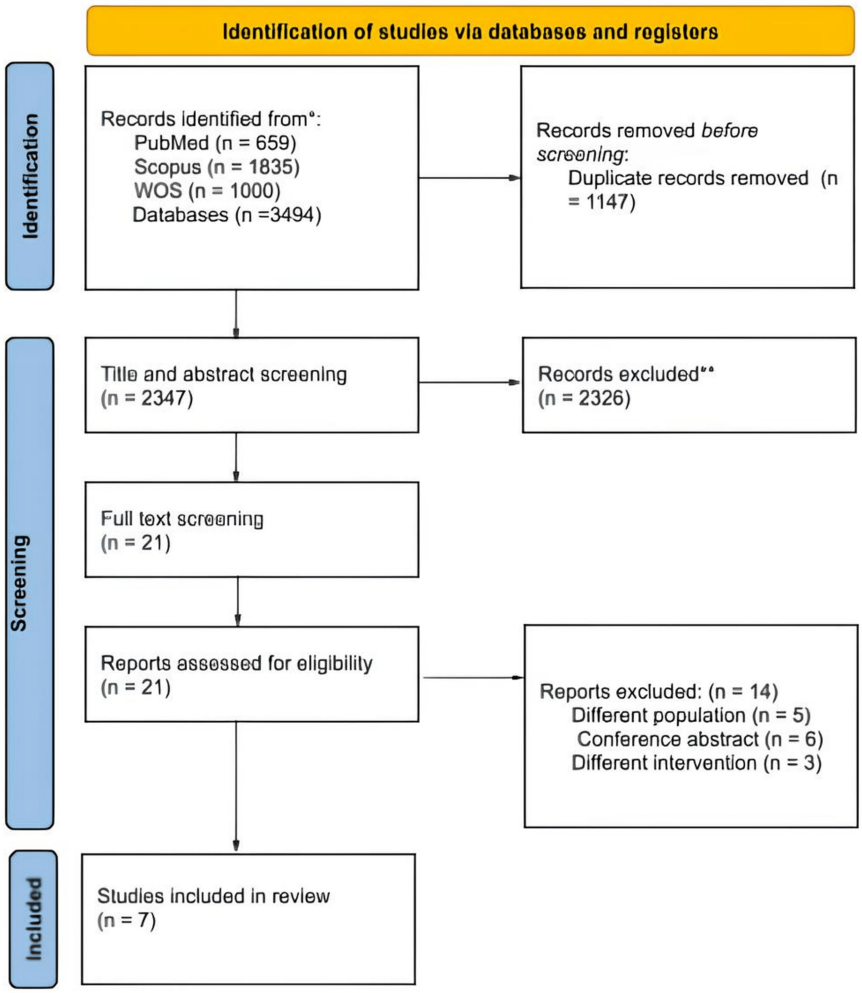


FIGURE 1: PRISMA 2020 flow diagram of study identification, screening, and inclusion

The diagram summarizes study identification, screening, eligibility assessment, and inclusion in the systematic review, adapted from the PRISMA 2020 statement [16].

* Reporting the number of records identified from each database

Characteristics of the Included Studies

Seven RCTs published between 2017 and 2025 were included. The trials were conducted in Greece, China, the United States, Germany, South Korea, and Canada and evaluated adult patients undergoing endoscopic resection of colorectal polyps or lesions. The studies included lesions ranging from 6-10 mm to large nonpedunculated colorectal polyps measuring ⩾20 mm. Follow-up periods ranged from 1 to 6 months. Across the included trials, CS-EMR was compared directly with HS-EMR, with outcomes including resection efficacy, procedure duration, recurrence or residual adenoma, bleeding, perforation, post-polypectomy syndrome, and other adverse events. A summary of the included studies and the characteristics of their populations is shown in Tables *1*-*2*.

