Efficacy and safety of cold versus hot snare polypectomy for small (5–9 mm) colorectal polyps: a multicenter randomized controlled trial

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ABSTRACT

Background Resection techniques for small polyps include cold snare polypectomy (CSP) and hot snare polypectomy (HSP). This study compared CSP and HSP in 5–9 mm polyps in terms of complete resection and adverse events.

Methods This was a multicenter, randomized trial conducted in seven Spanish centers between February and November 2019. Patients with ≥1 5–9 mm polyp were randomized to CSP or HSP, regardless of morphology or pit pattern. After polypectomy, two marginal biopsies were submitted to a pathologist who was blinded to polyp histology. Complete resection was defined as normal mucosa or burn artifacts in the biopsies. Abdominal pain was only assessed in patients without < 5 mm or > 9 mm polyps.

Results 496 patients were randomized: 237 (394 polyps) to CSP and 259 (397 polyps) to HSP. Complete polypectomy rates were 92.5 % with CSP and 94.0 % with HSP (difference 1.5 %, 95 % confidence interval −1.9 % to 4.9 %). Intraprocedural bleeding occurred during three CSPs (0.8 %) and seven HSPs (1.8 %) ($P = 0.34$). One lesion per group (0.4 %) presented delayed hemorrhage. Post-colonoscopy abdominal pain presented similarly in both groups 1 hour after the procedure (CSP 18.8 % vs. HSP 18.4 %) but was higher in the HSP group after 5 hours (5.9 % vs. 16.5 %; $P = 0.02$). A higher proportion of patients were asymptomatic 24 hours after CSP than after HSP (97 % vs. 86.4 %; $P = 0.01$).

Conclusions We observed no differences in complete resection and bleeding rates between CSP and HSP. CSP reduced the intensity and duration of post-colonoscopy abdominal pain.

Introduction

Colorectal cancer (CRC) is an important cause of morbidity and mortality worldwide [1]. CRC screening programs reduce CRC incidence [2], as the endoscopic removal of adenomas prevents their progression to CRC [3–5].

Hot snare polypectomy (HSP) has been the standard of care for the resection of lesions over 5 mm. However, cold snare polypectomy (CSP) has recently grown in popularity, as it presents a low risk of complications [6, 7], even in patients receiving anticoagulant therapy [8]. Furthermore, CSP shortens the proce-

dure time [9, 10]. Thus, the recent European Society of Gastrointestinal Endoscopy clinical guidelines recommend CSP for removal of polyps ≤ 5 mm and suggest CSP for flat/sessile lesions 6–9 mm [11].

There is contradictory evidence on the risk of residual polyp, and therefore an optimal assessment of the resection margin is of paramount importance. A pilot study evaluating CSP resection of 6–9 mm polyps showed important rates of retrieval failure and inadequate histopathological evaluation of the horizontal margins [6]. Similarly, a prospective observational study concluded that the lateral margins of 67.1 % of polyps < 10 mm resected by CSP were inadequate for assessment [12]. Thus, evaluation of biopsies from the margins of the mucosal defect is the preferred method for determination of the complete resection rate of CSP [12, 13].

A recent multicenter clinical trial conducted in Japan, which employed biopsies from the mucosal defect margin to compare complete resection rates, demonstrated that CSP is not inferior to HSP (98.2 % vs. 97.4 %) [14]. This result is supported by previous studies of lower statistical power [15, 16].

Studies comparing the impact of CSP and HSP on post-colonoscopy symptoms are lacking however. A single-center trial reported a higher proportion of overall abdominal symptoms in patients undergoing HSP (20 % vs. 2.5 %) [16], but the abdominal pain assessment was dichotomous, without any further information about its temporal evolution.

Therefore, our aim was to compare HSP and CSP for small polyps in terms of complete resection and to assess the association between the polypectomy technique and adverse events, namely post-procedural abdominal pain, and intraprocedural and delayed bleeding.

Methods

The study was a multicenter, prospective, randomized clinical trial comparing two endoscopic polypectomy techniques in colorectal polyps of 5–9 mm in size. The study was conducted between February and November 2019 at seven Spanish centers, including primary, secondary, and tertiary hospitals. Participating endoscopists had a minimum experience of 300 colonoscopies per year. The institutional review boards of all centers approved the study protocol between October 2017 and February 2019, and all patients provided written informed consent.

