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Colonic Polyps: Treatment

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Abstract

Colonic polyps are considered to be precursors of colon cancer based on several different molecular pathway models and should be resected with a principle of complete excisional biopsy. Several techniques are available for excisional biopsy, ranging from endoscopic techniques such as snare polypectomy, endoscopic mucosal resection (EMR), and endoscopic submucosal dissection (ESD) to surgical colonic resection and colonic endolaparoscopic surgery (CELS). This article focuses on these modalities with contemporary recommendations for choice of modality based on the size and features of the polyp encountered upon endoscopy. In addition, the morphologically apparent risk factors for polyps harboring invasive malignancy are discussed along with implications for management. Current literature on the comparative risks and benefits of EMR, ESD, CELS, and surgical resection is reviewed, as well as recommendations regarding cancer risk and subsequent surveillance.

Keywords

- adenomatous polyp
- endoscopic mucosal resection
- endoscopic submucosal dissection
- laparoscopic colectomy
- colonic endolaparoscopic surgery

"Polyp" is a generic term referring to several neoplastic lesions of the colon, as described in the first article of this issue. Polyps are described as they appear on endoscopy, including degree of pedunculation (growth on a stalk vs. sessile or flat appearance); presence of features of malignancy (friability, ulceration, adherence to underlying layers of tissue, and induration); size; and location. Three morphologic growth patterns are now recognized: polypoid, nonpolypoid, and depressed (representing surface, spreading, and deeply invading patterns of growth in the mucosa, respectively).[1] In 2002, an international group of endoscopists, surgeons, and pathologists published the Paris classification (►**Table 1**), which further categorized these lesions based on their "superficial" morphology and histology to standardize the nomenclature.[2] For practical purposes, however, the most important factors to consider when evaluating these superficial neoplastic colonic lesions are mucosal footprint, suspicion of invasive adenocarcinoma, and growth pattern, as these influence the choice of an appropriate excision modality.

Adequate excisional resection of nonmalignant colonic polypoid lesions is important because more than 95% of colonic malignancies arise from initially benign, premalignant adenomatous polyps or adenomas.[3] Resection of benign-appearing adenomas reduces the incidence of colon cancer by 75 to 90%,[4] and adenoma detection rate on colonoscopy is inversely proportional to the risk of interval colorectal cancer (CRC) in large cross-sectional studies.[5] Polypectomy is therefore a preventative measure for CRC. Polypoid lesions must be removed in their entirety for adequate histologic evaluation, and important risks of polypectomy include bleeding and perforation. The choice of an appropriate technique for resection depends on careful consideration of the risks and benefits.

Risk of Malignancy

Adenomatous polyps with specific features (size $\geq$10 mm, villous appearance, friability, ulceration, adherence, or induration) have a greater chance of harboring an invasive malignancy.[6,7] One study of over 7,000 adenomas removed from

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Table 1 Paris classification of colonic neoplastic lesions

Paris classification	Characteristics	Description
0-Ip	Polypoid	Protruded, pedunculated
0-Is		Protruded, sessile
0-IIa	Nonpolypoid	Superficial, elevated
0-IIb		Flat
0-IIc		Superficial shallow depressed
0-III	Nonpolypoid and excavated	Excavated

4,216 patients demonstrated a correlation between size over 1 cm and a 38.5% chance of advanced pathological features (high-grade dysplasia or invasive carcinoma).[8] Although size is not in itself a contraindication to endoscopic resection, polyps with a non-smooth but textured villous-appearing surface, friability, significant firmness, a central ulcer, or a tactile sensation of underlying deep attachment to the colonic wall, were referred for surgical resection in most studies.[7,9] These features suggest invasive adenocarcinoma that may have progressed into the submucosa, necessitating surgical resection. Villous adenomas have a reported 8.3 to 41% incidence of invasive carcinoma, as compared with an estimated 2.1 to 4.8% for all colorectal adenomas.[6] Some studies also suggest a higher risk of malignancy in endoscopically unresectable polyps distal to the splenic flexure as compared with ascending colon polyps.[10] Laterally spreading tumors (LSTs) are a newer descriptor for nonpolypoid, superficial, early colonic mucosal neoplasms demonstrating a lateral or circumferential growth pattern. First described in Japan using advanced techniques such as high magnification and chromoendoscopy, LSTs may be more difficult to detect because of their low profile. The frequency of LSTs with invasive carcinoma is lower than that of polypoid lesions of a similar size[11]; however, LSTs harboring carcinoma demonstrate a direct correlation between depth of submucosal invasion and rate of lymph node metastasis.[12,13] While LSTs were previously considered endoscopically unresectable, newer techniques have rendered them treatable without surgery as long as there is no suspicion of invasion beyond the submucosa.[14]

