Communication from the ASGE Technology Committee

TECHNOLOGY STATUS EVALUATION REPORT

ASGE American Society for Gastrointestinal Endoscopy

Endoscopic polypectomy devices

Vinay Chandrasekhara, MD, FASGE,[1,*] Nikhil A. Kumta, MD, MS,[2,*] Barham K. Abu Dayyeh, MD, MPH, FASGE,[1] Manoop S. Bhutani, MD, FASGE,[3] Pichamol Jirapinyo, MD, MPH,[4] Kumar Krishnan, MD,[5] John T. Maple, DO, FASGE,[6] Joshua Melson, MD, MPH, FASGE,[7] Rahul Pannala, MD, MPH, FASGE,[8] Mansour A. Parsi, MD, MPH, FASGE,[9] Amrita Sethi, MD, FASGE,[10] Guru Trikudanathan, MBBS,[11] Arvind J. Trindade, MD, FASGE,[12] David R. Lichtenstein, MD, FASGE[13]

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Technology Status Evaluation Reports are drafted by 1 or 2 members of the American Society for Gastrointestinal Endoscopy Technology Committee, reviewed and edited by the committee as a whole, and approved by the Governing Board of the American Society for Gastrointestinal Endoscopy. When financial guidance is indicated, the most recent coding data and list prices at the time of publication are provided. For this review, the MEDLINE database was searched through March 2020 for articles related to polypectomy and colonoscopy crossed with snare, bipolar snare, detachable snares, biopsy, hot biopsy, forceps, submucosal injection, mucosal resection cap, and hemoclip, among others. Technology Status Evaluation Reports are scientific reviews provided solely for educational and informational purposes. Technology Status Evaluation Reports are not rules and should not be construed as establishing a legal standard of care or as encouraging, advocating, requiring, or discouraging any particular treatment or payment for such treatment.

BACKGROUND

Resection of GI polyps is one of the most commonly performed therapeutic endoscopic procedures. Polyps are found in a variety of sizes, shapes, and locations, and removal can occasionally be challenging. Various polypectomy devices and techniques are available, and their use is often subject to availability and preferences.[1] Familiarity with polypectomy devices is important for optimal selection and safe use. This status evaluation will describe devices and agents available for endoscopic polypectomy.

TECHNOLOGY UNDER REVIEW

The goal of polypectomy is the safe removal of the polyp in its entirety. Polyp removal can be achieved via "cold" mechanical cutting or with concurrent application of electrocautery for resection and/or ablation. This document will refer to devices for the performance of standard polypectomy, typically for polyps <20 mm in size. Prior documents have addressed technology for the resection of large polyps, specifically using endoscopic mucosal resection (EMR) and endoscopic submucosal dissection. Devices available for standard polypectomy include snares, biopsy forceps, submucosal injection agents, and ancillary devices.

Snares

Polypectomy snares are designed to entrap targeted tissue for resection and are made of monofilament or braided wires of various shapes, lengths, gauges, and stiffness. Most polypectomy snares incorporate a monopolar wire loop electrode that allows for use with electrocautery. Tissue is thereby transected using mechanical and electrosurgical cutting as the snare is closed and withdrawn into a plastic insulating catheter, also referred to as hot snare polypectomy (HSP). However, snares can be used without electrocautery, relying solely on mechanical cutting as the snare is closed, also referred to as cold snare polypectomy (CSP). Certain newer snares have been designed without a monopolar electrode solely for the use of CSP for small polyps. Rotatable snares allow for rotation of the wire loop to the desired orientation relative to the targeted tissue. Snare modifications have been designed to facilitate

