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A Comparative Study of Endoscopic Cold Snare Polypectomy and Hot Snare Polypectomy in the Treatment of Colorectal Polyps

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Abstract

Objective: To compare the efficacy and safety of endoscopic cold snare polypectomy (CSP) and hot snare polypectomy (HSP) in the treatment of 5 - 15 mm colorectal polyps, and to evaluate whether CSP is non-inferior to HSP. **Methods:** A total of 201 patients scheduled for polypectomy at the Department of Gastroenterology, Zhongshan Guzhen People's Hospital from December 2025 to June 2026 were enrolled. Simple randomization (1:1) was performed using random numbers generated by SPSS software, with allocation concealment implemented by independent personnel, and patients were randomly assigned to the CSP group (99 cases) and the HSP group (102 cases). The histological complete resection rate, procedure time per polyp, number of titanium clips used, immediate intraoperative bleeding rate, and other adverse events were evaluated. The complete resection rate and procedure time per polyp were designated as the primary efficacy endpoints for non-inferiority testing (one-sided $\alpha = 0.05$), and titanium clip usage served as a secondary outcome. **Results:** The histological complete resection rates of the CSP and HSP groups were 91.5% (162/177) and 93.9% (169/180), respectively; the between-group difference was −2.4% (90% CI: −6.6% to 1.9%), and the lower bound of the 90% CI was greater than the non-inferiority margin of -10%, demonstrating that CSP was non-inferior to HSP ($P = 0.002$). The procedure time per polyp in the CSP group was shorter than that in the HSP group [(213.97 ± 40.02) s vs. (264.54 ± 49.78) s; non-inferiority test $P < 0.001$], and fewer titanium clips were used [(1.21 ± 1.03) vs. (1.88 ± 1.31); $P < 0.001$]. The immediate intraoperative bleeding rate (per polyp: 9.0% vs. 1.1%) and the delayed postoperative bleeding rate (per patient: 1.0% vs. 7.8%) differed significantly between the two groups ($P < 0.001$ and $P = 0.035$, respectively). **Conclusion:** For 5 - 15 mm col-

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orectal polyps, the complete resection rate of CSP is non-inferior to that of HSP, with a shorter procedure time and less titanium clip usage. CSP is associated with more immediate intraoperative bleeding, whereas HSP is associated with more delayed postoperative bleeding. CSP is worthy of clinical promotion.

Keywords

Colorectal Polyps, Cold Snare Polypectomy, Hot Snare Polypectomy, Non-Inferiority Trial, Complete Resection Rate

1. Introduction

The incidence and mortality rates of colorectal cancer in China continue to show an upward trend. According to Global Cancer Statistics 2020, the incidence and mortality of colorectal cancer in China rank 2nd and 5th among all malignant tumors, respectively, with 555,000 new cases and 286,000 deaths in 2020 [1]. Colorectal polyps are precancerous lesions of colorectal cancer, most of which develop through the adenoma-carcinoma sequence [2]. Based on the developmental characteristics of colorectal cancer, early selection of an appropriate surgical method and strengthened follow-up to block the adenoma-carcinoma pathway are the keys to improving the prognosis of patients with colonic adenomas [3]. Therefore, colorectal polypectomy techniques have become a focus of daily research and improvement for endoscopists.

At present, endoscopic hot snare polypectomy (HSP) and endoscopic cold snare polypectomy (CSP) are the main methods used in clinical practice. As a traditional technique, HSP provides reliable hemostasis; however, when high-frequency current is delivered, the heat energy generated is readily transmitted to the deep submucosal layer and the muscularis propria, thereby increasing the risk of complications, such as delayed postoperative bleeding, perforation, and post-polypectomy coagulation syndrome [4]-[6]. According to the 2024 guideline of the European Society of Gastrointestinal Endoscopy (ESGE), HSP is recommended for 10 - 19 mm non-pedunculated adenomas, with submucosal injection suggested according to lesion characteristics to reduce the risk of deep thermal injury; for selected 10 - 19 mm flat adenomas, cold snare resection or cold EMR may be considered [7]. In contrast, CSP requires no electrosurgical connection and achieves lesion excision through mechanical cutting. Its action is confined to the mucosa and the superficial submucosal layer, preserving the integrity of the deep vascular network and the muscularis propria [8]-[9]. The ESGE guideline has listed CSP as one of the recommended techniques for 6 - 9 mm small polyps [7]. However, CSP has not yet been widely adopted in China [10], and clinical comparisons of CSP for 5 - 15 mm polyps remain limited. Therefore, this study aimed to investigate the histological complete resection rate, procedural efficiency, and safety of CSP versus HSP in the treatment of 5 - 15 mm colorectal polyps using a non-inferiority design, so as to provide an evidence-based medical basis for clinical practice.