Systematic and thorough evaluation of surface lesions using magnified endoscopy and indigo carmine staining techniques (i.e., chromoendoscopy) is a relatively newer development most prevalent in Japan. Magnified colonoscopy can distinguish fine surface characteristics of colonic lesions that can help predict submucosal invasion. In 1 study of 4,445 patients examined with magnified colonoscopy, diagnostic accuracy on lesions larger than 5 mm was 75% for nonneoplastic lesions, 94% for adenomatous polyps, and 85% for invasive carcinoma when compared with their subsequent histologic assessment.[15] A magnifying colonoscopy allows visualization of lesions at up to ×100, as well as performance of regular colonoscopy, using a simple rotation of a knob. The addition of chromoendoscopy, in which a dye such as methylene blue or indigo carmine is applied to the surface, can help increase detection of malignant change in colonic lesions as well.[16] After a suspicious lesion is identified, the mucosa is washed to clear it of any adherent mucus, then sprayed with indigo carmine dye to bring the surface into relief. Detailed observations about the mucosal pattern can then be made which help predict invasive behavior (►**Table 2**).[1] Specific endoscopic features including Paris classification 0-IIa + c (flat or ulcerated), nongranular surface features, and Kudo pit pattern type V (irregular nonstructured pits, ►**Table 2**–[1]) should raise suspicion of submucosal invasion and therefore an increased risk of invasive carcinoma.[17]

When a lesion concerning for invasive carcinoma is encountered on colonoscopy, the area should be tattooed to make subsequent localization of the lesion possible either intraoperatively or during surveillance endoscopy. Tattooing is usually performed with multiple endoscopic submucosal injections of ink (or other dye that will linger for subsequent identification) circumferentially in the vicinity of the pathology. This is especially important for flat lesions, which may be difficult to detect on subsequent endoscopic follow-up or at the time of surgery, and for concerning lesions that are endoscopically resected but may require surgical resection if found to contain invasive carcinoma and the precise location of the lesion would be difficult to identify after endoscopic resection.

Endoscopic Resectability

Resectability is based on the principles of feasibility (whether the polyp can be physically removed in its entirety), efficacy (whether the resection is adequate for histologic/cancer

Table 2 Kudo pit patterns and associated histology

Histology	Description	Pit pattern	Treatment selection
Nonneoplastic	Normal mucosa (normal round crypts, regular)	I	No treatment
	HP lesion (enlarged stellar crypts, regular)	II	
Neoplastic, adenomatous	Neoplastic lesion (elongated, sinuous crests)	IIIL	Endoscopic resection
	Neoplastic lesion (narrowed round pits, irregular)	IIIS	
	Neoplastic lesion (branched or gyrus-like crests)	IV	
Neoplastic, cancer	Malignant lesion (irregular surface)	Vi	Endoscopic resection
	Malignant lesion (amorphous surface)	VN	Surgery

prevention purposes), and safety (whether the procedure carries significant risk to the patient). Pedunculated polyps, even when very large and filling the entire lumen, are usually good targets for endoscopic resection. For sessile polyps, the technical feasibility of endoscopic resection is highly operator dependent. Most guidelines recommend that endoscopic removal of large, sessile polyps be performed only by "experienced" endoscopists, although specific qualifications are not outlined.[18,19] Polyps that pose specific technical challenges include sessile polyps with a wide base (typically described as having a total base diameter over 3 cm, greater than one-third of the circumference of the colon wall, and/or crossing two haustral folds), and those located close to the appendiceal orifice.[20] These parameters are theoretically associated with an increased risk of thermal injury to the serosa and/or perforation, as well as bleeding. In addition, the ability of the endoscopist to circumscribe the polyp and remove it in its entirety may be compromised in the setting of these features. Newer techniques, including endoscopic mucosal resection (EMR) and endoscopic submucosal dissection (ESD), have allowed endoscopists to push the envelope of technical resectability.

Endoscopic Techniques

Cold and Hot Forceps Biopsy

For small (1–3 mm) lesions, biopsy with "cold" forceps (without cautery) is the standard endoscopic removal technique. A pair of forceps is used to grasp and pull the polyp tissue away from the mucosa, and the area is then closely inspected with additional residual fragments being taken in the same manner to ensure a full resection. Cold biopsy is easy to perform, does not require complex instrumentation, and carries low risk for perforation or significant bleeding. Larger polyps (7–8 mm) may require the application of electrocautery for cutting ("hot"). Electrocautery entails the application of a current to cut through tissue, where the current may either ground through the patient (monopolar) or in a circuit between conducting tips of an instrument (bipolar). The risks of perforation are increased with removal of larger polyps using cautery, and cautery may disrupt the histological margin. However, the ability of cautery to prevent or control bleeding when resecting larger lesions is a major benefit. The most basic application of electrocautery is in the use of hot forceps biopsy, where current is applied to the biopsy forceps to assist in removing the polyp specimen. Several other endoscopic devices are also available for use with electrocautery, including cautery needle-tip "knives" and snares. The use of cold versus hot forceps has not been studied in a randomized, controlled fashion and therefore is primarily based on user comfort and preference.