Patient selection

Patients over the age of 18 years referred for colonoscopy for any indication (positive fecal occult blood test, post-polypectomy follow-up, CRC family history/other screening, previous CRC, or symptoms) were prospectively invited to participate. Exclusion criteria for randomization included pregnancy and polypectomy contraindication owing to continuation of anticoagulant/antithrombotic agents (except aspirin) or uncorrected severe coagulopathy/thrombocytopenia. Those who were found to have one or more polyps measuring 5–9 mm were enrolled. All 5–9 mm lesions were considered eligible, regardless of morphology or pit pattern classification. After enrollment, polyps lost for histological analysis or those presenting normal mucosa in the histological analysis of the polypectomy specimen were further excluded.

Randomization and concealment

Enrolled patients were assigned in a 1:1 ratio to the CSP or HSP group using a computer-generated random sequence. Randomization was stratified by institution, so each center received a unique set of completely opaque, sequentially numbered envelopes containing the assignments. After identifying the first 5–9 mm polyp, an envelope was opened. Once the polypectomy technique was assigned, it was employed in all 5–9 mm lesions in that patient.

Intervention

All colonoscopies were performed by trained endoscopists with appropriate preparation and sedation according to the usual clinical practice at each center. Standard video colonoscopes were used. High definition, magnification, and image enhancement functions were not mandatory.

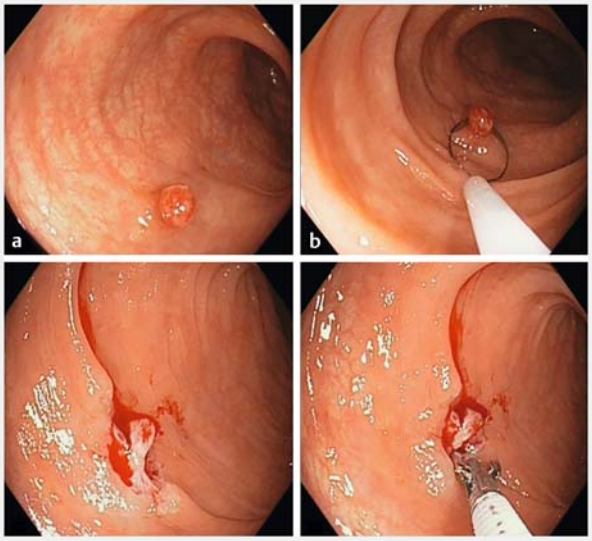
Polyp size was estimated using an open snare as reference. The morphology was defined by the Paris classification [17]. Once eligibility was confirmed, the polyp was removed by HSP or CSP as randomly determined. The type of snare was freely chosen by the endoscopist in the HSP group from the following devices: 25 mm round snare (Olympus, Barcelona, Spain); 13, 15, 20, and 33 mm round snares (Boston Scientific, Marlborough, Massachusetts, USA); 15 mm asymmetric snare (MTW, Wesel, Germany); 15 mm round snare (Cook Medical, Bloomington, Indiana, USA). In the CSP group, in addition to all previously mentioned snares, CSP-dedicated 10 mm snares (Boston Scientific) could also be employed. Submucosal injection was not permitted.

In the CSP group, the technique used was cold resection of the polyp without tenting, followed by suction of the transected polyp. In the HSP group, an electrocoagulation unit (Erbe Elektromedizin, Tübingen, Germany) was used in the Endocut mode. When a polyp could not be removed using the CSP technique, HSP rescue was permitted. Polyps under 5 mm or over 9 mm were treated according to usual clinical practice.

After resection, the mucosa was carefully observed. When residual polyp tissue was clearly recognized, additional removal using the same snare was allowed. After confirming the absence of residual polyp tissue by endoscopic inspection, random biopsies from the right and left edges of the margins of the mucosal defect were performed (▶ **Fig. 1**). Directed biopsies were also permitted in case-specific areas of the marginal mucosa that had a suspicious appearance (e. g. wrinkled folds, distorted pit pattern).

Endoscopic hemostasis was carried out when active hemorrhage continued for ≥ 60 seconds. Preventive hemostasis, defined as prophylactic coagulation of vessels or red spots in the ulcer or clipping of a nonbleeding post-polypectomy mucosal defect, was not allowed.

Patients received and were trained to complete a questionnaire after the procedure. The questionnaire included items on



▶ **Fig. 1** Study procedure for cold snare polypectomy (CSP). **a** A sessile polyp detected in the colon. **b** The Boston Scientific 10-mm polypectomy snare was used for CSP. The size of this polyp was estimated to be 6 mm. **c** CSP was performed. **d** Biopsy samples were taken from two marginal sites located symmetrically on the left and right of the mucosal defects to determine the presence or absence of residual polyp tissue.

the evolution of abdominal pain and other possible adverse events.

