

Safety and efficacy of hot avulsion as an adjunct to endoscopic mucosal resection  
(with videos)

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**Abstract:**

**Background:** Excision of all visible neoplastic tissue is the goal of endoscopic mucosal resection (EMR) of colorectal laterally spreading tumors (LSTs). Flat and fibrotic tissue can resist snaring. Ablation of visible polyps is associated with high recurrence rates. Avulsion is a technique to continue resection when snaring fails.

**Methods:** We retrospectively analyzed colonic EMRs of 564 consecutive referred polyps between 2015 and 2017. Hot avulsion was used when snaring was unsuccessful. Polyps treated with and without avulsion were compared.

**Results:** Hot avulsion was used in 20.9% (n=112) of all resected lesions. The recurrence rates on follow up colonoscopy were 17.52% in avulsion group versus 16.02% in the non-avulsion group ( $p=0.76$ ). Hot avulsion was associated with a trend toward higher rates of delayed hemorrhage (5.35% vs 2.58%;  $p=0.15$ ) and post-coagulation syndrome (1.8% vs 0.47%;  $p=0.15$ ), but polyps treated with any avulsion were larger than those in which no avulsion was used ( $p<0.001$ ). There were an insufficient number of adverse events to perform a multivariable analysis testing the effects of avulsion, size, and location on the risk of overall adverse events.

**Conclusion:** Unlike previous reports of using argon plasma coagulation to treat visible polyp during EMR, hot avulsion of visible/fibrotic neoplasia was associated with similar EMR efficacy compared with cases that did not require hot avulsion. The safety profile of hot avulsion appears acceptable.

Key Words: colonoscopy, endoscopic mucosal resection (EMR), hot avulsion, argon plasma coagulation

## Introduction

Endoscopic mucosal resection (EMR) is a widely used approach to resection of lateral spreading tumors (LSTs) during colonoscopy. EMR consists fundamentally of submucosal injection followed by snare resection, which is often performed piecemeal in the cases of larger LSTs. Compared with endoscopic submucosal dissection (ESD), EMR has a high recurrence rate, and is more likely to result in adjuvant surgical resection when superficial submucosally invasive cancer is present.<sup>1</sup> However, EMR has a substantially lower risk of perforation compared with ESD, is quicker to perform, and has similar long-term outcomes.<sup>1</sup>

Although snare resection (piecemeal or en bloc) of the entire LST is the goal of EMR, it is not uncommon for some portion of an LST to resist attempts at snare resection, usually because of flat shape or submucosal fibrosis. In the past, flat or fibrotic neoplastic tissue that resisted snaring was usually treated with an ablative technique, most commonly using argon plasma coagulation (APC).<sup>2,3</sup> However, ablation to treat visible residual neoplastic tissue that has resisted snaring is associated with an increased recurrence rate at follow-up.<sup>4,5</sup> This finding suggests that ablation is fundamentally inferior to resection, probably because endoscopists performing ablation cannot be certain whether the thermal injury has been deep enough to destroy all neoplastic tissue.<sup>6,7</sup> Logically, continued resection in the same submucosal plane<sup>8</sup> developed by snaring seems likely to be more effective than ablation.

Recent studies found that the process of continuing resection in flat or fibrotic polyp tissue that has resisted snaring can be achieved using avulsion. In avulsion, flat or fibrotic tissue is grasped with a forceps and pulled off. The grasping capacity of forceps enables the success of avulsion in removal of tissue that resists capture with a snare.

There is some controversy as to whether avulsion should be performed without electrocautery (cold avulsion) or with electrocautery (performed with hot forceps and called hot avulsion). Hot forceps are no longer used or advocated for the removal of diminutive polyps, because they are ineffective<sup>7</sup> and have been associated with deep thermal injury.<sup>9</sup> Additionally, hot forceps removal of diminutive polyps generally used forced coagulation current, and thermal injury likely accounts for all hot forceps related adverse events.<sup>9,10</sup> Advocates of hot avulsion (vs cold avulsion) during EMR often cite lack of bleeding with hot compared with cold avulsion, and the clean separation that occurs in the submucosal plane with the hot technique. Hot avulsion as part of EMR is often performed using a low voltage current to reduce the risk of thermal injury. Advocates of cold avulsion<sup>11,12</sup> cite concern about the risk of grasping and injuring the muscularis propria during hot avulsion. Some endoscopists follow cold avulsion with soft coagulation treatment of the avulsion defect using the snare tip. Whether snare tip soft coagulation of the defect is safer than hot avulsion using low voltage current is unknown.