Snare Polypectomy

Snare polypectomy is the traditional method of endoscopic polypectomy for larger lesions and is most appropriate for pedunculated polyps. Snare polypectomy entails the use of a wire loop to encircle the base of the polyp and divide the polyp stalk either mechanically (cold) or hot with electrocautery. Cold is usually reserved for smaller polyps, while hot is used for larger lesions or those with a greater propensity to bleed at or after the polypectomy. The endoscopist must be careful to avoid snaring a fold or deeper layers (causing transmural injury). Snared pedunculated specimens are delivered en bloc, and typically afford proper histological margins. As with all techniques, bleeding is a potential complication, and perforation is of higher risk the larger the lesion and when cautery is utilized.

Endoscopic Mucosal Resection

EMR is an adaptation of the snare technique for endoscopic resection of larger sessile polyps, sometimes in a piecemeal fashion. Using a combination of saline "lift" techniques and piecemeal specimen shaving, endoscopists can resect "giant" polyps larger than 3 cm. Saline is first injected endoscopically in the submucosa at the base of the polyp to separate the submucosa from the muscularis propria, and then a wire loop is used to slowly shave the polyp tissue away from the surrounding mucosa, using bursts of electrocautery as the snare is slowly closed (►**Fig. 1**). Some polyps might require multiple endoscopic sessions at 3- to 4-week intervals for complete resection. One earlier study of snare polypectomy in 176 benign-appearing "giant" (3–8 cm) polyps recorded 48% of sessile polypectomies requiring at least one repeat session for complete resection to grossly normal mucosa, while 96% of pedunculated polyps, regardless of size, were resected in a single session.[21] Newer studies, using indigo carmine dyed injections to lift and visualize the submucosal layer, achieve up to 89% complete removal in a single session.[17]

Following successful complete resection of the polyp, patients are required to have close endoscopic surveillance with follow-up colonoscopies every 3 months over the first year, depending on the final histologic diagnosis. Surveillance is intended to monitor for recurrence at the resection site, which is suggestive of incomplete resection with microscopic disease remaining. Some recent studies of large (>2 cm) and giant (>4 cm) sessile colonic polyps resected in a piecemeal fashion demonstrated that argon plasma coagulation (APC) applied to the resected polyp base and edges was useful and safe as an ablative adjunct for achieving complete resection with recurrence rates ranging from 9.2 to 21.9%, with the main risk being bleeding occurring in 12 to 13.5%.[18,22–24] APC treatment of the resection margins was subsequently demonstrated in a small randomized study to decrease the risk of recurrence.[25] Perforation is a rarer occurrence, reported at 0 to 1.3%.[26]

EMR has also made the endoscopic resection of LSTs feasible, usually in a piecemeal fashion. Because piecemeal resection does not provide as high a quality specimen for histology, it is not useful if submucosal invasion is suspected. Uraoka and colleagues evaluated 511 colorectal LSTs resected via EMR with magnified colonoscopy, using eight prospectively collected criteria (size >2 cm, large nodule, surface redness, demarcated depressed area, sclerous wall change, fold convergency, chicken skin mucosa, and pit pattern).[14] They found that LSTs with nongranular surface characteristics had a 14% (vs. 7% in LSTs with granular surface characteristics) risk of submucosal invasion.[9] An important conclusion from this work is that larger LSTs with concerning surface characteristics should be removed using a technique that allows for en bloc rather than piecemeal resection, either using ESD or