Post-procedure monitoring

All patients were contacted via a centralized telephone call 21–28 days after the colonoscopy by a single experienced research nurse who was blinded to procedure allocation. Patients underwent a standardized interview regarding possible adverse events to retrieve the abdominal symptomatology data from the questionnaire. For patients in whom adverse events had required medical evaluation, local investigators were contacted and asked to submit a report. The endoscopic finding of active bleeding, adherent clots or visible vessels confirmed the source of bleeding in post-colonoscopy hemorrhages. In patients with multiple polypectomies where none of the previously stated findings could be found, the largest 5–9 mm polyp was considered the probable source of bleeding, regardless of the number and size of polypectomies.

Histological analysis

All polypectomy specimens were evaluated at each center according to its usual protocol. Biopsies of the mucosal defect were centrally assessed by a single pathologist who had more than 5 years' experience in digestive pathology (J.F.) and was blinded to the histological diagnosis of the lesion and the polypectomy technique.

Outcomes and definitions

The primary end point of the study was the complete resection rate. Complete resection was defined as the presence of normal mucosa or burn artifacts in the biopsies from the margins of the mucosal defect.

Secondary end points included the assessment of adverse events (intraprocedural and delayed bleeding, post-procedure abdominal pain, and other minor adverse events) and predictive factors associated with incomplete resection. Randomization of patients instead of polyps was required to assess delayed bleeding and post-procedure abdominal pain. Intraprocedural bleeding was defined as spurting or oozing that continued after 60 seconds of observation without continuous washing. Bleeding that ceased within the 60-second observation time was not labelled as an adverse event but was instead recorded as a self-limited bleed. Delayed hemorrhage was defined as rectal bleeding between discharge and the telephone follow-up contact. Severity of adverse events was defined according to the American Society for Gastrointestinal Endoscopy recommendations [18]. The evolution of abdominal pain was self-assessed at 1, 3, and 5 hours after the endoscopic procedure using a visual analog scale, which was later categorized as follows: 0 absent, 1–3 mild, 4–6 moderate, 7–10 severe. The first day with absence of pain was also recorded.

The type of polypectomy was defined according to how the polypectomy was performed, regardless of the assigned group. The following categories were included: CSP en bloc resection in a single maneuver; CSP en bloc resection with snare relocation (maneuvers to relocate the snare were needed to complete the polypectomy); piecemeal CSP; HSP en bloc resection; and piecemeal HSP.

Failed CSP was defined as those polypectomies randomized to CSP that could not be completed and that were finally performed with a hot snare.