TABLE 1. Commonly used polypectomy snares in the United States

Manufacturer	Device (design shape)	Working length (cm)	Loop diameter (mm)	Sheath size	Wire diameter (mm)	Minimum channel size (mm)
Boston Scientific	Captivator Oval – Stiff*	240	13/27	2.4 mm	NR	2.8
	Captivator Large Oval – Medium Stiff	240	30	2.4 mm	NR	2.8
	Captivator Large Oval – Flexible	240	30	2.4 mm	NR	2.8
	Captivator Hexagonal – Stiff*	240	13/27	2.4 mm	NR	2.8
	Captivator Medium Crescent – Stiff	240	27	2.4 mm	NR	2.8
	Captivator II Rounded – Stiff*	240	10/15/20/25/33	2.4 mm	NR	2.8
	Captivator COLD	240	10	2.4 mm	NR	2.8
	Profile Oval-Flexible*	240	11/13/27	1.9 mm	NR	2.0
	Single-Use Rotatable Snare*	240	13/20	2.4 mm	NR	2.8
	Captiflex Oval – Flexible*	240	11/13/27	2.4 mm	NR	2.8
	Sensation Oval – Flexible*	240	13/27	2.4 mm	NR	2.8
	Sensation Oval – Medium Stiff*	240	13/27/30	2.4 mm	NR	2.8
	Sensation Medium Crescent – Medium Stiff	240	27	2.4 mm	NR	2.8
ConMed	Singular Oval – Firm*	230	11/16/23/32	2.3 mm	NR	NR
	Singular Oval – Soft*	230	11/16/23/32	2.3 mm	NR	NR
	Singular Crescent – Firm	230	24	2.3 mm	NR	NR
	Singular Hexagonal – Firm	230	25	2.3mm	NR	NR
	Optimizer Oval – Firm*	230	11/16/23/32	2.3 mm	NR	NR
	Optimizer Oval – Soft*	230	11/16/23/32	2.3 mm	NR	NR
	Orbit-Snare Rotatable Oval – Firm*	230	15/25/35	2.5 mm	NR	NR
	Orbit-Snare Rotatable Hexagonal – Firm	230	25	2.3 mm	NR	NR
Cook Medical	Acusnare Mini	240	15 × 30	7F	NR	2.8
	Acusnare Standard	240	25 × 55	7F	NR	2.8
	Acusnare Jumbo	240	30 × 60	7F	NR	2.8
	Acusnare Mini Hexagonal	240	15 × 25	7F	NR	2.8
	Acusnare Hexagonal	240	30 × 45	7F	NR	2.8
	Soft Acusnare Micro Mini	240	10 × 15	7F	NR	2.8
	Soft Acusnare Mini	240	15 × 30	7F	NR	2.8
	Soft Acusnare Standard	240	25 × 55	7F	NR	2.8
	Soft Acusnare Jumbo	240	30 × 60	7F	NR	2.8
	Soft Acusnare Mini Hexagonal	240	15 × 25	7F	NR	2.8
	Soft Acusnare Hexagonal	240	30 × 45	7F	NR	2.8
	Acusnare Duckbill	240	15/25	7F	NR	2.8
Olympus	SnareMaster Oval*	230	10/15/25	NR	0.47	2.8
	SnareMaster Crescent	165/230	25	NR	0.3	2
	SnareMaster Oval Spiral	230	20	NR	0.48	2.8
	SnareMaster Oval Soft*	230	10/15/25	NR	0.4	2.8
	Reusable Oval	165/230	25	NR	0.43	2.8
	Reusable Oval	165/230	25	NR	0.47	2.8
	Reusable Mini Oval*	230	15	NR	0.43/0.47	2.8
	Reusable Crescent	190	23	NR	0.30	2

(*continued on the next page*)

TABLE 1. Continued

Manufacturer	Device (design shape)	Working length (cm)	Loop diameter (mm)	Sheath size	Wire diameter (mm)	Minimum channel size (mm)
Steris	Short Throw Mini	230	12.5 × 30	2.4 mm	0.46	2.8
US Endoscopy	Short Throw Standard Oval	230	25 × 54	2.4 mm	0.46	2.8
	Short Throw Standard Oval Enteroscopy	350	25 × 54	2.4 mm	0.46	2.8
	Lariat	230	30 × 50	2.4 mm	0.41	2.8
	iSnare system – Oval	230	25 × 40	3.0 mm	0.46	3.2
	iSnare system – Hexagonal	230	25 × 40	3.0 mm	0.46	3.2
	Traxtion	230	25 × 40	2.4 mm	0.46	2.8
	Exacto Cold Snare	230	9	2.4 mm	0.30	2.8
	Histolock Resection Device	230	14 × 27	2.4 mm	0.20	2.8
	Rotator Snare – Mini	230	12.5 × 30	2.4 mm	0.46	2.8
	Rotator Snare – Standard	230	25 × 54	2.4 mm	0.46	2.8

NR, not reported.
*Available in multiple sizes.

grasping of flat polyps, including varying snare sizes, shapes, wire thickness, and wire configuration (Table 1).

Biopsy forceps

Biopsy forceps are used for grasping and removing tissue. Biopsy forceps used for polypectomy include standard cold biopsy forceps (CBF), large-capacity or jumbo biopsy forceps, and hot biopsy forceps (HBF). CBF commonly have a needle-spike between the opposing biopsy jaws to enable direct lesion sampling, stabilization of the forceps jaws, and holding tissue to permit a second biopsy.[2] Jumbo biopsy forceps sample a larger area of tissue encompassing 2 to 3 times the surface area compared with standard forceps.[3] HBF were developed for simultaneous tissue biopsy and coagulation. The HBF polypectomy technique involves grasping the polyp with the forceps, pulling back the forceps to tent the mucosa, and then applying thermal energy to achieve a white coagulum adjacent to the polypectomy site.[4] HBF is not recommended for routine polypectomy by the United States Multi-Society Task Force (USMSTF) or American Society for Gastrointestinal Endoscopy[5,6] (Table 2).