2. Materials and Methods

2.1. General Information and Grouping

This study was approved by the Medical Ethics Committee of our hospital (Approval No.: LLPS-20251204-01). Patients scheduled for polypectomy at the Department of Gastroenterology, Zhongshan Guzhen People's Hospital from December 2025 to June 2026 were enrolled. Inclusion criteria: 1) age ≥ 18 years; 2) the presence of 5 - 15 mm colorectal polyps confirmed by preoperative evaluation; 3) polyps classified as NICE (NBI International Colorectal Endoscopic) type 1 or type 2 on preoperative endoscopic evaluation.

Exclusion criteria: 1) coagulation disorders; 2) use of antiplatelet or anticoagulant medications within 1 week before the procedure; 3) pregnancy; 4) suspected early cancer on preoperative endoscopy; 5) inability to provide informed consent.

According to the above inclusion and exclusion criteria, 201 patients were ultimately enrolled and randomized. Simple randomization was performed using random numbers generated by SPSS software, and patients were assigned in a 1:1 ratio to the cold snare polypectomy (CSP) group (99 cases) or the hot snare polypectomy (HSP) group (102 cases). Allocation concealment was implemented by an independent researcher who was not involved in patient recruitment or the endoscopic procedures: the randomization results were generated and kept confidential by this independent researcher, and the corresponding resection method was disclosed to the operator only after the patient had completed enrollment evaluation, signed the informed consent, and finished preoperative preparation, immediately before the procedure; thus, the operator could not foresee the allocation before assignment. The resection method used for each patient was determined entirely by the randomization result; all eligible polyps from the same patient were resected using the assigned method, with no upper limit on the number of polyps included per patient. In this study, the polyp specimens (Specimen 1) and wound-base specimens (Specimen 2) of all 201 randomized patients were successfully retrieved with complete pathological data; no case was excluded because of specimen retrieval failure in either group, and all 201 patients were included in the analysis.

2.2. Equipment and Instruments

The procedures utilized Fujifilm lower gastrointestinal endoscopes (EC-601WM, EC-590ZW; Japan), disposable endoscopic injection needles (IN02-22423230; Micro-Tech, Nanjing), single-use electrosurgical snares (MTN-PFS-E-20/23; Micro-Tech, Nanjing), single-use endoscopic biopsy forceps (MTN-ABF-23/23-C-2; Micro-Tech, Nanjing), an ERBE VIO300S high-frequency electrosurgical unit, and Compound Polyethylene Glycol Powder (137.15 g/bag).

2.3. Preoperative Preparation

After signing the informed consent, patients received bowel preparation with 1 L of polyethylene glycol (PEG) solution orally 10 - 12 hours before the procedure

and 2 L of PEG solution 4 - 6 hours before the procedure. Intravenous anesthesia was administered according to patient preference.

2.4. Surgical Methods

All endoscopic procedures in this study were performed by two endoscopists with more than 10 years of experience in digestive endoscopy, and all operators received standardized training in CSP and HSP before the study began. When a colorectal polyp was identified endoscopically, its characteristics, including size, morphological classification, and anatomical location, were recorded. During the procedure, the operator decided whether to perform submucosal injection of normal saline according to the polyp morphology, and the snare was then used to capture the polyp together with a 2 - 3 mm margin of normal mucosa at the outer edge of the polyp base. In the CSP group, the snare was tightened and the polyp was resected directly without energization (cold resection); in the HSP group, after the snare was tightened, high-frequency electrosurgical resection was performed (ENDO CUT Q mode: Effect 3, cut duration 1, cut interval 4). After the initial resection, the wound was irrigated and inspected; if visible residual tissue remained, repeated resection was performed according to the assigned method of each group (cold resection in the CSP group and hot resection in the HSP group), and biopsy forceps were used when snare resection was difficult, until no residual tissue was visible endoscopically. The retrieved polyp specimen was documented as Specimen 1. Verification EMR was then performed to evaluate histological complete resection: after endoscopic confirmation of the absence of residual polyp tissue, 1 - 5 mL of normal saline was injected into the submucosa at the mucosal defect to elevate the tissue, and the base of the defect together with a 1 - 2 mm margin was resected with the snare; the verification resection in the CSP group was likewise performed without energization (cold resection), whereas that in the HSP group adopted high-frequency electrosurgical resection. If the base resection failed and the wound base could not be obtained, four biopsies were taken from the four quadrants of the wound using biopsy forceps. The wound specimen was retrieved and documented as Specimen 2. All specimens were placed in formalin solution and evaluated by pathologists who were blinded to the patient group assignment. The criteria for titanium clip use were consistent between the two groups: clips were placed therapeutically when active bleeding occurred at the wound (immediate bleeding lasting more than 30 seconds and requiring endoscopic intervention); when there was no active bleeding at the wound, prophylactic clip placement was left to the operator's discretion.