No randomized controlled trials of hot vs. cold avulsion have been performed. In this report we describe our experience with hot avulsion in the performance of EMR

in a tertiary referral center for resection of complex polyps. We describe the efficacy of hot avulsion and adverse event rate of EMRs performed with versus without hot avulsion.

## Methods

We evaluated a quality database of EMRs performed by DKR. All lesions were referred by other endoscopists for resection. The study interval was January 2015 through June 2017, and the beginning of the study interval corresponds to when DKR began to use hot avulsion to complete selected EMRs. Permission to review the database for the study was granted by the Institutional Review Board at Indiana University on May 30, 2018.

All resected lesions were flat or sessile, and nearly all had sufficient diameter to be called lateral spreading tumors. For most lesions, the submucosal injection fluid was hydroxyethyl starch, but Eleview (Aries Pharmaceuticals, San Diego, Calif) was used in some cases. The maximum polyp diameter was measured in all cases using a stiff snare of 15 or 20 mm diameter. In all cases lesion size was recorded as the size measured at our center and not as the size measured or estimated by the referring physician. Although most previous reports from our database have involved EMR of lesions  $\geq 20$  mm in size, in this report we include all referred lesions during the study interval. After submucosal injection, polyps were typically resected using stiff snares 20, 15, or 10 mm size (Boston Captivator 2, Boston Scientific, Nadick, Mass). If there were fibrotic areas or areas that were flat or resisted snaring, avulsion was performed using Boston Scientific hot forceps. The technique for avulsion was to grasp the re-

residual polyp tissue firmly with the hot forceps, tent, and apply electrocautery using Endocut I (3-1-3 setting; Erbe, Erlangen, Germany) and mechanically pull the tissue off. If any part of the lesion was removed by avulsion, the lesion was designated an avulsion EMR. If the entire lesion was removed by snare resection, the lesion was termed a non-avulsion lesion. During part of the interval, snare tip soft coagulation (STSC) was used to ablate the normal-appearing tissue at the rim of the EMR defect of both avulsion and non-avulsion lesions. Many of the defects were closed completely or partially with hemostatic clips.

Patients were generally scheduled for follow-up at 6- to 12-month intervals, depending on the size of the lesion and whether the EMR was performed piecemeal or en bloc. At follow-up, a residual polyp was deemed to be present if magnified inspection (Olympus narrow-band imaging on close focus) demonstrated residual polyp tissue (regardless of whether residual tissue was confirmed by pathology), or if the EMR scar appeared normal but random biopsy specimens of the scar using cold forceps demonstrated residual polyp histologically.

Patients were called within 30 days after EMR to identify adverse events. Delayed hemorrhage was defined as bleeding that occurred after discharge from the endoscopy unit and which required repeat colonoscopy, transfusion, or hospitalization. Post-coagulation syndrome was defined as abdominal pain requiring hospitalization and/or antibiotic treatment, without radiographic evidence of perforation.

Rates of residual polyp, delayed hemorrhage, and post-coagulation syndrome were compared by chi-square. There were an insufficient number of adverse events to

perform a multivariable analysis of whether avulsion predicted delayed hemorrhage independent of polyp size and location. Mean polyp size and location in avulsed vs. non-avulsed polyps were compared by t tests and chi square or Fischer exact test. The study was observational, and no sample size calculation was made.

## Results

During the study interval, there were 564 lesions referred for EMR in 506 patients. 27 lesions were deemed unresectable and so were excluded from analysis giving a total of 537 lesions (95.2% of all referred lesions) in 482 patients. The patient population consisted of 51.45% (n= 248) females and males (n=234). The mean age was 64.62 years (ranging from 34-91). The sizes of lesions in the study as measured at our center were <10 mm (n=15/537; 2.8% of all lesions), 10 to 19 mm (n=150; 27.93%), 20 to 29 mm (n=198; 36.87%), 30 to 39 mm (n=97; 18.06%), 40 to 49 mm (n=33; 6.15%), 50 to 69 mm (n=35; 6.52%), 70 to 100 mm (n=9; 1.68%).