HBF can be used for avulsion techniques to remove visible neoplasia when snare resection is incomplete. With hot avulsion, HBF are used to grasp and retract visible neoplasia while applying low-voltage cutting current (settings vary based on the electrosurgical generator).[7,8] Hot avulsion differs from traditional HBF polypectomy in that mechanical traction (rather than tenting) is simultaneously combined with low-voltage cutting current (rather than coagulation current) to remove neoplastic tissue and minimize the risk of transmural injury.[9] Hot avulsion has been discussed in a prior technology status evaluation report.[10]

Agents for submucosal injection

Submucosal injection is used to lift the target lesion to facilitate polyp removal and create separation between the mucosal resection surface and deeper layers of the bowel wall to minimize the risk of deep thermal injury, bleeding, and perforation.[4,11,12] Submucosal solutions are usually delivered with 21- to 25-gauge needles, with more viscous injectates requiring larger-bore needles.[13] Saline solution is commonly used because of its low cost and wide availability. However, disadvantages to saline solution include rapid dispersion into neighboring tissue planes and clear color.[11] A variety of injectable substances including dextrose 50%, glycerol, succinylated gelatin, methylcellulose, hyaluronic acid, fibrinogen, and hydroxyethyl starch have been evaluated for ease of injection and duration of submucosal lift.[14-16] Epinephrine has been used for submucosal injection to prevent postpolypectomy bleeding.[17]

Newer agents for submucosal injection use a combination of a viscous agent to maintain elevation and a coloring dye such as methylene blue or indigo carmine. Coloring dye can assist in both the delineation of polyp margins and identification of the submucosal plane (Video 1, available online at www.VideoGIE.org). The coloring dye may also help to identify residual polyp after endoscopic resection and improve recognition of perforations. If the muscularis propria layer is inadvertently resected during polypectomy, the transected surface will have a white/gray central circular disk surrounded by dye-stained submucosal connective tissue, giving it the appearance of a target (target sign).[18] With early recognition, small perforations can be successfully treated with various endoscopic methods.[19]

Two premixed injection solutions are currently approved by the U.S. Food and Drug Administration. The

TABLE 2. Commonly used biopsy forceps in the United States

Manufacturer	Device (design shape)	Working length (cm)	Jaw O.D. (mm)	Needle (+ = with - = without)	Minimum channel size (mm)
Boston Scientific	Radial Jaw 4 standard capacity	160/240	2.2	+ / -	2.8
	Radial Jaw 4 large capacity	160/240	2.4	+ / -	2.8
	Radial Jaw 4 jumbo	160/240	2.8	+ / -	3.2
	Radial Jaw 4 pediatric	160	1.8	+ / -	2.0
	Multibite forceps	160/240	2.4	-	2.8
	Radial Jaw 4 hot	240	2.2	-	2.8
ConMed	Precisor EXL (oval)	160/230	2.3	+ / -	2.8
	Precisor EXL (alligator)	160/230	2.3	+ / -	2.8
	Precisor EXL Jumbo (oval)	230	3.1	+ / -	3.2
	Precisor EXL Jumbo (alligator)	230	3.1	+ / -	3.2
	Pediatric forceps (oval)	160	1.8	-	2.0
	Pediatric forceps (alligator)	160	1.8	-	2.0
	Precisor hot (oval)	230	2.3	-	2.8
	Precisor hot (alligator)	230	2.3	-	2.8
Cook Medical	Captura Pro (serrated)	160/230		+ / -	2.8
	Captura Pro Jumbo (serrated)	160/230		+ / -	3.2
	Captura Pro Max (serrated)	230		+ / -	3.8
	Captura mini	160		-	2.0
	Captura hot (serrated)	230		-	2.8
Micro-Tech	Standard forceps (oval)	180/230		+ / -	2.8
	Standard forceps (alligator)	180/230		+ / -	2.8
	Standard forceps (serrated)	180/230		+ / -	2.8
	Large capacity forceps (alligator)	230		+ / -	2.8
	Jumbo forceps (oval)	230		+ / -	3.2
	Jumbo forceps (alligator)	230		+ / -	3.2
Olympus	EndoJaw biopsy forceps (oval)	155/230		+ / -	2-3.2
	EndoJaw biopsy forceps (alligator cup)	155/230		+ / -	2-3.2
	EndoJaw jumbo	230		+ / -	3.7
	EndoJaw hot	230		-	2.8
Steris	Centra (plain cup, serrated)	230	2.3	+ / -	2.8
US Endoscopy	Biopsy forceps (oval)	160/230	2.3	+ / -	2.8
	Biopsy forceps – sheathed (oval)	230	2.3	+	2.8
	Biopsy forceps – pediatric (oval)	160	1.8	+ / -	2.0
	Hot biopsy forceps (oval)	230	2.3	-	2.8

O.D., outer diameter.

solutions can be drawn up into syringes for injection (SIC-8000 [Eleview], Aries Pharmaceutical, San Diego, Calif, USA) or come in prefilled syringes (ORISE Gel, Boston Scientific, Marlborough, Mass, USA). SIC-8000 consists of a 10-mL premixed emulsion of methylene blue, water, medium-chain triglycerides, bulking/cushioning agent poloxamer 188, surfactant agent polyoxyl-15-hydroxystearate, and sodium chloride.[11] ORISE submucosal lifting gel is a similar 10-mL solution that contains food-grade coloring dye, polysaccharide-based thickening agent, and proprietary biocompatible materials. Additional submucosal lifting agents are currently under development.