2.5. Outcome Measures and Definitions

Outcome measures: 1) patient gender, age, polyp size, and polyp location; 2) the complete resection rate of polyps, procedure time per polyp, and the number of titanium clips used; 3) the rates of immediate intraoperative bleeding, delayed bleeding, and delayed intestinal perforation. Immediate intraoperative bleeding

was analyzed per polyp (resection site), whereas delayed bleeding and delayed perforation were analyzed per patient.

Definitions: 1) Complete resection (histological complete resection): defined as the absence of polyp tissue in the final wound-base specimen (Specimen 2); this determination reflects the final clearance status after the initial snare resection and any necessary additional resection (snare or biopsy forceps), rather than evaluating the initial snare resection alone. 2) Immediate intraoperative bleeding: continuous bleeding from the wound after polypectomy lasting more than 30 seconds and requiring endoscopic hemostasis. 3) Delayed postoperative bleeding: hematochezia or melena occurring within 96 hours after treatment, regardless of whether hemostatic therapy was required. 4) Procedure time per polyp: the time from the insertion of the snare into the working channel to the completion of polyp resection; for patients undergoing submucosal injection, timing commenced from the insertion of the injection needle into the working channel. For patients with multiple polyps, the procedure time was calculated separately for each polyp.

Postoperative follow-up and adverse event monitoring: after discharge, patients were followed up by telephone until 96 hours after the procedure, and the occurrence of hematochezia, melena, abdominal pain, fever, and re-admission was inquired about and recorded to monitor adverse events such as delayed bleeding and delayed perforation. All 201 patients completed telephone follow-up, with no loss to follow-up.

2.6. Statistical Methods

All data in this study were analyzed using SPSS 25.0 statistical software. Patient-level data (age and gender) were expressed as n (%) or mean ± standard deviation ($\overline{x} \pm s$), and between-group comparisons were performed using the chi-square test and the t test, respectively. Given that the same patient could contribute multiple polyps and that polyp-level observations exhibited within-patient clustering, polyp-level outcomes (histological complete resection rate, procedure time per polyp, titanium clip usage, and immediate intraoperative bleeding) were analyzed using generalized estimating equations (GEE) for cluster correction: the patient was used as the cluster unit and the polyp as the observation unit, with an independent working correlation structure, and the covariance was estimated using robust (sandwich) standard errors. Procedure time and titanium clip usage were continuous outcomes modeled with a normal distribution and an identity link, whereas the histological complete resection rate and immediate intraoperative bleeding were binary outcomes modeled with an identity link (linear probability model) to estimate risk differences. Polyp-level baseline data (polyp size and location) were also compared between groups using the above GEE and cluster-robust Wald tests. All between-group differences were calculated as the CSP group minus the HSP group, and effect sizes were expressed as the differences with their 90% confidence intervals (CIs), which were computed from the point estimates and robust standard errors. The histological complete resection rate and procedure

time per polyp were designated as the primary efficacy endpoints, and non-inferiority testing was used to evaluate whether CSP was non-inferior to HSP: the non-inferiority margin was set at 10%, with a one-sided significance level of α = 0.05 ($Z_{1-\alpha}$ = 1.645) and a power of 80% ($Z_{1-\beta}$ = 0.842). Sample size estimation: taking the histological complete resection rate as the primary outcome and referring to the complete resection rate (approximately 94%) reported in previous literature [5], assuming that the true complete resection rates of the two groups were identical, with a non-inferiority margin of −10%, a one-sided α of 0.05, and a power of 80%, the sample size formula for non-inferiority trials yielded a minimum of 70 polyps per group; considering the clustering effect arising from multiple polyps within the same patient and approximately 10% specimen retrieval failure or attrition, no fewer than 90 patients per group were planned for enrollment. A total of 201 patients were actually enrolled in this study (99 in the CSP group and 102 in the HSP group, with 357 polyps in total), meeting the sample size requirement. Non-inferiority decision rules: the complete resection rate is a "higher-is-better" endpoint, and CSP was deemed non-inferior to HSP if the lower bound of the 90% CI of the between-group difference (CSP - HSP) was greater than −10%; procedure time is a "lower-is-better" endpoint, and CSP was deemed non-inferior to HSP if the upper bound of the 90% CI of the between-group difference was less than +26.45 s (the two-sided 90% CI is equivalent to the one-sided 95% CI). Titanium clip usage was compared between the two groups as a secondary outcome. A P value < 0.05 was considered statistically significant.