Study ID	Study design	Location	Study Patients CS-EMR/HS-EMR	Lesions analysed CS-EMR/HS-EMR	Year	Population	Intervention	Comparator	Follow-up duration	Outcome measures	Key findings
□ei 2020 [10]	Prospective RCT	China	55/55	62/69	2020	Patients with sessile polyps sized 6-10 mm	Cold snare EMR	Hot snare EMR	6 months	Complete resection rate, procedure time, adverse events (intraoperative/postoperative bleeding or perforation), and 6-month polyp recurrence	CS-EMR shortened procedure time ((2.2 min vs 3.6 min), P<0.001) with equivalent complete resection (95.2% vs 91.3%) and similar recurrence
Oh 2024 [11]	Multicenter, prospective RCT	Korea	51/46	70/68	2024	Patients with small polyps sized 6-9 mm	Cold snare EMR	Hot snare EMR	6 months	Residual or recurrent adenoma (RAA) rate (primary); en bloc resection rate, R0 resection rate, total procedure time, and adverse events (secondary)	CS-EMR was non-inferior to HS-EMR for residual/recurrent adenoma (0% vs 1.5%) with a shorter procedure time
Steinbrück 2024 [14]	Multicenter RCT	Germany	184/192	193/203	2024	Patients with large nonpedunculated polyps	Cold snare EMR	Hot snare EMR	4 months	Major adverse events (perforation, postendoscopic bleeding) (primary); major AE subcategories, intraprocedural bleeding, postpolypectomy syndrome, technical success, resection speed	Cold resection of large, nonpedunculated colorectal polyps appears to be considerably safer than hot EMR
Li 2020 [12]	Prospective RCT	China	132/137	252/267	2020	Patients with polyps measuring 6-20 mm	Cold snare EMR	Hot snare EMR	2 weeks	Histologic complete resection rate (primary); en bloc resection rates, early/delayed bleeding, perforation, tissue retrieval rates, and procedure duration	CS-EMR is safe and effective in the treatment of 6-20 mm colorectal polyps.
Pohl 2025 [15]	Multicenter RCT	Canada	336/324	371/343	2025	Patients with large non-pedunculated polyps	Cold snare EMR	Hot snare EMR	6 months	Severe adverse events (SAEs) (primary); polyp recurrence rate at first surveillance colonoscopy, SAE subtypes (bleeding, perforation, postpolypectomy syndrome) (secondary)	Cold EMR did not significantly lower SAEs (unless cold EMR could be completed) and doubled the recurrence rate compared with hot EMR
Rex 2022 [13]	Prospective, multicenter RCT	USA	63/56	82/65	2022	Patients with nonpedunculated lesions 6-15 mm.	Cold snare EMR	Hot snare EMR	1 month	Efficacy of resection defined by margin/center defect biopsies (primary); en bloc resection, resection time, overall removal time, and intraprocedural adverse events (secondary)	Cold snare resection without injection dominated for 6-15 mm lesions, showing 100% complete resection for 6-9 mm polyps, faster times, and zero serious adverse events
Papastergiou 2018 [9]	Dual-center randomized trial	Greece	77/78	83/81	2018	Patients with nonpedunculated polyps sized 6-10 mm	Cold snare EMR	Hot snare EMR	1 month	Histological complete resection rate evaluated by postpolypectomy biopsies (primary); polyp retrieval rate, intraprocedural bleeding, postprocedural bleeding, and perforation (secondary)	CS-EMR was non-inferior to HS-EMR for histological complete resection in 6-10 mm polyps (92.8% vs 96.3%) without diathermy-related major complications.

TABLE 1: Summary of included studies

RCT, randomized controlled trial; CS-EMR, cold snare endoscopic mucosal resection; HS-EMR, hot snare endoscopic mucosal resection; RAA, residual or recurrent adenoma; SAE, severe adverse event; R0, complete resection with negative margins