Ancillary devices

A variety of other devices are often used for the performance of polypectomy. These include injection needles, hemostatic clips, detachable snares and loop devices, transparent caps, retrieval devices, and a variety of ablation devices including electrosurgical generators. Many of these

instruments have been discussed in other technology status evaluation reports.[13,20-24]

Hemostasis devices

Devices designed to ensure hemostasis after polypectomy include endoscopic clips, detachable loop devices, and hemostatic forceps. Clips and endoloops have been used to clamp or to ensnare the base or stalk of large pedunculated polyps before or after polypectomy to reduce the incidence of postpolypectomy bleeding. Clips are also used to close mucosal defects after polypectomy. Clips are available in a variety of sizes, and most new iterations are easily rotatable and may be reopened without deployment if initial placement is not satisfactory. They are discussed in another American Society for Gastrointestinal Endoscopy technology status evaluation report.[22] The only currently available detachable loop-ligating device in the United States is a preassembled nylon loop with a diameter of 30 mm (PolyLoop, Olympus, Center Valley, Pa, USA) (Video 2, available online at www.VideoGIE.org). A reusable loop cutter is available in a variety of lengths for removing deployed loops. Hemostatic forceps are not routinely used with standard polypectomy and are discussed in the endoscopic submucosal dissection technology status evaluation report.[13]

EFFICACY AND SAFETY

Snares

CSP is increasingly used for removal of colorectal polyps of less than 1 cm because of its high complete resection rates and low rates of delayed postpolypectomy bleeding (DPPB). In a randomized controlled trial (RCT) of 54 consecutive patients with 117 polyps (70% adenomas) with a mean size of 3.66 mm (+ 1.13), the rate of complete eradication was higher with CSP compared with cold forceps polypectomy (93.2% vs 75.9%; $P = .009$).[25] CSP was also found to be faster than cold forceps polypectomy (14.3 vs 22.0 seconds; $P < .001$), although 6.8% of CSP specimens were not successfully retrieved. Another RCT of 208 patients with 283 diminutive colorectal polyps measuring 3 to 5 mm compared CSP with hot forceps biopsy.[26] CSP was associated with a higher rate of en bloc resection (99.3% vs 80.0%; $P < .0001$) and complete resection (80.4% vs 47.4%; $P < .0001$) with similar rates of immediate bleeding (8.6% vs 8.1%; $P = 1.0$) without any incidents of DPPB or perforation in either group.

Multiple studies have now compared CSP with HSP for small polyps, including multiple meta-analyses. A meta-analysis of 8 RCTs including 1665 patients and 3195 interventions for small polyps (majority 5-7 mm) demonstrated no differences between CSP and HSP with respect to complete resection rate (RR, 1.02; 95% CI, 0.98-1.07; $P = .31$) and polyp retrieval rate (RR, 1.00; 95% CI, 1.00-1.01; $P = .60$), but did note longer procedural duration with HSP (mean difference 7.13 minutes; 95% CI, 5.32-8.94; $P < .001$).[27] A second meta-analysis included 12 RCTs involving 2481 patients with 4535 diminutive (<5 mm) or small polyps (6-10 mm) and again found no difference in complete resection rates between CSP and HSP (OR, 0.86; 95% CI, 0.60-1.24).[28] Similar incomplete resection rates (2.4% for HSP vs 4.7% for CSP; OR, 0.51; 95% CI, 0.13-1.99; $P = .33$) have been noted in a meta-analysis of 3 RCTs including 1051 patients with 1485 polyps measuring 4 to 10 mm.[29]

CSP has been associated with lower rates of DPPB compared with HSP.[30,31] Much of this difference has been attributed to thermal injury resulting in DPPB. Although CSP results in a larger immediate mucosal defect compared with HSP, this defect rapidly shrinks, whereas the defect with HSP increases after 1 day.[32] Furthermore, CSP results in a more superficial resection, with a small percentage of resections capturing submucosal tissue.[32,33] However, several meta-analyses have not demonstrated significant differences in immediate bleeding requiring treatment, DPPB, or overall adverse event rates between CSP and HSP, although a trend toward higher rates of DPPB with HSP was noted in one of the analyses (RR, 7.35; 95% CI, 0.91-59.33; $P = .06$).[27,28] A single meta-analysis of RCTs identified a lower rate of immediate bleeding requiring treatment with HSP (3.3%) compared with CSP (6.6%), yielding a pooled OR of 0.48 (95% CI, 0.27-0.86; $P = .01$), without differences in DPPB (0.4% vs 0%; $P = .45$) and no perforations in either group.[29]

CSP has been associated with lower postpolypectomy bleeding rates in patients still taking antiplatelet or antithrombotic medications.[34-36] An RCT compared 92 patients treated with CSP while on anticoagulants and 90 patients treated with heparin bridging and HSP for subcentimeter colon polyps.[37] DPPB requiring endoscopic therapy was not statistically significant in the CSP group (4.7%; 95% CI, 0.2%-9.2%) compared with the HSP group (12.0%; 95% CI, 5.0%-19.1%). CSP was associated with shorter polypectomy time (60 vs 94 seconds; $P < .001$) and shorter mean length of hospital stay in patients receiving warfarin (2.0 vs 9.6 days; $P < .001$).