3. Results

3.1. Baseline Characteristics

A total of 201 patients were included in this study (99 in the CSP group and 102 in the HSP group). There were no statistically significant differences in baseline characteristics between the two groups (Table 1 and Table 2).

3.2. Comparison of Surgical Efficacy

The histological complete resection rates of the two groups were 91.5% (162/177) and 93.9% (169/180), respectively; the between-group difference (CSP - HSP) was −2.4%, with a GEE robust standard error of 2.6% and a 90% CI of −6.6% to 1.9%.

Table 1. Comparison of general clinical baseline characteristics.

Group (patients)	Age (years, Mean ± SD)	Gender: male, n (%)	Gender: female, n (%)
CSP group (N = 99)	56.84 ± 12.67	57 (57.6%)	42 (42.4%)
HSP group (N = 102)	55.70 ± 11.30	60 (58.8%)	42 (41.2%)
Test statistic	t = 0.674	χ^2 = 0.001	
P value	0.501	0.971	

Table 2. Baseline comparison of polyp size and location.

Group (polyps)	Polyp size (mm, Mean ± SD)	Polyp location				
		Rectum, n (%)	Sigmoid, n (%)	Descending, n (%)	Transverse, n (%)	Ascending, n (%)
CSP group (N = 177)	7.78 ± 1.44	24 (13.6%)	46 (26.0%)	31 (17.5%)	41 (23.2%)	35 (19.8%)
HSP group (N = 180)	7.52 ± 1.47	30 (16.7%)	42 (23.3%)	25 (13.9%)	44 (24.4%)	39 (21.7%)
Test statistic	Z = 1.714 (GEE)	χ^2 = 0.880 (Wald, df = 4)				
P value	0.087	0.927				

The lower bound was greater than the non-inferiority margin of −10%, demonstrating that the complete resection rate of CSP was non-inferior to that of HSP (Z = 2.955, P = 0.002). The procedure time per polyp in the CSP group was shorter than that in the HSP group [(213.97 ± 40.02) s vs. (264.54 ± 49.78) s]; the between-group difference (CSP - HSP) was −50.58 s, with a GEE robust standard error of 4.87 s and a 90% CI of −58.59 to −42.57 s, the upper bound of which was less than the non-inferiority margin of +26.45 s (10% of the mean value in the HSP group), demonstrating that the procedure time of CSP was non-inferior to that of HSP (Z = 15.817, P < 0.001). The number of titanium clips used in the CSP group was lower than that in the HSP group [(1.21 ± 1.03) vs. (1.88 ± 1.31)]; the between-group difference (CSP - HSP) was −0.66 (90% CI: −0.91 to −0.42), and the difference remained statistically significant after GEE cluster correction (Z = −4.495, P < 0.001) (Table 3).

Table 3. Comparison of surgical efficacy.

Group (polyps)	Complete resection, n (%)	Titanium clips (n, Mean ± SD)	Procedure time (s, Mean ± SD)
CSP group (N = 177)	162 (91.5%)	1.21 ± 1.03	213.97 ± 40.02
HSP group (N = 180)	169 (93.9%)	1.88 ± 1.31	264.54 ± 49.78
Between-group difference (90% CI)	−2.4% (−6.6% to 1.9%)	−0.66 (−0.91 to −0.42)	−50.58 (−58.59 to −42.57)
Non-inferiority margin	−10%	—	26.45 s
Test statistic	Z = 2.955	Z = −4.495	Z = 15.817
P value	0.002	< 0.001	< 0.001

3.3. Comparison of Surgical Safety

Regarding complications, the immediate intraoperative bleeding rates of the CSP and HSP groups were 9.0% (16/177) and 1.1% (2/180), respectively; the risk difference was 7.9% (90% CI: 4.2% to 11.6%), and the difference was statistically significant after GEE cluster correction by patient (Z = 3.545, P < 0.001). The delayed bleeding rates of the two groups were 1.0% (1/99) and 7.8% (8/102), respectively, with a statistically significant difference (Fisher's exact test, P = 0.035). No delayed perforation occurred in either group during the follow-up period (Table 4).