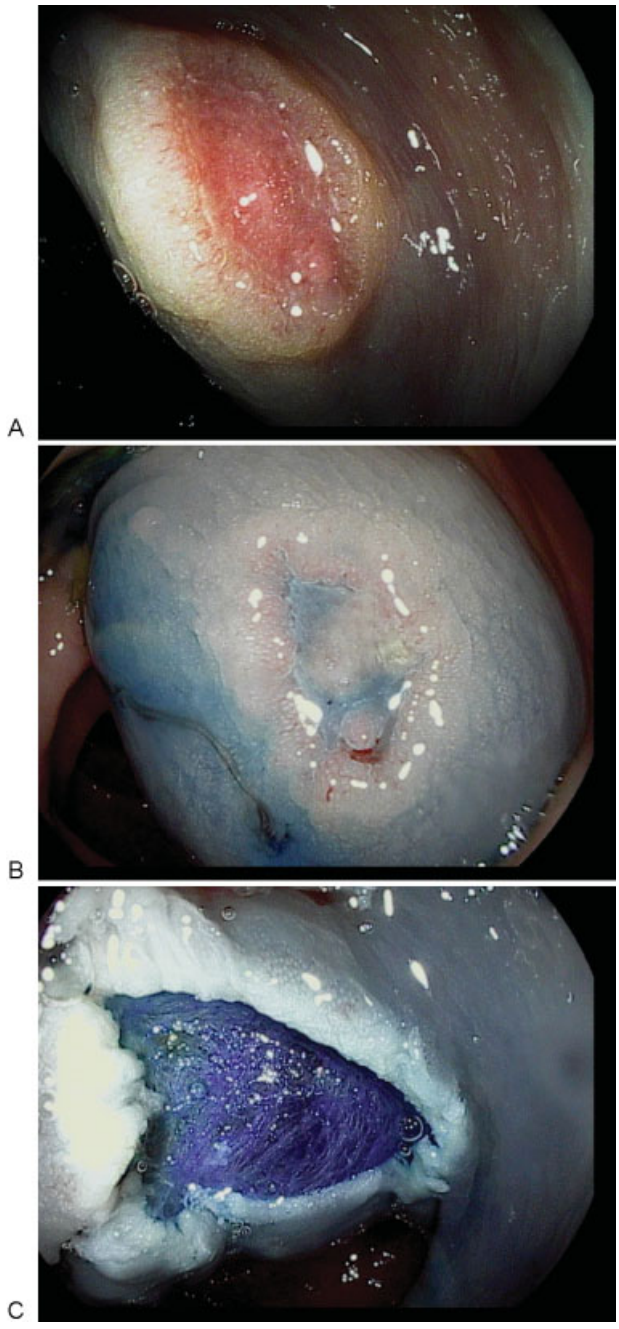

Fig. 1 **(A)** A sessile, centrally ulcerated lesion with features suggestive of intramucosal adenocarcinoma, **(B)** after "lifting" with submucosal indigo carmine dye and saline injection, and **(C)** after endoscopic mucosal resection. The submucosa is visible and intact. (Photo courtesy of Jeffery Lee, MD, assistant professor, Gastroenterology, UCSF.)

surgical resection. This is particularly important in light of data demonstrating that incomplete EMR is a risk factor for accelerated growth of residual cancer and for distant metastasis.[27,28]

Endoscopic Submucosal Dissection

ESD is a widely accepted minimally invasive treatment for gastric cancer (particularly in Japan), but has only recently been adopted for use in the colon due to the technical difficulty of maneuvering within a longer and narrower lumen with thin walls.[29] Because of these anatomical properties, the risk of perforation during ESD in the colon is higher. ESD is performed with a special endoscopic dissection knife (frequently either monopolar or bipolar cautery; these may be needle-tipped, flat-tipped, or ball-tipped to achieve optimal dissection and hemostasis). The submucosa under the lesion is injected with a solution to lift the lesion from the underlying tissue, a circumferential incision is made around the lesion in the mucosa, and the dissection is carefully carried along beneath the lesion to remove it in one piece. After ESD, the muscularis propria layer should be visible in the resultant resection bed.

This technique is still limited to specialized centers and mainly practiced in Japan. The main advantage of ESD over EMR is the ability to remove lesions en bloc, allowing for optimal histological evaluation. This is particularly important in cases where there is a concern for invasive adenocarcinoma with possible submucosal infiltration in the lesion. ESD is usually practiced in concert with magnified colonoscopy to examine the surface characteristics of the lesion (see Paris classification and Kudo pit pattern, ►**Tables 1** and **2**). These characteristics can help the endoscopist to make a determination that the lesion does not likely contain deep submucosal invasion and is therefore safe for excision via ESD. Key indications for ESD are (1) large lesion over 20 mm in diameter, (2) nongranular-type LST, (3) lesions with Kudo pit pattern type V, (4) suspected invasive adenocarcinoma with submucosal infiltration of less than 1,000 µm, (5) lesions with fibrosis where there are signs of nonlifting, (6) residual superficial cancer after EMR, and (7) sporadic tumors in a background of chronic inflammation (e.g., as in ulcerative colitis).[29,30]