Hot avulsion was used in 20.9% (n=112) of all resected lesions. Hot avulsion was used more commonly in adenomas (24.9%; n= 95/381) than serrated lesions (11.%; n= 17/154; p = 0.003). The use of hot avulsion increased with lesion size (Table 1). There were 2 lesions that were mucosal prolapse histologically, and neither required avulsion. Table 2 shows the overall size distribution and colonic location of the EMRs using avulsion vs no avulsion. There was no association of colonic location with the

use of avulsion, but EMRs in which avulsion was used were larger than EMRs not involving avulsion ( $P < 0.001$ ).

A substantial fraction of lesions referred for EMR were  $\leq 20$  mm in size. All lesions  $< 10$  mm in size had been either partially resected by the referring doctor, or it was noted they could not be reached or accessed adequately for polypectomy. A total of 409 lesions in 364 patients underwent their first follow-up examination at our center. Despite their larger size, the risk of residual polyp at first follow-up was similar in the avulsion 17.5% ( $n=17/97$ ) and non-avulsion groups 16.0% ( $n=50/312$ );  $P=0.76$ . (Table 1) In the avulsion group, 12 recurrences were associated with endoscopically visible recurrent polyp that was verified by pathology, 2 were endoscopically visible but not verified by pathology (pathology was negative likely because of tissue destruction during excision), and 3 cases had no endoscopically visible recurrence, but cold biopsies of the resection site demonstrated residual polyp. In the non-avulsion group, 37 recurrences were endoscopically visible and verified by pathology, 8 were endoscopically visible and not verified by pathology and 5 cases had no visible endoscopic recurrence but were path positive.

The risk of delayed post-polypectomy hemorrhage and post-polypectomy coagulation syndrome were both numerically higher in patients who underwent EMR involving avulsion (Table 2). However, absolute rates of adverse event in patients with EMRs involving avulsion were low, and as noted above EMRs using avulsion involved larger lesions than the non-avulsion lesions, and numerically were more common in the right colon. In the avulsion group 81 (72.3%) of resection sites underwent com-



plete and 8 (7.1%) underwent partial prophylactic clipping. In the non-avulsion group 274 (64.5%) lesions underwent complete and 13 (3.1%) partial clip closure. There was no difference between the groups in the fraction of resection sites to which clips were applied ( $p=0.32$ ). All 17 bleeds in the study (Table 2) were from proximal colon lesions.

There was an insufficient number of adverse events to perform a multivariable analysis testing whether avulsion, polyp size, and polyp location were independent predictors of adverse events. There were no perforations.

## Discussion

In this report we describe our experience using hot avulsion to perform endoscopic mucosal resection (EMR) in 537 nonpedunculated lesions undergoing endoscopic resection after referral to our center.

We found avulsion to be necessary in 20.9% of referred polyps that underwent resection. The remainder of the lesions were removed entirely by snare resection. Relative to published experience with APC,<sup>4,5</sup> avulsion was a successful method of continued treatment of residual polyp after snare resection was exhausted. Thus, unlike the published experience with APC,<sup>4,5</sup> avulsion was not associated with an increased risk of residual polyp at first follow-up compared with lesions removed without avulsion.

One concern regarding the use of hot avulsion, compared with cold avulsion, is the potential for an increased risk of thermal injury when avulsion is performed with electrocautery.<sup>10,13</sup> In order to reduce the risk of thermal injury, we performed avulsion using the low voltage Endocut I current, rather than the higher voltage Endocut Q current recommended for snaring. We did see a numerically higher rate of delayed hemorrhage and post-coagulation syndrome in patients whose lesions were removed with techniques including hot avulsion. However, the absolute risk of delayed hemorrhage and post-coagulation syndrome were both low, and the polyps in the avulsion group were significantly larger than those in the non-avulsion lesions, and numerically more likely to be located in the proximal colon. Polyp size is a known risk factor for adverse events, particularly for delayed hemorrhage, as is proximal colon location.<sup>14,15</sup> Thus, our data suggest that hot avulsion has an acceptable safety profile in the performance of EMR. Importantly, no perforations were noted with the use of hot avulsion.