A systematic review and pooled analysis also demonstrated excellent results with CSP of colorectal polyps >10 mm in terms of postpolypectomy bleeding, complete resection, and residual polyp rates.[38] Eight studies were included in the final analysis; these included 522 colorectal polyps with a mean polyp size of 17.5 mm (range, 10-60). The overall adverse event rate was 1.1% (95% CI, 0.2%-2.0%; $I^2 = 0\%$). Intra- and postprocedural bleeding rates were 0.7% (95% CI, 0%-1.4%) and 0.5% (95% CI, 0.1%-1.2%), respectively. Polyps >20 mm had a higher intraprocedural bleeding rate of 1.3% (95% CI, 0.7%-3.3%) and abdominal pain rate of 1.2% (95% CI, .7%-3.0%) but no delayed bleeding. No perforations were reported. The complete resection rate was 99.3% (95%

CI, 98.6%-100%). Overall pooled residual rates of polyps of any histology, adenomas, and SSPs were 4.1% (95% CI, 0.2%-8.4%), 11.1% (95% CI, 4.1%-18.1%), and 1.0% (95% CI, 0.4%-2.4%), respectively, during a follow-up period ranging from 154 to 258 days. RCTs comparing cold snare resection with hot snare resection of polyps >10 mm are required for further investigation.

Recent USMSTF guidelines suggest CSP for nonpedunculated polyps up to 10 mm to achieve en bloc resection.[6] The USMSTF also recommends that nonpedunculated polyps 10 to 19 mm without features suggestive of submucosal invasion be removed using CSP or HSP with or without submucosal injection.

Biopsy forceps

Multiple studies have reported variable complete resection rates with CBF ranging from 39% to 92.3% for polyps measuring less than 7 mm.[25,39-42] A systematic review and meta-analysis of 5 RCTs including 668 patients and 721 polyps less than 7 mm compared CBF with CSP and jumbo forceps polypectomy.[43] The pooled incomplete polyp resection rate with CBF was 19.0% versus 11.4% with CSP or jumbo forceps biopsy technique. There were no significant bleeding episodes or perforations in either group. A prospective, observational cohort study of 955 diminutive polyps (<5 mm) in 471 patients found that jumbo forceps polypectomy had an endoscopic complete resection rate of 99.4% with 2.1% local recurrence at 1-year follow-up.[44] Lesions >3 mm were significantly associated with local recurrence (OR, 3.4; $P = .02$).

Two RCTs compared jumbo forceps polypectomy with CSP. One prospective RCT of 169 patients with 196 diminutive colorectal polyps (<5 mm) found no significant difference between complete resection rates (92.0% vs 92.2%; $P = .947$), polypectomy procedure time (46.9 vs 44.5 seconds, $P = .468$), tissue retrieval rate, or adverse events.[45] A second prospective RCT of 151 patients with 261 polyps less than 6 mm found no difference in complete resection rates, although jumbo forceps polypectomy had higher tissue retrieval rates than CSP (100% vs 95.7%, $P = .02$).[46]

Studies have shown that the use of HBF for polypectomy is associated with incomplete polyp resection rates ranging from 17% to 22% for polyps less than 6 mm.[47-49] In a prospective study with 39 patients and 62 diminutive colon polyps removed with HBF, 17% had incomplete resection with residual polyp visualized on follow-up flexible sigmoidoscopy 1 to 2 weeks later.[49] Specimen quality after HBF was assessed in a prospective study with 179 patients and 237 diminutive colon polyps.[50] The study found the diagnostic quality of HBF specimens to be inferior to jumbo biopsy forceps (94 of 117, 80% vs 115 of 120, 96%; $P < .001$). Of the HBF specimens, 91.5% demonstrated cautery damage or crush artifact.