Several single-center, retrospective studies have examined the efficacy and safety of ESD, again mainly in Japan. Most notably, the group at National Cancer Center Hospital has published outcomes in ESD based on their experience in the early 2000s, as well as prospective data collected from multiple centers in Japan. The initial case series of 200 lesions treated via ESD in 198 patients reported an en bloc resection rate of 84% and curative resection rate of 83%, with a median operation time of 90 minutes and mean resected specimen size of 38 mm. Complications included perforation in ten cases (5%) and bleeding in four cases (2%). One of the perforations required surgery, while the others were controlled endoscopically.[31] When these same authors compared ESD with EMR at their institution in a retrospective case-controlled study, ESD was found to be associated with a longer procedure time (108 ± 71 vs. 29 ± 25 minutes), higher en bloc resection rate (84 vs. 33%), and larger resected specimens (37 ± 14 vs. 28 ± 8 mm), while cancer rates in resected specimens were comparable (69 vs. 66%).[32] ESD also had a higher rate of perforation (6.2%, 9/145 vs. 1.3%, 3/228). A prospective multicenter study in Japan that included 1,111 lesions resected via ESD found similar results; the en bloc and curative resection rates were 88 and 89%, respectively. The bleeding rate was 1.7%. Perforations occurred in 54 cases (4.9%) and were subdivided into immediate perforations (ineffective endoscopic clipping) and delayed perforations (four cases); two of the immediate perforations and three of the delayed perforations required emergency surgery.[33]

The higher rate of perforation for ESD as compared with EMR is worrisome, and reducing perforation rates with ESD is a worthwhile endeavor, because perforation can mean an extended hospitalization, peritonitis, and emergency surgery with all its attendant risks, significantly altering the patient's course compared with if surgical resection had been performed electively in the first place. Efforts to improve technology as well as techniques for ESD focus on minimizing this risk. For example, a hemostatic coagulating forceps introduced for thick submucosal vessels was shown in a case-controlled study of 250 ESD procedures to reduce perforation rates (2.3 vs. 9.6% in the control group) without changing bleeding rate.[34]

Undeveloped technical expertise is likely the main factor that has yet prevented the West from adopting ESD as a standardized technique. In a review examining 22 studies on ESD from around the world, two from Europe had substantially lower rates of R0 resection when compared with studies from Asia (65 vs. 88%).[35] The review published a relatively low overall rate of perforation (1% requiring surgery), but this meta-analysis included procedures performed on rectal polyps (which has different anatomic considerations and risks from ESD of colonic polyps), and did not comment on perforations not requiring surgery but costing the patient a hospitalization and antibiotics, at a minimum. A smaller study of 42 ESDs from Britain reported a curative resection rate of 74% and similar bleeding/perforation risks to other studies.[36] These data corroborate data from Japan that experienced endoscopists, frequently ones who had previously been trained in gastric ESD, have better results.[37]

More recently, the learning curve for ESD was studied in a European center for endoscopy. Among 82 ESDs performed for lesions mostly in the rectum (82%), the rate of en bloc resection rose from 60 to 96.2%, the rate of R0 resection rose from 48 to 85%, and the procedure time decreased from 200 to 136 minutes, over three consecutive study blocs spanning 2 years.[38] This suggested a steep learning curve and suggests the feasibility of ESD outside of Japan. It is important to note, however, that most of the resected lesions were from the rectum, which represents a lower risk for perforation due to its anatomic location. In fact, rectal lesions might serve as good early targets for honing the skills necessary for ESD in the colon, where the stakes are higher.

Surveillance after Endoscopic Resections

After EMR, most studies recommend surveillance via colonoscopy every 3 months up to a year, and then annually.[17,18,21,23] Surveillance is designed to provide an opportunity for visual inspection of the resection site at multiple separate points in time to detect residual tumor (which has a high regrowth rate) or recurrence.[39] After ESD, most studies followed up with examination by colonoscopy in 6 months, unless the resection was incomplete on histology (in which case follow-up colonoscopy occurred earlier at 3 months) or demonstrated invasive adenocarcinoma that did not meet curative criteria for local resection (in which case patients were referred for surgical resection).[31] Theoretically, ESD should provide more complete histological information for decision making, and therefore translate into earlier transition to longer surveillance intervals.

Criteria for Surgical Resection following Endoscopy

A segmental or more extended colectomy, including an adequate mesenteric resection to include all lymph nodes in the drainage basin of these lesions, is necessary when a colonic lesion is endoscopically unresectable; has demonstrated invasiveness beyond very superficial on pathology (i.e., positive margin); or there is a high suspicion of malignant potential based on suspicious features such as induration, ulceration, friability, or nonlifting. The incidence of invasive malignancy in endoscopically resected large polyps, greater than 2 cm, is reported at between 10 and 57%[14] and the incidence of invasive malignancy in endoscopically unresectable lesions is 16 to 43% at the time of surgical pathology.[14,40–42] In addition, submucosal invasion correlates directly with lymph node metastasis in adenomatous lesions.[8] It is estimated that approximately 10% of submucosally invasive cancers have metastasized to lymph nodes.[43]