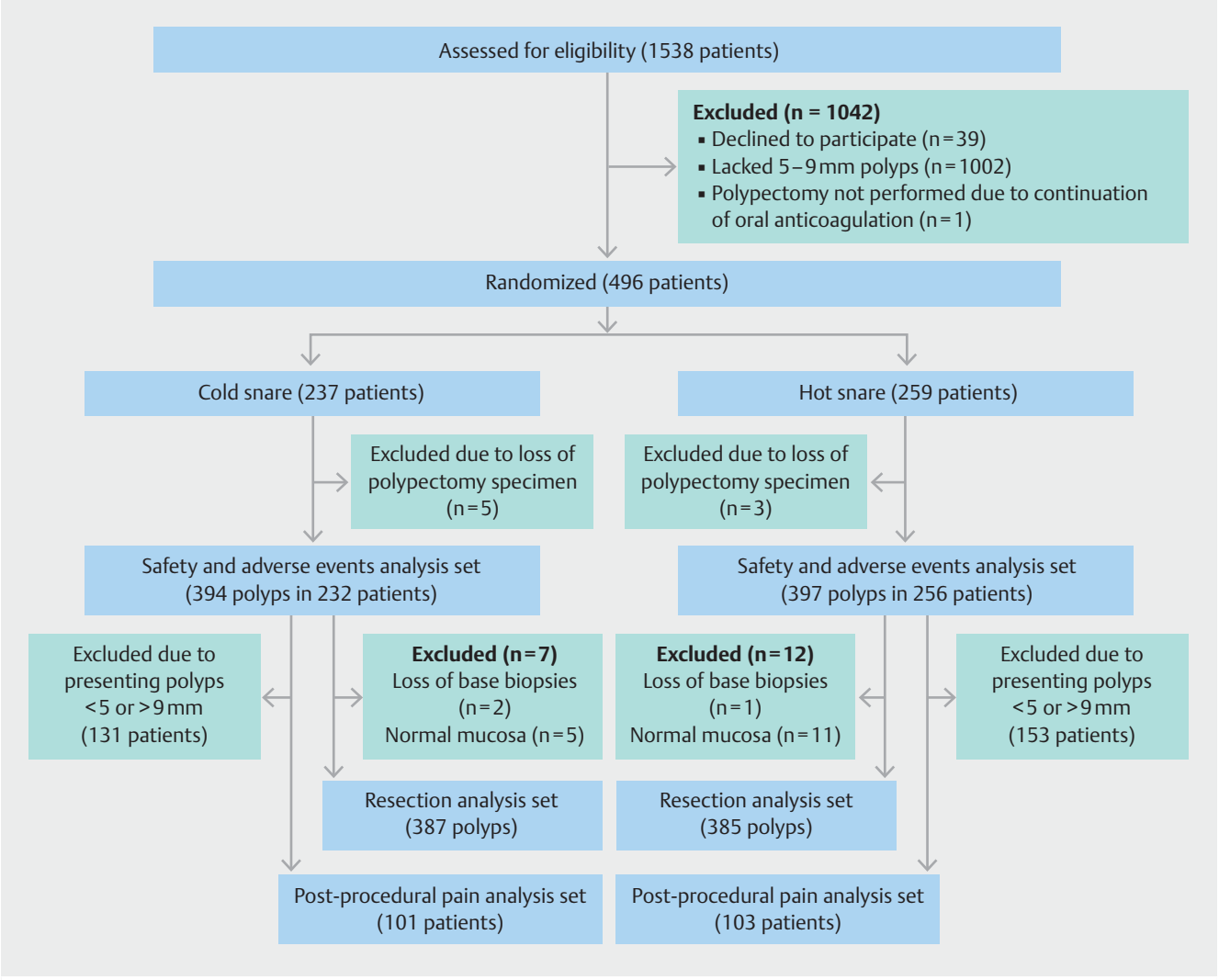
Sample size calculation

Sample size estimation was carried out using Stata software (StataCorp. 2013, College Station, Texas, USA). We anticipated a CSP incomplete resection rate of 10 %, according to the 6.5 %–22.7 % rates reported by Pohl et al. for individual endoscopists [19] and the 8.5 % reported in a previous study [20]. To detect a 7 % difference, with an α risk of 5 % and 80 % statistical power, a total of 315 lesions per group were deemed necessary. Assuming a conservative 20 % proportion of losses (polyps not recovered for histological assessment, failed CSPs, normal mucosa on histological analysis), we estimated 394 lesions/group would be required.

Data retrieval and statistical analysis

Data were collected and managed using the Spanish Digestive Endoscopy Society Research Electronic Data Capture tool. This is a secure, web-based application created to support data capture for research studies providing semi-automatic data quality control [21].

The statistical analysis was carried out using Stata software (StataCorp. 2013). Continuous variables were summarized



▶ **Fig. 2** Study flow chart.

using mean and standard deviation or median and interquartile range (IQR) for data with non-normal distribution according to the Kolmogorov–Smirnov test; categorical variables were expressed as percentages. Baselines characteristics were compared using the chi-squared test and *t* test, as appropriate.

The difference in the proportions of incomplete polypectomies (primary outcome) and adverse events was assessed using logistic regression models based on the generalized estimating equation considering intrasubject correlation. The proportion of patients with abdominal pain in both groups was compared using the *Z* test of homogeneity without the Yates correction. The analysis was carried out by intention to treat, regardless of the type of polypectomy finally performed.

To evaluate the factors associated with incomplete polypectomies and those associated with the presence of abdominal pain, multivariable logistic regression techniques were used. Incomplete polypectomy analysis was adjusted for cluster effect; variables first assessed by univariable analysis included: age, sex, working shift, time of the procedure (initial half vs. final half of the working shift), indication, procedure duration, total number of polyps and of 5–9 mm polyps, order of resection among 5–9 mm polyps, type of snare (size), polypectomy technique (CSP vs. HSP), type of polypectomy (en bloc vs. piecemeal), polyp size, location, and morphology, endoscopist experience in years, and endoscopist (including only endoscopists with ≥ 20 lesions, divided into terciles according to their individual complete resection rates). Risk factors for abdominal pain were assessed only in patients whose polyps were all 5–9 mm and excluded patients who also had polyps < 5 mm or > 9 mm. Factors included age, sex, indication, procedure duration, total number of 5–9 mm polyps, polypectomy technique, endoscopist, and gas employed for insufflation. Predictors with $P < 0.10$ in univariable analysis were then evaluated in multivariable logistic regression models to determine the adjusted odds ratios (OR).

Results

A total of 1538 patients were recruited between February and November 2019 across 7 centers by 20 endoscopists. Recruitment ended when the predetermined sample size was reached. As shown in ▶**Fig. 2**, 1042 patients were excluded, mostly because they did not have any 5–9 mm polyps. From 496 patients randomized (237 to CSP and 259 to HSP), 8 patients (5 in CSP group and 3 in HSP) were further excluded owing to retrieval failure of at least one of their polypectomy specimens. Thus, the CSP group included 232 patients with 394 polyps, and the HSP group included 256 patients with 397 lesions.