Table 4. Comparison of surgical safety.

Group	Immediate bleeding (per polyp), n (%)	Delayed bleeding (per patient), n (%)	Delayed perforation (per patient), n (%)
CSP group	16/177 (9.0%)	1/99 (1.0%)	0/99 (0.0%)
HSP group	2/180 (1.1%)	8/102 (7.8%)	0/102 (0.0%)
Test method and statistic	GEE (Z = 3.545)	Fisher's exact test	—
P value	<0.001	0.035	—

4. Discussion

With the gradual acceptance of colorectal cancer screening, the standardized management of 5 - 15 mm colorectal polyps has remained a focus of attention for endoscopists. This study compared the efficacy and safety of CSP and HSP within this size range using a non-inferiority design.

The traditional view holds that CSP, which relies solely on mechanical cutting, may result in residual polyps when dealing with larger polyps because of insufficient resection depth. This study found that, for 5 - 15 mm polyps, the complete resection rate of CSP was non-inferior to that of HSP. This suggests that, under standardized technique, CSP can achieve resection outcomes comparable to those of HSP for 5 - 15 mm colorectal polyps. In addition, CSP avoids the inherent "thermal coagulation artifact" of HSP, reducing excessive intervention caused by false-positive margins [11] [12].

In this study, the immediate intraoperative bleeding rate of the CSP group was higher than that of the HSP group, whereas the delayed bleeding rate was lower than that of the HSP group; this phenomenon has a clear pathophysiological basis. During electrosurgical cutting in HSP, heat energy can be transmitted to the deep submucosal layer and even the muscularis propria, causing local tissue eschar necrosis, and postoperative eschar detachment can lead to severe delayed bleeding or even perforation [13] [14]. In contrast, CSP relies entirely on mechanical cutting, and the wound is confined to the mucosa and the superficial submucosal layer. When larger polyps are resected, the rate of immediate oozing is higher owing to the lack of thermal coagulation; however, such superficial oozing is mostly self-limited, and its clinical hazard is far lower than that of deep delayed bleeding caused by HSP [5].

In terms of procedural efficiency, CSP offers certain advantages: the operator does not need to connect the high-frequency electrosurgical unit to the snare. In this study, the procedure time per polyp in the CSP group was shorter than that in the HSP group, and fewer titanium clips were used. However, it should be noted that prophylactic clip placement was determined by the operator, and the difference in titanium clip usage between the two groups partly arose from differences in placement strategies rather than being entirely attributable to the resection technique itself.

In summary, for the clinical management of 5 - 15 mm colorectal polyps, the complete resection rate of CSP is non-inferior to that of HSP, with a shorter procedure time and less titanium clip usage, and CSP is worthy of clinical promotion and application. This study has certain limitations: no detailed subgroup analysis of 5 - 9 mm and 10 - 15 mm polyps was performed; this was a single-center study, and the statistical power for rare adverse events remained limited; the long-term recurrence rate was not tracked; and the definition of delayed bleeding adopted a 96-hour time window, which may have missed later delayed bleeding events (such as those occurring after eschar detachment). In addition, the non-inferiority margin for procedure time (+26.45 s) was set post hoc with reference to 10% of the observed mean in the HSP group rather than being predetermined at the design stage. Therefore, future studies should increase the sample size, extend the follow-up period, and adopt unified criteria for titanium clip placement to improve research quality.

Author Contributions

Conceptualization, Yuan-Minghui and Zou-Chuanxin; methodology, Yuan-Minghui and Zou-Chuanxin; software, Yuan-Minghui; validation, Yuan-Minghui, Li-Jinhe and Zou-Chuanxin; formal analysis, Yuan-Minghui; investigation, Yuan-Minghui and Li-Jinhe; resources, Zou-Chuanxin and Li-Jinhe; data curation, Yuan-Minghui and Li-Jinhe; writing—original draft preparation, Yuan-Minghui; writing—review and editing, Yuan-Minghui, Li-Jinhe and Zou-Chuanxin; visualization, Yuan-Minghui; supervision, Zou-Chuanxin; project administration, Zou-Chuanxin; funding acquisition, Zou-Chuanxin. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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