In fact, for endoscopically resected lesions containing adenocarcinoma, submucosal invasion is the key criterion in determining the need for surgical resection. The Haggitt and three-layer submucosal (Sm) classifications are useful schema for guiding decisions about appropriate treatment of excised polyps containing focal invasive adenocarcinoma. The Haggitt classification divides submucosal invasion in pedunculated polyps into four levels, while for sessile or flat lesions, the submucosa can be divided into three levels: sm1, sm2, and sm3 (►**Tables 3** and **4**; ►**Figs. 2** and **3**). Haggitt Level 1 extends to the head of the polyp only, Level 2 extends to the neck, Level 3 extends to the stalk, and Level 4 invades below the stalk but remains above the muscularis propria (from most to least superficial). Sm1 is further divided into sm1-a, -b, and -c, in increasing order of horizontal involvement within the lesion; sm1-a refers to less than 25% of the total lesion involved, sm1-b refers to 25 to 50% involvement, and sm1-c refers to more than 50%. While endoscopic resection for up to Haggitt type 3 and sm1-a + b lesions is considered adequate, Haggitt type 4 and sm1-c and deeper lesions have a significantly increased risk of metastasis to lymph nodes.[44] For this reason, it is recommended that patients who are found to have a focus of invasive adenocarcinoma classified as Haggitt type 4 or sm1-c or deeper undergo surgical resection of the colon for appropriate regional lymphadenectomy.

Table 3 Haggitt classification schema for focal invasive adenocarcinoma in a pedunculated polyp

Haggitt level	Description
0	Carcinoma in situ or intramucosal carcinoma
1	Carcinoma invading into the submucosa, but involving only the head of the polyp
2	Carcinoma invading the neck of the polyp
3	Carcinoma invading the stalk of the polyp
4	Carcinoma invading the submucosa below the stalk of the polyp

Table 4 Submucosal division schema for focal invasive adenocarcinoma in a sessile or flat adenomatous lesion

Sm level	Description
Sm1-a	Carcinoma invading the top third of the submucosa, with horizontal spread to <25% of the total lesion
Sm1-b	Carcinoma invading the top third of the submucosa, with horizontal spread to 25–50% of the total lesion
Sm1-c	Carcinoma invading the top third of the submucosa, with horizontal spread to >50% of the total lesion
Sm2	Carcinoma invading the middle third of the submucosa
Sm3	Carcinoma invading the deepest third of the submucosa

Surgical Options

Laparoscopic Colectomy

While open colectomy is certainly acceptable for resection of endoscopically unresectable polyps (or those with concerning features as outlined), at least short-term outcomes are better when the patient can undergo laparoscopic colectomy. The authors acknowledge that not all patients are candidates for laparoscopy (e.g., severe comorbidities and extensive adhesions). While endoscopic resection of colonic neoplastic lesions carries risks of bleeding, perforation, residual tumor, and anesthesia, surgical resection carries a burden of hospitalization, pain, anesthesia, and setbacks in nutritional status. In addition, potential complications include bleeding, damage to surrounding structures (bowel, ureters, vessels), the potential conversion from laparoscopic to open resection with attendant morbidity, inadequate margins, minor postoperative complications (wound infection, urinary tract infection, deep-vein thrombosis), anastomotic leak, sepsis, and even death.[14,42,45] Large randomized controlled trials (notably the Clinical Outcomes of Surgical Therapy Study Group [COST] in North America and the UK Medical Research Council trial of Conventional versus Laparoscopic-Assisted Surgery in Colorectal Cancer [MRC CLASICC]) have investigated the safety and efficacy of laparoscopic colectomy in comparison to open colectomy for patients with colon cancer, given the theoretical risk of inadequate oncologic resection with laparoscopic techniques. Both the COST and CLASICC trials monitored data on oncologic outcomes including resection margins (circumferential and longitudinal), lymph node yield, cancer recurrence, and disease-free survival and demonstrated no significant difference in oncologic outcomes between the two surgical approaches. In the modern era, therefore, laparoscopic resection is deemed equivalent to open resection for oncologic outcomes in colon cancer.[45–47] Laparoscopy carries the benefit of faster postoperative recovery as evidenced by