In a retrospective study of 1525 diminutive colon polyps removed by HBF, the rate of significant hemorrhage was 0.4% overall, with the risk highest in the right colon segment (1.3% in the cecum and 1.0% in the ascending colon).[51] In a study with porcine models, HBF caused a wide range of lateral and deep thermal injury, including transmural necrosis in 9 of 41 (22%) polypectomies, partial muscularis propria necrosis in 14 of 41 (34%), and full-thickness muscularis propria inflammation with histologic serositis in 13 of 41 (32%).[52]

Recent USMSTF guidelines recommend against the use of CBF polypectomy to remove diminutive (≤5 mm) polyps because of high rates of incomplete resection. For diminutive lesions of ≤2 mm, jumbo or large-capacity forceps can be considered if CSP is technically difficult.[6] HBF is not recommended by the USMSTF or the American Society for Gastrointestinal Endoscopy for routine polypectomy because of high rates of incomplete resection, inadequate tissue sampling for histology, and high risks of adverse events such as deep thermal injury, delayed bleeding, and perforation.[1,5,6,53-56] However, HBF can be used for hot avulsion as an adjunctive measure to remove flat or fibrotic residual polyps.[57,58]

Submucosal injection

A systematic review and meta-analysis evaluated 11 randomized controlled trials for submucosal injection with viscous solutions (hydroxyethyl starch, sodium hyaluronate solution, 50% dextrose, and succinylated gelatin, and fibrinogen).[16] No solution was superior in complete resection rates or postpolypectomy adverse events. However, these viscous agents have shown superiority in other aspects of polyp resection, such as en bloc resection, Sidney resection quotient (size of the polyp divided by the number of pieces resected), and residual polyp tissue. A meta-analysis including 5 prospective RCTs with 504 patients similarly noted the superiority of viscous lifting agents compared with saline solution for resection of large sessile colon polyps (mean size of 21 mm) with a significant increase in en bloc resection (OR, 1.91; 95% CI, 1.11-3.29; $P = .02$; $I^2 = 0\%$) and decrease in residual lesions (OR, 0.54; 95% CI, 0.32-0.91; $P = .02$; $I^2 = 0\%$).[59]

Newer submucosal lifting agents may have additional benefits over saline solution or other viscous lifting agents but at an increased cost. In a prospective, double-blind RCT of submucosal injection solutions for colorectal lesions greater than 20 mm, SIC-8000 compared with saline solution had a lower mean injection volume (16.1 mL vs 31.6 mL; $P < .001$) and a trend toward shorter procedure times, lower number of resection pieces, and higher en bloc resection rates compared with normal saline solution with methylene blue.[60] Another prospective, double-blinded RCT found that SIC-8000 was superior to hydroxyethyl starch as a submucosal injectate for EMR.[61] There were significant differences between SIC-8000 and hydroxyethyl starch in the Sydney resection quotient (9.3 vs 8.1, $P = .001$) and in the total amount of fluid injected (14.8

TABLE 3. Current procedural terminology codes for performance of polypectomy

Description	*CPT code*
Esophagogastroduodenoscopy, flexible, transoral; with directed submucosal injection(s), any substance	43236
Esophagogastroduodenoscopy, flexible, transoral; with biopsy, single or multiple	43239
Esophagogastroduodenoscopy, flexible, transoral; with removal of tumor(s), polyp(s), or other lesion(s) by hot biopsy forceps	43250
Esophagogastroduodenoscopy, flexible, transoral; with removal of tumor(s), polyp(s), or other lesion(s) by snare technique	43251
Esophagogastroduodenoscopy, flexible, transoral; with ablation of tumor(s), polyp(s), or other lesion(s)	43270
Colonoscopy, flexible; with biopsy, single or multiple	45380
Colonoscopy, flexible; with directed submucosal injection(s), any substance	45381
Colonoscopy, flexible; with removal of tumor(s), polyp(s), or other lesion(s) by hot biopsy forceps	45384
Colonoscopy, flexible; with removal of tumor(s), polyp(s), or other lesion(s) by snare technique	45385
Colonoscopy, flexible; with ablation of tumor(s), polyp(s), or other lesion(s)	45388
Colonoscopy, flexible; with endoscopic mucosal resection	45390
Sigmoidoscopy, flexible; with biopsy, single or multiple	45331
Sigmoidoscopy, flexible; with removal of tumor(s), polyp(s), or other lesion(s) by hot biopsy forceps	45333
Sigmoidoscopy, flexible; with directed submucosal injection(s), any substance	45335
Sigmoidoscopy, flexible; with removal of tumor(s), polyp(s), or other lesion(s) by snare technique	45338
Sigmoidoscopy, flexible; with ablation of tumor(s), polyp(s), or other lesion(s)	45346
Sigmoidoscopy, flexible; with endoscopic mucosal resection	45349
Small intestinal endoscopy, enteroscopy beyond second portion of duodenum, not including ileum; with biopsy, single or multiple	44361
Small intestinal endoscopy, enteroscopy beyond second portion of duodenum, not including ileum; with removal of tumor(s), polyp(s), or other lesion(s) by hot biopsy forceps or bipolar cautery	44365
Small intestinal endoscopy, enteroscopy beyond second portion of duodenum, not including ileum; with removal of tumor(s), polyp(s), or other lesion(s) by snare technique	44364
Small intestinal endoscopy, enteroscopy beyond second portion of duodenum, not including ileum; with ablation of tumor(s), polyp(s), or other lesion(s) not amenable to removal by hot biopsy forceps, bipolar cautery or snare technique	44369

mL vs 20.6 mL, $P = .038$). There were nonstatistically significant trends toward superiority of SIC-8000 in the number of reinjections required, fewer numbers of resected pieces, and resection duration.