Advantages of hot avulsion compared with cold avulsion include an absence of immediate bleeding in most cases, allowing easy visualization of separation of the retained polyp tissue, which typically occurs in the same submucosal plane that the snare resection had created (Video 1-3; Figure 1). Hot avulsion leaves the endoscopic field dry and, in most cases, there is no need to apply snare tip soft coagulation to stop immediate oozing as some practitioners use after cold avulsion.

The technique for hot avulsion is straightforward and involves firmly grasping the flat or fibrotic residual polyp, tenting to move the forceps away from the muscle

layer, application of low voltage current, and nearly immediately pulling the tissue off mechanically (Video 1-3).

In a number of previous studies on polyp resection from our center, we reported only non-pedunculated lesions at least 20 mm in size.<sup>16-20</sup> However, in the current study it seemed reasonable to include all referred polyps. These data show that a substantial fraction of nonpedunculated colorectal lesions referred to a tertiary center are <20 mm in maximum dimension. This finding is consistent with our previous anecdotal experience and reports from others.<sup>21</sup>

Practitioners are sometimes confused by the assertion that APC applied to residual polyp results in a higher recurrence rate, whereas APC applied to the normal appearing edge after complete endoscopic resection of the polyp results in a lower recurrence rate.<sup>2,22,23</sup> However, ablating visible residual polyp, which has a negative impact on recurrence rates, is a completely separate and different concept from ablation of the normal appearing tissue at the rim of the EMR defect after resection by snaring (and avulsion if needed) of all visible polyp tissue has been completed. Treatment of the normal rim to reduce recurrence rates is now performed by most experts using the snare tip in the soft coagulation mode,<sup>24-26</sup> which is effective, and considerably less costly than APC. Thus, the roles of APC in EMR have been almost completely supplanted, including by avulsion to resect visible residual polyp, and STCS to treat the normal appearing rim of the EMR defect after resection has been completed.

Limitations of this study include its retrospective nature, though the database was constructed prospectively and our methods for collecting cases allow us to be certain that all referred cases were included. Also, we did not systematically collect data on factors that could increase submucosal fibrosis, such as previous partial resection, biopsy, and placement of tattoos that extended under the lesion. These factors could have an important influence on the need for avulsion during EMR.

In summary, we have demonstrated that hot avulsion has an acceptable safety profile and is an effective adjunct to snare resection during the process of EMR of selected lateral spreading tumors that have flat or fibrotic tissue resistant to snaring. A randomized controlled trial to compare the efficacy, safety, and efficiency of hot to cold avulsion appears warranted.

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Table 1. Use of avulsion in lesions referred for resection according to lesion size

Lesion size	Number of lesions	Number with avulsion used (%)
< 10 mm	15	0 (0)
11-19 mm	150	13 (8.7)
20-29 mm	198	41 (20.7)
30-39 mm	97	33 (34.0)
40-49 mm	33	14 (42.4)
50-69 mm	35	7 (20)
70-100 mm	9	4 (44.4)

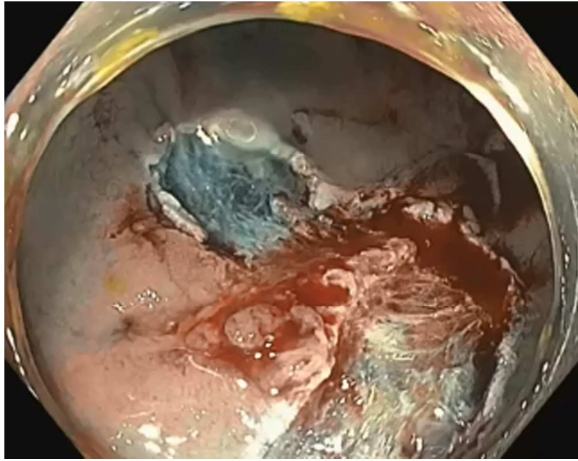
Table 2. Comparison of the avulsion and non-avulsion lesions