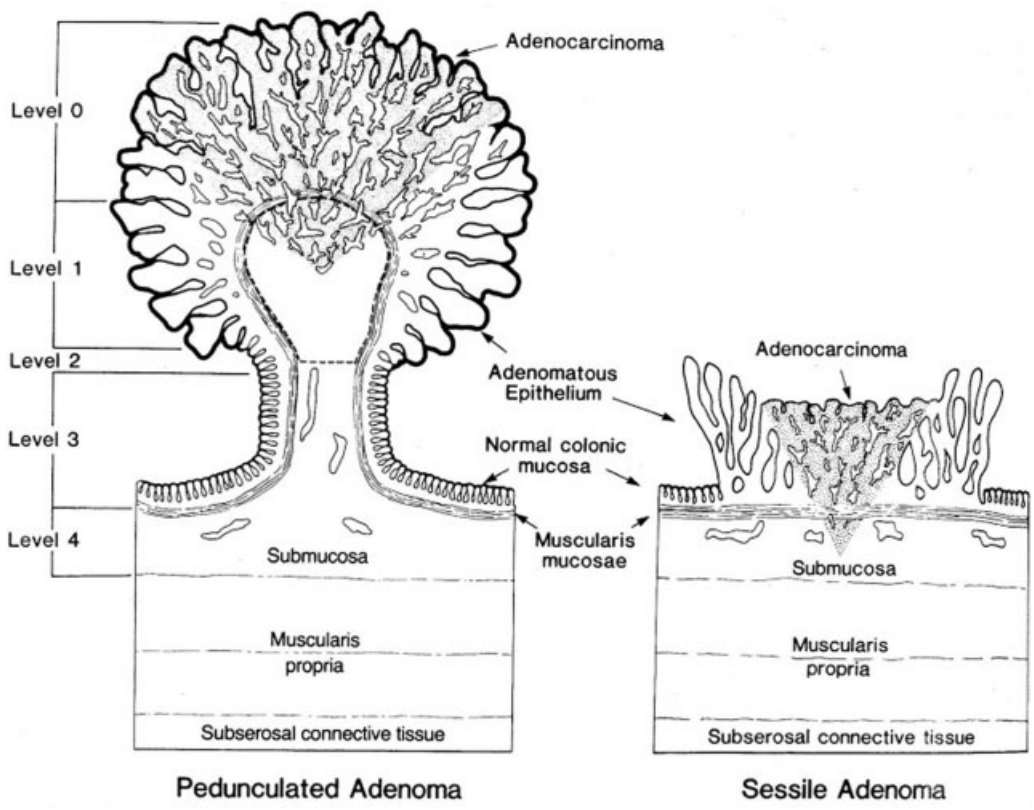

Fig. 2 Haggit's morphologic classification according to the depth of invasion in a polyp. (Adapted with permission from Nivatvongs S. Surgical management of malignant colorectal polyps [Review]. Surg Clin North Am 2002;82(5):959–966.)

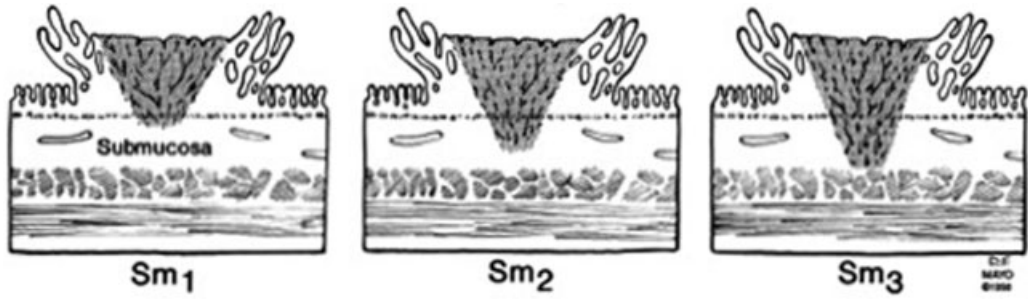

Fig. 3 Kudo's classification of submucosal invasion of sessile lesions into three levels. (Adapted with permission from Nivatvongs S. Surgical management of malignant colorectal polyps [Review]. Surg Clin North Am. 2002 Oct;82(5):959–66.)

shorter postoperative hospital stay (5 vs. 6 days) and shorter duration of postoperative parenteral narcotic use (3 vs. 4 days), while rates of complications, both intraoperative and postoperative, are not significantly different between the two approaches (21 vs. 20% overall).[47]

Outcomes for laparoscopic colectomy have been further improved by the new movement toward enhanced postoperative recovery methods.[48] These perioperative pathways use several evidence-based interventions to improve outcomes after colorectal surgery, and some studies have demonstrated postoperative hospital stays of as short as 2 to 3 days using an enhanced postoperative protocol, as well as significant reduction in rates of complications.[49,50] The enhanced recovery paradigm discourages use of mechanical bowel preparation; encourages preoperative oral carbohydrate treatment; encourages nonopioid analgesic adjuncts; and provides evidence of the benefits of early mobilization, intraoperative normothermia, and tight postoperative glucose control, among others.[48] When comparing postoperative outcomes in 953 patients before and after implementation of an enhanced pathway with close adherence in one study, overall postoperative complications were reduced (odds ratio [OR]: 0.73) and symptoms (OR: 0.53) significantly improved.[51] Specifically, restriction of intravenous fluid and use of preoperative carbohydrate drink were found to be major independent predictors of improved outcomes.