A meta-analysis of 6 studies with 1388 patients and 1523 colorectal polyps with a mean size of 15.8 mm examined the preventative effect of submucosal epinephrine injection on postpolypectomy bleeding.[17] The study found statistically significant reductions in overall (OR, 0.38; 95% CI, 0.21-0.66; $P = .0006$) and early bleeding (OR, 0.38; 95% CI, 0.20-0.69; $P = .002$), but not DPPB (OR, 0.45; 95% CI, 0.11-1.81; $P = .26$), when prophylactic submucosal epinephrine injection was performed before polypectomy.

A newer submucosal lifting agent, ORISE Gel, may remain present as amorphous submucosal deposits in resection specimens. The submucosal deposits are similar to mucin on hematoxylin and eosin staining and can mimic a number of other conditions, such as mucin pools, lymphangiomas, granulomatous inflammation, and amyloid deposition.[62] Endoscopists should communicate with pathologists regarding the use of these agents and their associated artefacts to minimize misdiagnosis on pathologic examination. Additional mucin stains (eg, periodic acid–Schiff with diastase digestion) may be considered if further differentiation is necessary.

Clips and detachable snares/loops

The practice of prophylactically clipping mucosal defects to reduce the rate of DPPB has been controversial; studies of efficacy demonstrate mixed results, and clips are expensive. Two meta-analyses found no benefit from prophylactic clipping.[63,64] One consistent feature of the negative trials has been minimal bleeding in the control group. There is also heterogeneity in the studies, with polyps of varying sizes, shapes, and pathologies using both standard HSP and EMR. Among 4 published RCTs,[65-68] 3 have shown a benefit.[66-68] The negative trial (no clipping benefit) was designed as an equivalence study and did not reach the intended sample size because of loss of funding, but the overall rate of delayed bleeding was similar to the control group, with no benefit in any subgroups.[65] Mean polyp size was 14 mm (16% were >20 mm, and 30% were pedunculated). The bleeding rate of 2.9% in the control group is low compared with the positive trials, where polyps were confined to

nonpedunculated lesions ≥20 mm, with a much higher control group rate of bleeding, particularly in the right colon segment, where the rate approaches 10%.[67,68]

One positive RCT included 919 patients with nonpedunculated lesions >20 mm removed by EMR.[67] Clipping could not be performed in 13%, mostly owing to large size, and 20% were only partially closed. Furthermore, 10% of the control lesions were clipped, generally for fear of perforation or need for anticoagulation. In the intention-to-treat analysis, delayed bleeding occurred in 7.1% of the control group versus 3.5% with clipping ($P = .015$). The benefit was confined to the proximal colon, with a delayed bleeding rate in the proximal colon of 9.6% in controls versus 3.3% with clipping ($P = .001$). The results were independent of lesion size, cautery setting, and antithrombotic agents. A second positive RCT enrolled 235 nonpedunculated lesions ≥20 mm in size (mean size, 37 mm), with 90% proximal to the splenic flexure.[68] In the clip arm, complete closure was achieved in 57%, partial in 28%, and 15% failed (no closure), with bleeding rates of 1.5%, 9.1%, and 11%, respectively. The complete closure group had an 89% reduction in delayed bleeding compared with controls. Only 1 of 35 transverse colon lesions in either arm bled. Thus, prophylactic clip placement may be a cost-effective strategy in patients deemed high risk for DPPB, including those with nonpedunculated lesions in the proximal colon (cecum, ascending or hepatic flexure) that are ≥20 mm and removed by EMR.

Clips and detachable loops and snares have been evaluated for ligation of large pedunculated polyps before snare resection. Data for prophylactic clip ligation are mixed. A prospective study of 47 patients with 56 pedunculated polyps (mean size 17 mm ± 8 mm) reported an immediate postpolypectomy bleeding rate of 3.6% and DPPB rate of 1.8% using a mean of 2 clips.[69] However, another prospective randomized study that included 98 patients with 105 large pedunculated polyps compared clip placement before snare resection versus standard snare resection and reported that adverse event rates were higher in the clip group (10.6% vs 7.7%).[70] Although the difference was not statistically significant, the study was terminated early because of unexpected increased morbidity in the clip group that was attributed to higher rates of mucosal burns and perforation.