Study ID	Group name	Number	Age (mean±SD)	Gender (Male), n (%)	Indication, no. (%)	Antithrombotics, n (%)
□ei 2020 [10]	Cold snare EMR	55	46.0 ± 15.1	32 (58)	Physical examination: 31 (56.4), postoperative review: 12 (21.8), other: 12 (21.8)	NA
	Hot snare EMR	55	45.2 ± 13.1	27 (49)	Physical examination: 26 (47.3), postoperative review: 11 (20.0), other: 18 (32.7)	NA
Oh 2024 [11]	Cold snare EMR	51	65 (58–73)	30 (58.8)	Symptoms: 24 (47.1), surveillance: 6 (11.8), polypectomy: 12 (23.5), cancer screening: 9 (17.6)	Antiplatelets: 7 (13.7), anticoagulants: 0
	Hot snare EMR	46	62 (55–71)	30 (65.2)	Symptoms: 16 (34.8), surveillance: 10 (21.7), polypectomy: 14 (30.4), cancer screening: 6 (13.0)	Antiplatelets: 6 (13.0), anticoagulants: 0
Steinbrück 2024 [14]	Cold snare EMR	184	65.11 ± 11.04	90 (48.9)	NA	35 (19.0)
	Hot snare EMR	192	66.34 ± 10.36	107 (55.7)	NA	54 (28.1)
Li 2020 [12]	Cold snare EMR	132	51.77 ± 14.545	73 (55.3)	Screening: 33 (25.0), surveillance: 35 (26.5), positive FOBT result: 9 (6.8), bleeding/anemia: 17 (12.9), other: 38 (28.8)	NA
	Hot snare EMR	137	51.59 ± 14.495	80 (58.4)	Screening: 22 (16.1), surveillance: 33 (24.1), positive FOBT result: 15 (10.9), bleeding/anemia: 20 (14.6), other: 47 (34.3)	NA
Pohl 2025 [15]	Cold snare EMR	336	65.6 (10.0)	179 (53.3)	NA	Antiplatelets: 82 (24.4), anticoagulants: 37 (11.0)
	Hot snare EMR	324	65.0 (10.5)	166 (51.2)	NA	Antiplatelets: 76 (23.5), anticoagulants: 21 (6.5)
Rex 2022 [13]	Cold snare EMR	63	65.0 (8.0)	35 (55.6)	Screening: 10 (15.9), surveillance: 43 (68.3), diagnostic: 7 (11.1), therapeutic: 3 (4.8)	NA
	Hot snare EMR	56	67.0 (8.4)	39 (69.6)	Screening: 8 (14.3), surveillance: 41 (73.2), diagnostic: 6 (10.7), therapeutic: 1 (1.8)	NA
Papastergiou 2018 [9]	Cold snare EMR	77	63.1 (10.3)	46 (59.7)	Screening: 38 (49.4), surveillance: 20 (26.0), other: 19 (24.7)	NA
	Hot snare EMR	78	64.1 (10.9)	45 (57.7)	Screening: 37 (47.4), surveillance: 22 (28.2), other: 19 (24.4)	NA

TABLE 2: Baseline characteristics

CS-EMR, cold snare endoscopic mucosal resection; HS-EMR, hot snare endoscopic mucosal resection; SD, standard deviation; NA, not available/not reported; FOBT, fecal occult blood test

Risk of Bias Assessment

Risk of bias was assessed for all seven included RCTs using the Cochrane Risk of Bias 2 (RoB 2) tool across five domains: the randomization process (D1), deviations from intended interventions (D2), missing outcome data (D3), measurement of the outcome (D4), and selection of the reported result (D5) (Figures 2-3). All seven studies were judged to be at low risk of bias in domains D1, D2, D3, and D5, whereas all seven were judged to be at high risk of bias in D4. Consequently, all seven trials were classified as having an overall high risk of bias, as each had at least one domain rated at high risk.