Baseline data

An overview of patient background characteristics and procedures is summarized in ▶**Table 1**. Carbon dioxide insufflation was used in 96.6 % of patients in the CSP group and in 94.1 % of patients in the HSP group. Both groups presented a median procedure time of 25 minutes ($P = 0.85$); this lack of differences was also observed in a further analysis limited to patients presenting only 5–9 mm lesions (21.2 minutes with CSP vs. 22.1 minutes with HSP; $P = 0.34$). Among the 488 patients included, 211 (43.2 %) presented one 5–9 mm polyp, 91 (18.6 %) presented 2 polyps, 37 (7.6 %) presented 3, and the remaining 149 patients (30.5 %) presented more than 4 lesions.

Overall, 394 lesions were included in the CSP group and 397 were included in the HSP group. Polyp characteristics are summarized in ▶**Table 2**. Background characteristics of the allocated polyps (location, morphology, histology, and size) were comparable between the two groups. One lesion (0.1 %) with superficial (< 1000 µm) submucosal cancer invasion was found in a 9 mm pedunculated polyp resected with cold snare; biopsies confirmed complete resection.

Polypectomy description

Among the 394 lesions found in the CSP group, rescue HSP was required in 4 (1.0 %) failed CSPs. All 397 polyps assigned to HSP were resected with this technique, although 13 (3.3 %) underwent a piecemeal HSP. Dedicated snares were employed in 187 lesions (47.5 %) of the CSP group. Directed biopsies were

▶**Table 1** Patient characteristics.

	CSP (n = 232)	HSP (n = 256)	*P*
Age, median (IQR), years	64.7 (56.7–70.5)	64.5 (57–70.7)	0.78
Male sex, n (%)	150 (64.7)	169 (66.0)	0.75
Pharmacological treatment, n (%)			
▪ ASA	28 (12.1)	17 (6.6)	0.04
▪ Other antiplatelet agents	3 (1.3)	6 (2.3)	0.51
▪ Acenocoumarol	7 (3.0)	8 (3.1)	0.95
▪ NOACs	8 (3.5)	6 (2.3)	0.47
Indication, n (%)			0.26
▪ Positive FOBT	86 (37.1)	74 (28.9)	
▪ Post-polypectomy follow-up	43 (18.5)	71 (27.7)	
▪ CRC family history/other screening	28 (12.1)	34 (13.3)	
▪ Previous CRC	12 (5.2)	8 (3.1)	
▪ Symptoms	63 (27.2)	69 (27.0)	
Colonoscopy duration, median (IQR), minutes	25 (20–32)	25 (20–33)	0.85
Insufflation method, n (%)			0.21
▪ CO_2	224 (96.6)	241 (94.1)	
▪ Ambient air	8 (3.5)	15 (5.9)	
Total number of polyps, n (%)			0.71
▪ 1–3	156 (67.2)	183 (71.5)	
▪ 4–5	41 (17.7)	43 (16.8)	
▪ 6–10	25 (10.8)	19 (7.4)	
▪ > 10	10 (4.3)	11 (4.3)	

CSP, cold snare polypectomy; HSP, hot snare polypectomy; ASA, acetylsalicylic acid; NOAC, novel oral anticoagulant; FOBT, fecal occult blood test; CRC, colorectal cancer; IQR, interquartile range.

▶ **Table 2** Polyp characteristics.

	CSP (n = 394)	HSP (n = 397)	*P*
Size, median (IQR), mm	6 (5–7)	6 (5–7)	0.92
Morphology, n (%)			0.50
▪ Is	252 (64.0)	235 (59.2)	
▪ Isp	14 (3.6)	19 (4.8)	
▪ Ip	24 (6.1)	32 (8.1)	
▪ IIa	93 (23.6)	102 (25.7)	
▪ IIb	11 (2.8)	8 (2.0)	
▪ IIc	0	1 (0.3)	
Location, n (%)			0.79
▪ Ascending colon	111 (28.2)	106 (26.7)	
▪ Hepatic flexure	23 (5.8)	22 (5.5)	
▪ Transverse colon	65 (16.5)	64 (16.1)	
▪ Splenic flexure	10 (2.5)	12 (3.0)	
▪ Descending colon	46 (11.7)	49 (12.3)	
▪ Sigmoid	92 (23.4)	108 (27.2)	
▪ Rectum	47 (11.9)	36 (9.1)	
Histology, n (%)			0.29
▪ Tubular adenoma	244 (61.9)	250 (63.0)	
▪ Villous/tubulovillous adenoma	25 (6.4)	38 (9.5)	
▪ Carcinoma in situ	1 (0.3)	0	
▪ SSA/P	65 (16.5)	52 (13.1)	
▪ Traditional serrated adenoma	16 (4.1)	9 (2.3)	
▪ Hyperplastic polyp	34 (8.6)	34 (8.6)	
▪ Normal mucosa/other lesions	9 (2.3)	14 (3.5)	
Directed biopsies, n (%)	68 (17.3)	43 (10.8)	0.01
Type of polypectomy, n (%)			n/a
▪ En bloc CSP	328 (83.2)	0	
▪ En bloc CSP, snare relocation	45 (11.4)	0	
▪ Piecemeal CSP	17 (4.3)	0	
▪ En bloc HSP	3 (0.8)	384 (96.7)	
▪ Piecemeal HSP	1 (0.3)	13 (3.3)	