Two prospective RCTs have demonstrated that in patients with large pedunculated colorectal polyps, use of a detachable snare significantly reduced the rate of postpolypectomy bleeding when compared with conventional polypectomy (0% vs 12%; $P < .05$)[71] or compared with epinephrine injection with conventional polypectomy (3.1% vs 12.5%; $P = .02$).[72] In a study of 33 patients with large pedunculated colonic polyps, endoloop placement was not possible in 4 patients and the snare became entangled in 1 patient.[73] Of the 28 patients (85%) with successful loop placement, bleeding occurred in 4 patients (14.3%). Risk factors for immediate bleeding included transection of a thin stalk (<4 mm) by the loop, whereas risk factors for bleeding included performance of polypectomy close to the loop, with subsequent loop dislodgement. Finally, a prospective RCT of 195 patients with 203 pedunculated colorectal polyps with heads ≥10 mm and stalks ≥5 mm found that overall bleeding rates were similar for those receiving prophylactic clip ligation (5.1%) and those treated with endoloop placement (5.7%; $P = .847$).[74] Recent USMSTF guidelines recommend prophylactic ligation with either a detachable loop or clips for pedunculated polyps with heads ≥20 mm or stalks ≥5 mm to reduce the risk of immediate postpolypectomy bleeding and DPPB.[6]

FINANCIAL CONSIDERATIONS

The Current Procedural Terminology codes relevant to polypectomy during upper endoscopy, colonoscopy, sigmoidoscopy, and enteroscopy are listed in Table 3. In general, when 1 or more polyps are removed during endoscopy, a separate code is reported for each technique used if the techniques are used for different polyps or separate sites. When multiple techniques are performed to resect polyps at different sites, different primary and secondary codes can be used with the -59 modifier on the second or subsequent code. If submucosal injection is performed, it can be separately used as a secondary procedure, again with -59 modifier. Control of bleeding induced by polypectomy and treated within the same session cannot be separately reported. EMR includes biopsy, control of bleeding, submucosal injection, and application of clips or cautery of residual edges within the same code as the snare lesion removal itself.

CONCLUSION

A wide array of devices is available for polypectomy. Ongoing review and familiarity with advances in polypectomy devices and techniques will help the practicing endoscopist achieve optimal outcomes. CSP and jumbo forceps polypectomy of diminutive and small polyps are associated with higher complete resection rates than cold forceps polypectomy. Compared with competing techniques for resecting small polyps, hot biopsy forceps polypectomy is associated with high incomplete resection rates, suboptimal pathologic specimens, and high adverse event rates. Therefore, CSP is recommended for resection of nonpedunculated polyps less than 10 mm. CSP or HSP with or without submucosal injection is recommended for nonpedunculated polyps 10 to 19 mm without features of submucosal invasion. Hot biopsy forceps are useful for hot avulsion of residual flat or fibrotic neoplastic tissue after conventional snare polypectomy. Routine clip closure

does not reduce the risk of DPPB after standard uncomplicated polypectomy and should not be routinely used. Clip closure of mucosal defects can be considered in patients or lesions deemed to be at higher risk for DPPB. In particular, clip closure is recommended after EMR with electrocautery of lesions ≥20 mm from the right colon segment. Pedunculated polyps with heads ≥20 mm or stalks ≥5 mm are recommended to undergo prophylactic mechanical ligation with a detachable loop before resection or clip closure after resection to reduce the risk of immediate postpolypectomy bleeding and DPPB.

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Abbreviations: CBF, cold biopsy forceps; CSP, cold snare polypectomy; DPPB, delayed postpolypectomy bleeding; EMR, endoscopic mucosal resection; HBF, hot biopsy forceps; HSP, hot snare polypectomy; RCT, randomized controlled trial; USMSTF, United States Multi-Society Task Force.

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*Drs Chandrasekhara and Kumta are co-first authors and contributed equally to this article.

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Department of Gastroenterology and Hepatology, Mayo Clinic, Rochester, Minnesota (1), Division of Gastroenterology, Mount Sinai Hospital, New York, New York (2), Department of Gastroenterology Hepatology and Nutrition, Division of Internal Medicine, The University of Texas MD Anderson Cancer Center, Houston, Texas (3), Division of Gastroenterology, Hepatology and Endoscopy, Brigham and Women's Hospital, Boston, Massachusetts (4), Division of Gastroenterology, Department of Internal Medicine, Harvard Medical School and Massachusetts General Hospital, Boston, Massachusetts (5), Division of Digestive Diseases and Nutrition, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma (6), Division of Digestive Diseases, Department of Internal Medicine, Rush University Medical Center, Chicago, Illinois (7), Department of Gastroenterology and Hepatology, Mayo Clinic, Scottsdale, Arizona (8), Section for Gastroenterology and Hepatology, Tulane University Health Sciences Center, New Orleans, Louisiana (9), Department of Digestive and Liver Diseases, Columbia University Medical Center/New York-Presbyterian, New York, New York (10), Department of Gastroenterology, Hepatology and Nutrition, University of Minnesota, Minneapolis, Minnesota (11), Department of Gastroenterology, Zucker School of Medicine at Hofstra/Northwell, Long Island Jewish Medical Center, New Hyde Park, New York (12), Division of Gastroenterology, Boston Medical Center, Boston University School of Medicine, Boston, Massachusetts (13).