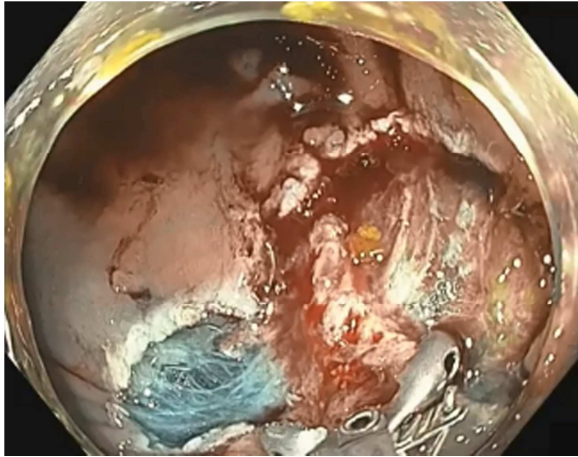
	Avulsion group	Non-avulsion group	P value
<b>No. of lesions</b>	112	425	
<b>Size of polyp, Mean (<math>\pm</math> SD)</b>	30.55 mm (SD $\pm$ 12.70)	24.85 mm (SD $\pm$ 13.11)	<0.001
<b>Location of polyps</b> Right sided Left sided	98 (87.5%) 14 (12.5%)	341 (80.24%) 84 (19.76%)	0.76
<b>Adverse events (total)</b>			
Number with delayed bleeding	6 (5.35%)	11 (2.58%)	0.15
Mean size of polyp associated with bleeding event ( $\pm$ SD)	44.16 mm (SD $\pm$ 21.07)	31 mm (SD $\pm$ 11.57)	0.20
Postcoagulation syndrome	2 (1.8%)	2 (0.47%)	0.15
<b>Recurrence</b>	(17/97) 17.52%	(50/312) 16.02%	0.76

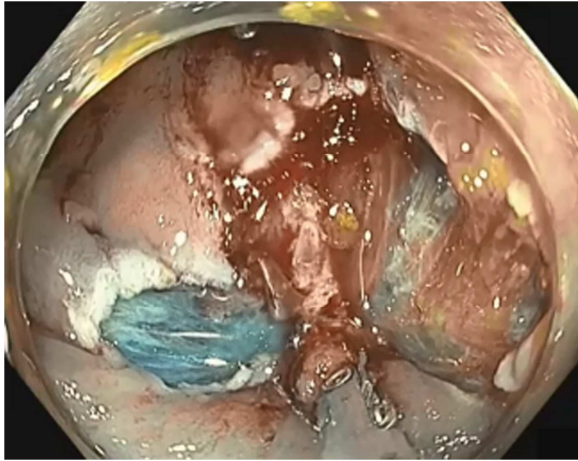
Figure legend 1. Avulsion of flat portion of a lateral spreading tumor. 1A, Residual flat lesion in center of an EMR defect. 1B, Placement of hot forceps. 1C, Grasping of tissue (1D) lifting (1E) defect shows separation of the grasped tissue in the submucosal resection plane. The submucosal resection plane where the grasped tissue was removed is designated by the *arrow*. 1F, More tissue grasped followed by (1G) lifting or tenting of tissue before cautery and pulling tissue off. 1H, Defect after avulsion of the flat tissue in 4 bites.

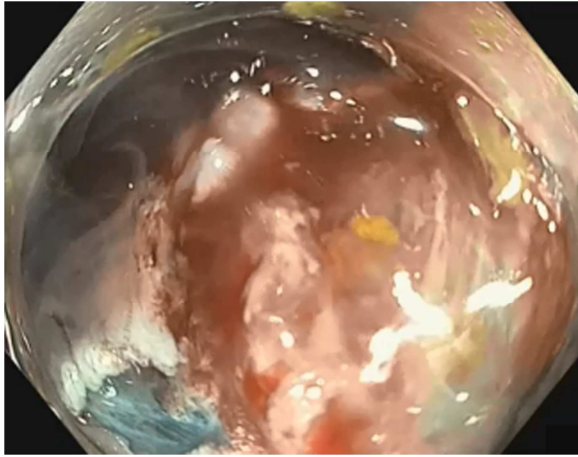
Videos 1-3. Edited videos of hot avulsion of 3 different lateral spreading tumors