CSP, cold snare polypectomy; HSP, hot snare polypectomy; IQR, interquartile range; SSA/P, sessile serrated adenoma/polyp.

performed more frequently in the CSP group than in the HSP group (17.3 % vs. 10.8 %; *P* = 0.01).

Resection rates

A total of 394 polyps from 232 patients in the CPS group and 397 polyps from 256 patients in the HSP group were retrieved. Overall, 16 polypectomy samples showing normal colonic mucosa (5 CSP and 11 HSP) and 3 lesions whose marginal biopsy containers were lost (2 CSP and 1 HSP) were excluded from the resection rate analysis; thus, 387 polyps in the CSP group and 385 in the HSP group were finally analyzed. We observed no differences in resection rates between the two groups: CSP 358/387 (92.5 %) vs. HSP 362/385 (94.0 %); difference 1.5 %, 95 % confidence interval [CI] –1.9 % to 4.9 % (*P* = 0.38).

Polyps undergoing directed biopsy had an incomplete resection rate of 13.1 % (8/61) with CSP and 14.0 % (7/50) with HSP

▶ **Table 3** Univariable and multivariable odds ratios for risk factors of incomplete resection[1].

	Univariable analysis		Multivariable analysis	
	OR (95 %CI)	*P* value	aOR (95 %CI)	*P* value
Female sex	1.78 (1.04–3.05)	0.04	2 (1.10–3.64)	0.02
Endoscopist[2]	2.21 (1.60–3.05)	<0.001	2.57 (1.83–3.59)	<0.001
Piecemeal polypectomy	3.78 (1.50–9.55)	0.01	4.27 (1.47–12.40)	0.01
Nonadenomatous polyps	1.99 (1.14–3.46)	0.02	2.02 (1.07–3.82)	0.03
Resection order number (first as reference)	1.21 (1.00–1.48)	0.05	1.38 (1.09–1.74)	0.01
Flat polyps	0.39 (0.18–0.87)	0.02		
Sessile polyps	1.94 (1.03–3.68)	0.04		
8–9 mm polyp size	1.84 (1.01–3.35)	0.05		

(a)OR, (adjusted) odds ratio; CI, confidence interval.
[1] Only variables reaching a *P* value <0.10 in the univariable analysis are presented in the table. Other variables assessed by univariable analysis were: patient age, working shift, time of the procedure (initial half vs. final half of the working shift), indication, procedure duration, total number of polyps and of 5–9 mm polyps, type of snare, polypectomy technique (cold vs. hot snare), polyp location, and endoscopist experience in years).
[2] Individual endoscopist performance according to terciles of complete endoscopic resection; best tercile as reference.

(*P* = 0.88), whereas in polypectomies undergoing random biopsies, incomplete resection rates were 6.1 % (21/342) and 4.7 % (16/340), respectively (*P* = 0.46).

Among the CSP procedures, dedicated 10 mm cold snares did not improve complete resection rates compared with conventional snares: 95.7 % (67/70) vs. 91.4 % (661/723), respectively (*P* = 0.20). Among endoscopists who performed ≥ 20 polypectomies, individual incomplete resection rates ranged from 1.5 % (1/65) to 13.9 % (5/36). Univariable and multivariable analysis assessing risk factors for incomplete resection are shown in ▶ **Table 3**.

Adverse events

Overall adverse events were identified in 58 (25.0 %) of the 232 CSP patients and in 75 (29.3 %) of the 256 HSP patients (*P* = 0.29).

Intraprocedural bleeding was observed in only 3/394 CSP procedures (0.8 %; 2 Is and 1 Ip polyp) and 7/397 HSP procedures (1.8 %; 2 Ip, 1 Isp, and 4 Is lesions) (*P* = 0.34); successful endoscopic clipping was applied in all cases. Self-limited bleeding was observed in 58 CSP procedures (14.7 %) and in 17 HSPs (4.3 %; difference 10.4 %, 95 %CI 6.4 % to 14.5 %; *P* < 0.001).