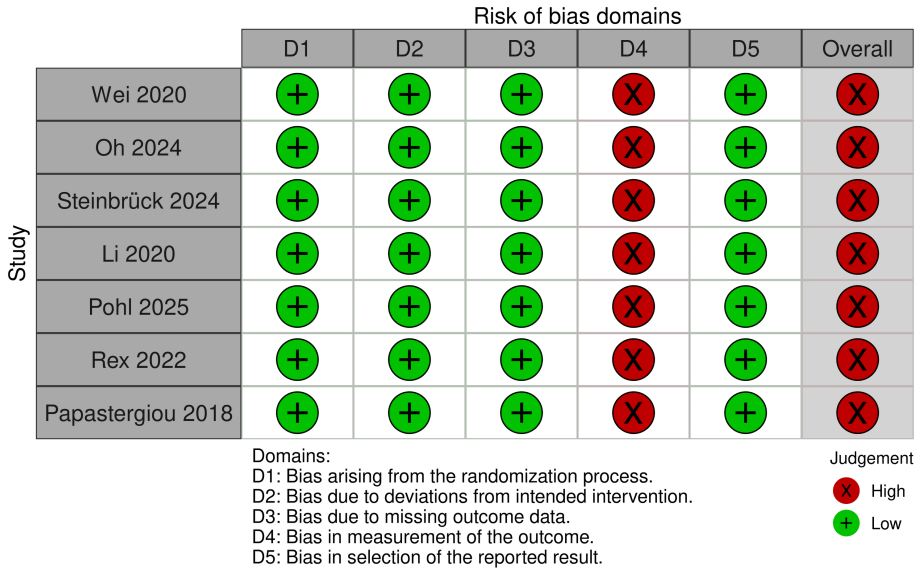


FIGURE 2: Risk of bias plot showing RoB 2 domain level and overall judgements

Source: [9-15]

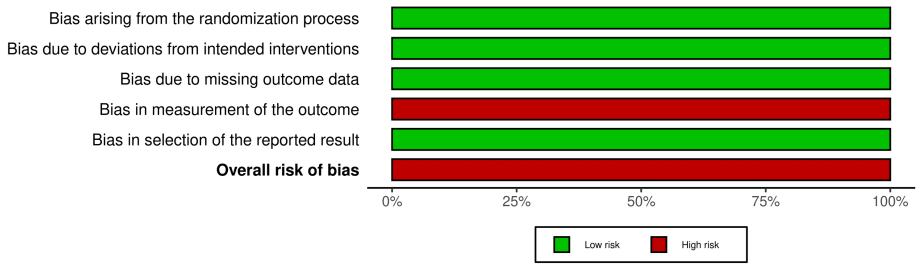


FIGURE 3: Weighted bar plot showing the distribution of RoB-2 risk-of-bias judgements across all included trials

Efficacy Outcomes

En bloc resection: No significant difference in the risk of en bloc resection was observed between cold and hot snare (RR: 0.91, 95% CI: 0.77-1.06, p = 0.22). Pooled studies were heterogeneous (p < 0.00001, I^2 = 91%; Figure 4).

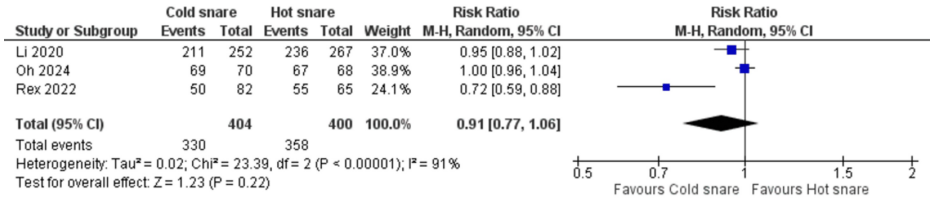


FIGURE 4: Forest plot: En bloc resection

Forest plots were generated using Review Manager (RevMan, version 5.4.1; Cochrane Collaboration, London, UK).

Source: [11-13]

Recurrent or residual adenoma: CS-EMR was associated with a significantly higher risk of recurrent or residual adenoma compared with HS-EMR (RR: 1.88, 95% CI: 1.43-2.48; p < 0.00001). Pooled studies were homogeneous (chi-square p = 0.47; I^2 = 0%; Figure *5*).

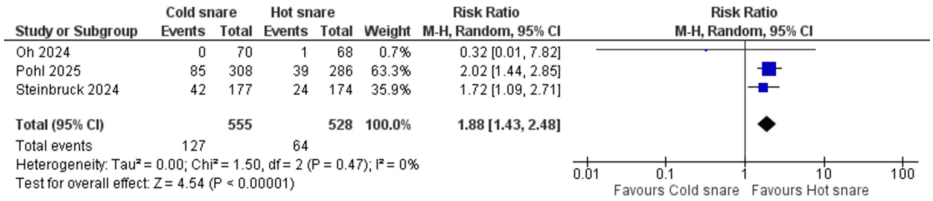


FIGURE 5: Forest plot: Recurrent or residual adenoma

Forest plots were generated using Review Manager (RevMan, version 5.4.1; Cochrane Collaboration, London, UK).

Source: [11,14,15]

Wei et al. reported no recurrences in either arm (0/51 vs 0/50) and therefore could not be included in the pooled estimate for recurrent or residual adenoma [10].