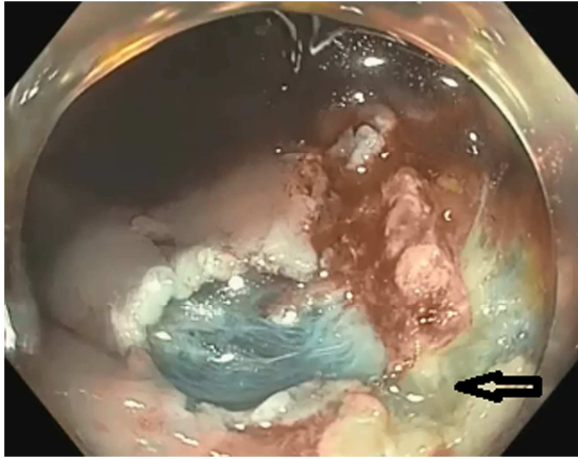


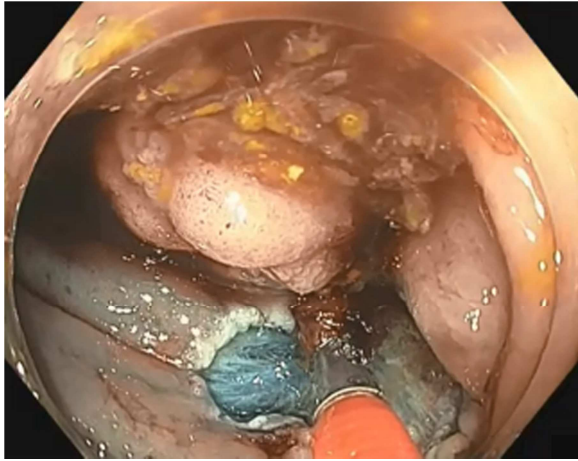


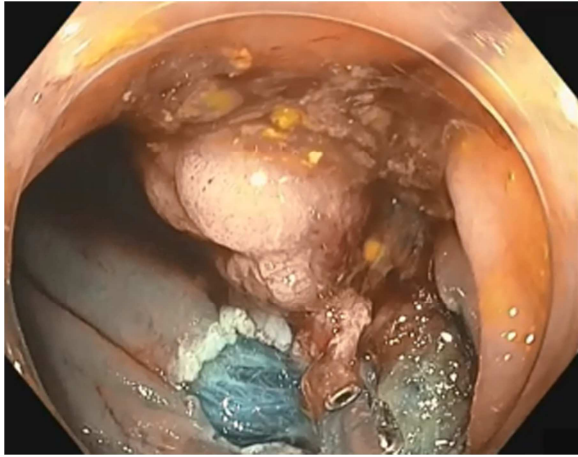


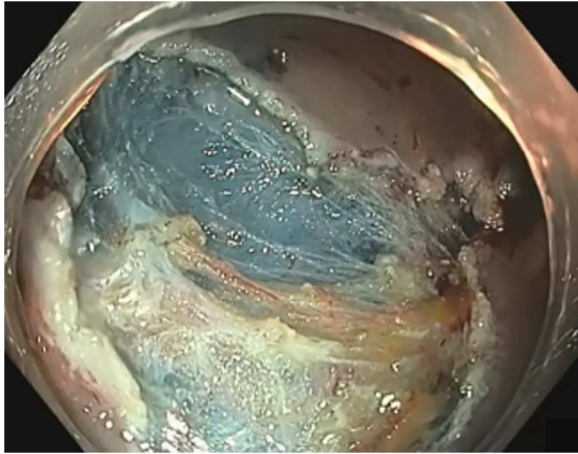














## Acronyms

EMR: endoscopic mucosal resection

LST: laterally spreading tumors

ESD: endoscopic submucosal dissection

APC: argon plasma coagulation

Vs: versus

DKR: Douglas K Rex MD

CA: California

MA: Massachusetts

STSC: snare tip soft coagulation

Mm: millimeters

No: Number