Only two patients presented delayed hemorrhage at 24 and 48 hours after the procedure, respectively, and both of them required hospitalization (one 5 mm sessile tubular adenoma in the CSP group and one 9 mm semi-pedunculated tubular adenoma in the HSP group). In another 36 patients (17 in the CSP group and 19 in the HSP group; *P* = 0.97), minimal post-colonoscopy rectal bleeding was recorded, which did not warrant medical attention.

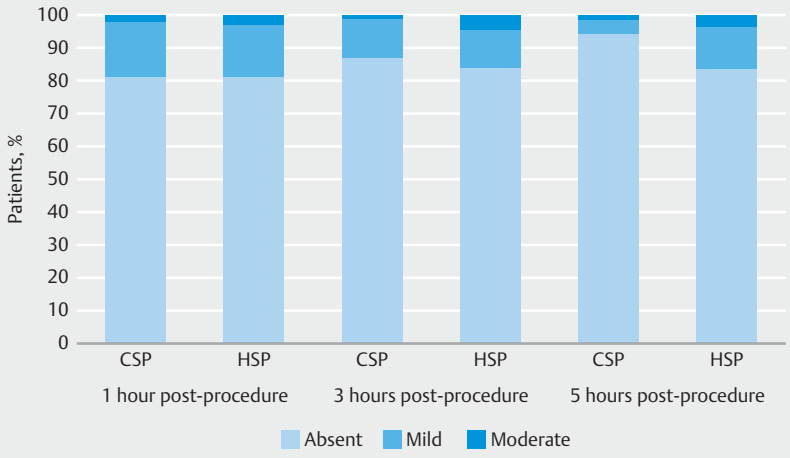
The abdominal pain analysis was performed only in patients whose polyps were all 5–9 mm and excluded patients who also had polyps < 5 mm or > 9 mm; thus, 204 patients (101 in the CSP group and 103 in the HSP group) were included. Ambient air insufflation was employed in two patients (2.0 %) in the CSP group and in four patients (3.9 %) in the HSP group (*P* = 0.68). The evolution of abdominal pain is shown in ▶ **Fig. 3**. At 1 hour after the procedure, both groups presented similar proportions of symptomatic patients (19/101 [18.8 %] with CSP vs. 19/103 [18.4 %] with HSP); however, at 5 hours after the procedure, only 6/101 (5.9 %) presented symptoms in the CSP group (4.9 % mild and 1 % moderate), whereas 17/103 patients (16.5 %) recorded pain in the HSP group (12.6 % mild, 3.9 % moderate) (*P* = 0.02). In the CSP arm, 97.0 % (98/101) of patients were asymptomatic 24 hours after the procedure, whereas in the HSP group 86.4 % (89/103) were asymptomatic (*P* = 0.01), resulting in a 10.6 % (95 %CI 3.2 % to 18 %) decrease in the proportion of symptomatic patients following CSP. Multivariable analysis identified HSP as the only risk factor for post-procedure abdominal pain at 5 and 24 hours after the procedure (OR 3.13, 95 %CI 1.18 to 8.30, *P* = 0.02 and OR 4.97, 95 %CI 1.38 to 17.7, *P* = 0.01, respectively).

Other minor adverse events were flatulence, reported in seven patients (3.0 %) in the CSP group and in nine patients (3.5 %) in the HSP group (*P* = 0.75), and anal pruritus in four patients (1.7 %) and seven patients (2.7 %), respectively (*P* = 0.45).

Discussion

Our multicenter randomized trial comparing CSP and HSP for 5–9 mm colorectal polyps did not find significant differences regarding incomplete resection rates or post-polypectomy bleeding. However, CSP was associated with a significant reduction in the intensity and duration of post-procedural abdominal pain.

Incomplete resection rates found in our study resemble previously reported data. Pohl et al. reported a 6.8 % incomplete resection rate for 5–9 mm nonpedunculated polyps, with larger size and a diagnosis of sessile serrated adenoma/polyps (SSA/Ps) being the strongest predictors of incomplete resection



▶ **Fig. 3** Temporal evolution of post-polypectomy abdominal pain. Pain was measured using a visual analog scale and categorized into: absent (0), mild (1–3), moderate (4–6), severe (7–10). Only patients without lesions <5 mm or >9 mm were included. CSP, cold snare polypectomy; HSP, hot snare polypectomy.