Procedure Duration

The overall SMD between the cold snare and the hot snare favours the cold snare group (pooled Std MD = -0.17, 95% CI: -0.33 to -0.02; p = 0.03). Pooled studies were homogeneous (chi-square p = 0.63; I^2 = 0%; Figure *6*).

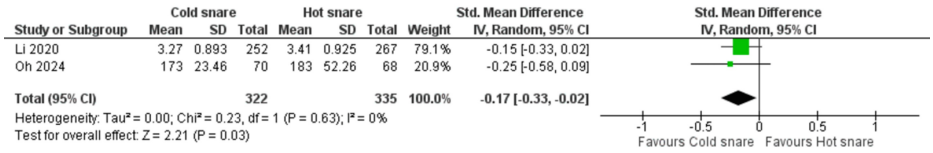


FIGURE 6: Forest plot: Procedure duration

Forest plots were generated using Review Manager (RevMan, version 5.4.1; Cochrane Collaboration, London, UK).

Source: [11,12]

Safety Outcomes

Immediate bleeding: No significant difference in the risk of immediate bleeding was observed between cold and hot snare (RR: 1.1, 95% CI: 0.51-2.35, p = 0.81). Pooled studies were homogeneous (p = 0.17, I^2 = 40%; Figure *7*).

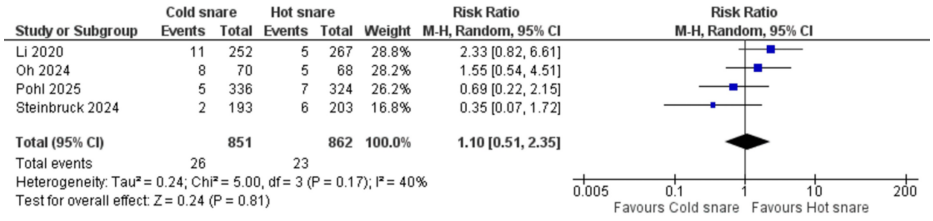


FIGURE 7: Forest plot: Immediate bleeding

Forest plots were generated using Review Manager (RevMan, version 5.4.1; Cochrane Collaboration, London, UK).

Source: [11,12,14,15]

Delayed bleeding: No significant difference in the risk of delayed bleeding was observed between cold and hot snare (RR: 0.46, 95% CI: 0.14-1.52; p = 0.2). Pooled studies were homogeneous (p = 0.38, I^2 = 0%; Figure *8*).

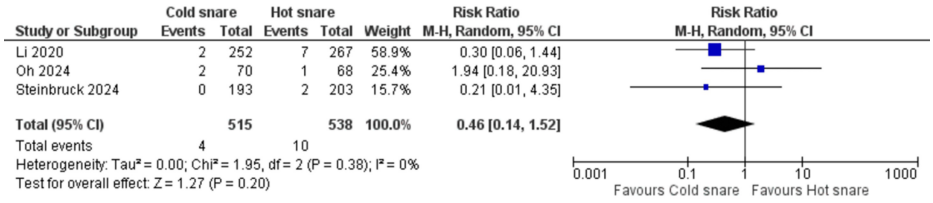


FIGURE 8: Forest plot: Delayed bleeding

Forest plots were generated using Review Manager (RevMan, version 5.4.1; Cochrane Collaboration, London, UK).

Source: [11,12,14]

Perforation: Cold snare was associated with a significantly lower risk of perforation compared with hot snare (RR: 0.10, 95% CI: 0.02-0.55; p = 0.0008). Pooled studies were homogeneous (chi-square p = 0.83; I^2 = 0%; Figure *9*).

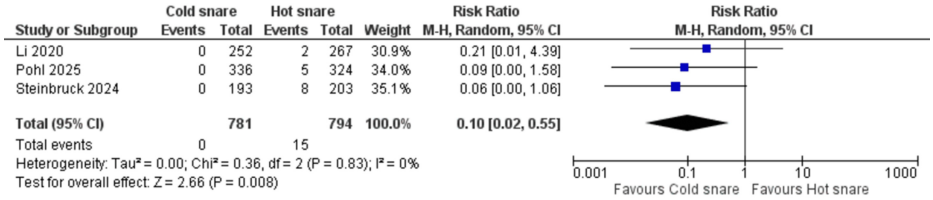


FIGURE 9: Forest plot: Perforation

Forest plots were generated using Review Manager (RevMan, version 5.4.1; Cochrane Collaboration, London, UK).