Combined Endoscopic–Laparoscopic (Endolaparoscopic) Surgery

Combined endolaparoscopic surgery (CELS) is a newer modality that may be useful for the resection of suspected benign polyps that are complex or located in anatomically challenging locations. In this technique, which requires both surgeon and endoscopist, the abdomen is insufflated while colonoscopy is performed under direct laparoscopic vision, with the ability to manipulate the colon extrinsically using laparoscopic instruments. Laparoscopic assistance can help provide retraction for additional exposure in situations where endoscopic manipulation becomes difficult due to severe angulation or folds (►**Fig. 4**) or when the risk of perforation may be higher due to thin bowel wall (e.g., the right colon). The polyp is removed endoscopically through any of the means discussed earlier, and any real or potential full-thickness defects are then repaired laparoscopically, if needed, without having to resect the bowel. Consideration of frozen section analysis of the resected polyp should be entertained in the event that an immediate conversion to resection would be possible. The patients should be consented for resection at the time of informed consent for CELS, as well as be aware of the potential that future resection may be needed should concerning pathology be found on final pathology after CELS. For those with favorable pathology, by avoiding a surgical resection, CELS removes some of the risks of colonic surgery, including anastomotic leak (although repair-site leaks can occur) and damage to surrounding organs due to surgical dissection. This "bowel sparing" procedure may also be of benefit in situations where the alternative is a significant colonic resection, such as an endoscopically unresectable transverse colon polyp that is synchronous with a rectosigmoid cancer.

Recent studies have examined the safety and feasibility of CELS and borne out this advantage. In most retrospective reviews of prospectively collected data, successful excision rates of 58 to 100% are demonstrated, with a less than 5% conversion rate.[52–54] Patients converted to colectomy were typically due to concern for cancer or technical difficulty. Length of hospital stay is typically shorter than that for

Fig. 4 A sessile polyp overlying a haustral fold. Such lesions can be difficult to remove endoscopically, and entail a higher risk of perforation. (Photo courtesy of Jeffery Lee, MD, assistant professor, Gastroenterology, UCSF.)

laparoscopic colectomy (reported as 0–7 days, with a tendency toward shorter length of stay [mean: 1–1.5 days] in studies reporting > 20 cases). Recurrence rates are low, ranging from 0 to 10%, and in most cases, patients can undergo repeat CELS to remove residual or recurrent polypoid tissue. In concert with the previously described improved techniques for detecting malignancy risk, the conclusion is that CELS may save some patients from undertaking the risk of surgical colectomy for benign colonic neoplastic lesions that are too difficult to remove endoscopically. When balancing all of the risks and benefits of an endoscopic resection, particularly for a large, traditionally "unresectable" mucosal lesion with its attendant risks of harboring invasive malignancy, the decision should still include consideration of surgical resection, as laparoscopic colectomy is widely accepted and formal colectomy is oncologically superior to local resection. As CELS continues to undergo improvements in technique, for example, the recent adoption of CO_2 rather than room air colonoscopic insufflation to prevent prolonged colonic distention from impeding laparoscopic visualization and manipulation, it will likely develop into a valuable tool for resection of colonic neoplasms.[54]

Conclusion

Colonic neoplastic lesions should be excised in their entirety when encountered on colonoscopy, due to their prospect of containing malignancy or devolving into malignant lesions. Several endoscopic techniques are available for excision, and the choice of a technique should be based on feasibility, efficacy, and safety. Feasibility depends on the available expertise and equipment. While snare polypectomy is widely performed, only experienced endoscopists in the United States perform EMR, and ESD is mainly practiced in Asia. The learning curve for the more complex procedures such as ESD is likely in the range of a 100 procedures. Efficacy, or the ability to completely excise the lesion without residual disease while obtaining an adequate specimen for histologic evaluation, depends on the characteristics of the lesion, and in turn the probability that the lesion invades more deeply than the mucosa. The ability to assess invasion endoscopically is rapidly evolving including techniques for staining tissue and advanced endoscopy using magnification or light filters, and has resulted in the development of useful classification schema for predicting risk of invasive malignancy, such as the Paris classification and Kudo pit patterns. Safety for endoscopic procedures is mainly related to the risks of perforation (an acceptable rate of between 1 and 2% in most studies) and bleeding (rate between 10 and 20%). With CELS, endoscopists and surgeons are pushing the boundaries of endoscopic resectability to minimize bowel resections for patients with lesions in which there is a low suspicion for invasive malignancy. The principles of oncologic resection should be applied to any patients with lesions that appear to harbor invasive malignancy beyond the most superficial submucosa. As in any treatment decision, individual patient risk factors should also be taken into account when balancing the risks and benefits of each resection approach.

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