[19]. Other studies have reported incomplete resection rates ranging between 1.8%–8.5% for CSP and 2.6%–3.7% for HSP [14, 15, 20]. The CRESCENT study reported an excellent 1.8% for CSP and 2.6% for HSP [14], but excluded SSA/Ps and hyperplastic polyps. Additional removal using the allocated technique was also allowed, as in our design, but cold biopsy forceps could also be employed. In our study, directed biopsies were more frequently performed in the CSP group, maybe due to better differentiation of suspicious tissue in the absence of burning artifacts. Other studies using post-polypectomy endoscopic mucosal resection to assess incomplete resection rates report values of 3.4% for CSP in 1–7 mm polyps [13] and 3.9% in 1–9 mm polyps [22].

Self-limited bleeding was more frequently encountered in the CSP group, but there was no difference between the groups in rates of intraprocedural and delayed bleeding, a finding that concurs with recent meta-analyses demonstrating the efficacy and safety of CSP [23, 24]. One patient in each group required hospitalization for delayed bleeding. Most previous reports present delayed bleeding rates under 1%, supporting these findings [10, 14–16, 20, 25]. Interestingly, we observed these results despite not allowing prophylactic clipping and with only three lesions (0.8%) in the CSP group and seven (1.8%) in the HSP group receiving therapeutic clipping, whereas other studies report a proportion of prophylactic/therapeutic clipping ranging between 1.8%–35% and 1.1%–37% for CSP and HSP, respectively [14, 20, 25]. Our reduced use of clipping might be related to the 60-second observation period set in our protocol, distinguishing inconsequential self-limited bleeding from intraprocedural bleeds. This low rate of delayed bleeding in CSP supports previous findings demonstrating the safety of this technique even in patients under continuous anticoagulant treatment [26]. Moreover, our study included 56 pedunculated and 33 semi-pedunculated lesions, which are usually excluded from CSP due to a theoretical higher risk of delayed bleeding. The lack of differences observed supports the specific evaluation of CSP in 5–9 mm Ip and Isp lesions in further studies.

Our study showed that CSP shortened and reduced the intensity of post-polypectomy abdominal pain compared with conventional polypectomy, although it did not lead to decreased health care utilization, extending the scarce available evidence supporting this hypothesis [16]. It has been suggested that abdominal symptoms may be related to the number of polyps removed or procedure duration [9]; in our study however, HSP was the only risk factor for pain at 5 and 24 hours after the colonoscopy in patients whose polyps were all 5–9 mm. Abdominal pain and tenderness within 12 hours after the polypectomy form the typical picture of the post-polypectomy coagulation syndrome [27], presenting in 0.14%–2% of patients undergoing HSP [28, 29]. We hypothesize that post-polypectomy coagulation syndrome represents a full spectrum of disease, of which only the most severe cases are usually diagnosed. Thus, we consider the increased number of symptomatic patients in the HSP group represent mild cases, which in clinical practice do not seek medical care.

Although not a primary study aim, we found a wide range of incomplete resection rates among endoscopists. This finding is consistent with the CARE study [19], where incomplete resection rates ranged from 6.5% to 22.7%. Female sex was also associated with incomplete polyp resection. We hypothesize that in female anatomy, which requires longer cecal intubation times [30], straightening the scope to an optimal position to visualize the lesion and adequately ensnare a rim of normal mucosa might be more technically demanding.

Our study presents a series of strengths. We kept as close as possible to real clinical practice. We included primary, secondary, and tertiary centers, snares were chosen according to endoscopist preference and center availability, and all types of

polyps, regardless of optical diagnosis, morphology, and location were included. We consider this heterogeneity allows us to better approach incomplete resection rates in a real-life scenario. We also randomized patients instead of lesions, allowing the assessment of post-procedure symptoms. Nevertheless, this study has certain limitations that should be acknowledged. First, we evaluated residual tissue immediately after polypectomy. Biopsy results obtained immediately after HSP may not be useful to predict recurrence rates as samples include nonviable burnt tissue. Second, there are various possible sources of bias: the endoscopist who performed the procedure also took the biopsy samples and could choose the biopsy site; although the pathologist was blinded to the procedure type, the burning effect of HSP is easily detectable. Despite these limitations, our study provides important information regarding the usefulness and safety of the CSP technique.

In conclusion, CSP is an effective and safe method that shortens and improves post-polypectomy abdominal symptoms and should be recommended as the standard technique for 5–9 mm colorectal polyps.

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Clinical trial

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Competing interests

The authors declare that they have no conflict of interest.

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CORRECTION

Efficacy and safety of cold versus hot snare polypectomy for small (5–9mm) colorectal polyps: a multicenter randomized controlled trial

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In the above-mentioned article, the abstracts has been corrected. Correct is: Patients with ≥1 5–9 mm polyp were randomized to CSP or HSP, regardless of morphology or pit pattern.
This was corrected in the online version on November 30, 2021.