Source: [11,14,15]

Post-polypectomy syndrome: No significant difference in the risk of post-polypectomy syndrome was observed between cold and hot snare (RR: 0.58, 95% CI: 0.23-1.47; p = 0.25). Pooled studies were homogeneous (p = 0.68, I^2 = 0%; Figure *10*).

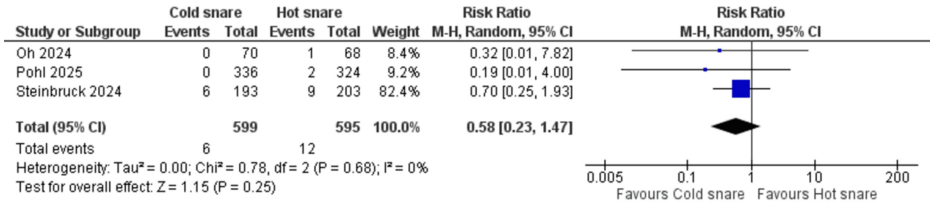


FIGURE 10: Forest plot: Post-polypectomy syndrome

Forest plots were generated using Review Manager (RevMan, version 5.4.1; Cochrane Collaboration, London, UK).

Source: [11,14,15]

Any adverse event: No significant difference in the risk of any adverse event was observed between cold and hot snare (RR: 0.58, 95% CI: 0.28-1.22; p = 0.15). Pooled studies were homogeneous (p = 0.46, I^2= 0%; Figure *11*).

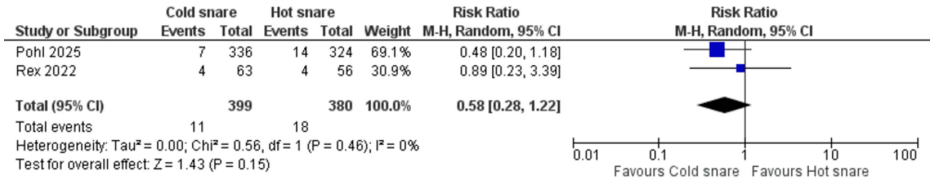


FIGURE 11: Forest plot: Any adverse event

Forest plots were generated using Review Manager (RevMan, version 5.4.1; Cochrane Collaboration, London, UK).

Source: [13,15]

Discussion

This systematic review and meta-analysis of seven RCTs, comprising 1,786 patients, compared CS-EMR with HS-EMR across a broad spectrum of colorectal polyp sizes. Three findings emerged as clinically noteworthy: cold snare resection was associated with a significantly lower risk of perforation, a shorter procedure duration, and a comparable en bloc resection rate relative to hot snare resection. However, this safety and efficiency advantage was accompanied by a nearly twofold increase in the risk of recurrent or residual adenoma. All other safety outcomes examined, including immediate bleeding, delayed bleeding, postpolypectomy syndrome, and any adverse event, did not differ significantly between the two techniques.

Taken together, these results suggest that the choice between CS-EMR and HS-EMR involves a genuine trade-off rather than a uniform advantage for either technique. Cold resection appears to reduce the risk of thermal injury to the bowel wall, which plausibly contributes to the observed reduction in perforation risk, while the omission of electrocautery-based cutting and coagulation steps likely contributes to the shorter procedural times observed [5,6]. At the same time, the absence of a thermal cutting plane may result in shallower or less complete tissue capture in some lesions, potentially leaving neoplastic tissue at the resection margin or defect base, particularly in larger or piecemeal-resected lesions [4]. This may help explain the higher recurrence or residual adenoma rate observed with the cold technique. The perforation and procedure-duration findings are biologically plausible and consistent with the known mechanism of electrocautery-related bowel wall injury [5,6]. Electrocautery produces thermal injury beyond the immediate resection margin and may extend toward the muscularis propria, potentially contributing to perforation and postpolypectomy syndrome. In contrast, cold snare transection is mechanical and avoids electrocautery-related thermal injury. This mechanistic distinction provides a plausible explanation for the markedly lower perforation risk observed with cold resection, despite the relatively small number of perforation events available for pooling. The absence of a significant difference in bleeding outcomes, despite the theoretical safety advantages of avoiding electrocautery, may partly reflect the use of submucosal injection in EMR, which can provide a tamponade effect on submucosal vessels irrespective of whether electrocautery is subsequently applied.

These findings are broadly consistent with the individual trials included in this analysis. Papastergiou et al. reported that CS-EMR was non-inferior to HS-EMR for histologically complete resection of nonpedunculated colorectal polyps measuring 6-10 mm [9]. Similarly, Wei et al. reported comparable

resection efficacy between the two techniques for small colorectal polyps, with shorter procedure times with CS-EMR [10]. Rex et al. evaluated colorectal lesions measuring 6-15 mm across cold and hot resection strategies and provided evidence supporting the feasibility of cold resection for appropriately selected small-to-intermediate lesions [13]. These smaller-polyp trials are consistent with the pooled findings of comparable en bloc resection and shorter procedure duration observed in the present meta-analysis. The recurrence findings, however, appear to be strongly influenced by trials involving larger lesions. The CHRONICLE trial by Steinbrück et al., which included large nonpedunculated colorectal polyps ⩾20 mm, demonstrated significantly lower major adverse events and perforation with cold resection but a higher rate of residual adenoma after cold resection (23.7% vs 13.8%) [14]. Similarly, Pohl et al. reported recurrence in 27.6% of examined resection sites (lesions) after cold EMR compared with 13.6% after hot EMR, while perforation was less frequent after cold EMR [15]. These findings are directly consistent with the higher pooled risk of recurrent or residual adenoma observed in the present analysis. The higher recurrence or residual adenoma rate with cold resection may be related to the absence of electrocautery and the resulting differences in tissue capture and resection depth, particularly in larger or technically complex lesions requiring piecemeal resection. Our pooled result therefore provides quantitative support for the observation that the safety advantage of cold resection may be accompanied by a clinically important efficacy trade-off as lesion size and complexity increase. Conversely, our finding of no significant difference in en bloc resection contrasts somewhat with early assumptions that cold snaring, lacking thermal cutting capability, would necessarily compromise en bloc removal. This may be explained by the characteristics of the trials contributing to this outcome, which predominantly enrolled small-to-medium polyps for which a single cold snare pass may be technically adequate to remove the lesion intact. In larger lesions, piecemeal resection becomes more common, and differences in residual or recurrent neoplasia may become more clinically relevant.

Strengths and Limitations

This meta-analysis has several strengths, including its restriction to RCTs, the use of the Cochrane RoB2 tool for a structured and transparent risk-of-bias assessment, and the inclusion of trials spanning a wide range of polyp sizes and geographic settings. Additionally, low statistical heterogeneity was observed for several pooled outcomes, including perforation, delayed bleeding, postpolypectomy syndrome, any adverse event, and procedure duration, supporting the consistency of the corresponding pooled estimates. Nonetheless, several limitations warrant consideration. First, lack of endoscopist blinding was an inherent limitation across the included trials because the resection technique is apparent to the operator during the procedure. Although outcome assessors were blinded in some studies, the nature of the intervention may have contributed to the high risk-of-bias assessment for the outcome-measurement domain in our RoB2 evaluation. Second, considerable clinical heterogeneity existed across trials in terms of polyp size range (6-10 mm to ⩾20 mm).

Conclusions

This meta-analysis of seven RCTs indicates that CS-EMR, compared with HS-EMR, significantly reduces the risk of perforation and shortens procedure duration, without increasing bleeding, postpolypectomy syndrome, or overall adverse events, while achieving comparable en bloc resection rates. However, CS-EMR is associated with a significantly higher risk of recurrent or residual adenoma, an effect driven predominantly by trials involving large nonpedunculated polyps. These findings indicate a clinically relevant trade-off between procedural safety and recurrence risk, with CS-EMR showing favorable safety and efficiency characteristics for appropriately selected small- and intermediate-sized colorectal polyps, while its use in large nonpedunculated lesions requires consideration of the higher risk of residual or recurrent neoplasia and the need for appropriate surveillance. Further large-scale randomized trials with longer follow-up and standardized definitions of recurrence are needed to better define the lesion-size thresholds and patient populations in which cold versus hot resection may be most appropriate.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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