Flat Serrated Polyps at CT Colonography: Relevance, Appearance, and Optimizing Interpretation

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Abbreviations: SSP = sessile serrated polyp, 3D = three-dimensional, TSA = traditional serrated adenoma, 2D = two-dimensional

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

■ Describe the types of serrated polyps and their typical clinical presentations.
■ Undertake the interpretative steps to optimize detection and characterization of SSPs.
■ Avoid common interpretative pitfalls associated with serrated polyps.

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Serrated polyps are a recently recognized family of colonic polyps with subgroups that harbor future malignant potential. In the past, the significance of these lesions to the colorectal cancer carcinogenesis pathway was not recognized nor well understood. It is now known that serrated polyps account for approximately one-fourth of all sporadic colorectal cancers. The sessile serrated polyp (SSP) (also known as a sessile serrated adenoma [SSA]) is the main lesion of interest given its prevalence and subtle presentation. These lesions are often flat—only minimally raised from the colonic surface—and occur in the right colon. These lesions have been a likely common cause of screening failure at colonoscopy, although detection has improved with improved recognition over time. Although detection is difficult with image-based screening, serrated lesions can be detected at CT colonography. The prevalence in CT colonography screening populations mirrors the rates at colonoscopy for similar size categories. CT colonography allows identification of SSPs despite their minimally raised profile owing to the phenomenon of lesion contrast material coating. This contrast material coat aids in lesion detection by highlighting the subtle morphologic changes as well as increasing confidence that a true lesion exists despite a flat morphology. It is important to optimize contrast material coating with specific bowel preparations and other technical parameters. Radiologists should be aware of these technical and interpretation issues. Armed with this knowledge, radiologists should expect excellent results in detection of these subtle but important lesions.

Introduction

Serrated polyps are a recently recognized colorectal cancer precursor, distinct from colorectal adenomas. They represent a minor but significant pathway to cancer, and their removal (as in the case of adenomas) can disrupt this process. Historically, serrated polyps have largely been misrecognized as a benign hyperplastic polyp, presumably with no future malignant potential. Coupled with an often subtle presentation, these lesions have likely been a major source of screening failures, with development of interval cancers despite prior structural colonic screening.

This review examines the current conceptual understanding of these lesions and their place in colorectal carcinogenesis. The typical clinical presentation of serrated polyps at colonoscopy and the implications for computed tomographic (CT) colonography are reviewed. The actual experience detecting these lesions at CT colonography in a large-scale university screening program is reported. Practical tips on optimizing detection at CT colonography and potential pitfalls that may hamper interpretation are highlighted.
Colorectal Carcinogenesis and the Serrated Polyp

The pathobiology of colorectal cancer is well suited for screening, which can disrupt the pathway to cancer (Fig 1). There is a benign precursor polyp that is present in the colon for many years before possible transformation to cancer, thus allowing a wide temporal window in which this lesion can be identified with screening and a potential future cancer removed.

Classically, it had been thought that all precursor polyps were histologically of adenomatous origin (including tubular adenomas, tubulovillous adenomas, and villous adenomas) (2,3). Under this classic paradigm, only adenomas had the capacity to undergo genetic transformation to cancer, whereas other histologic polyp types such as hyperplastic polyps and mucosal polyps could not. Although most adenomas never transform to cancer, a small number of these lesions continue to grow over many years with stepwise progression of mutational changes to various genes including APC, KRAS, and p53, ultimately leading to cancer development (4).

Serrated polyps represent a family of serrated polyps (SSPs) (also known as sessile serrated adenomas [SSAs]) as an entity that was discretely separate from hyperplastic polyps was argued (5). There is now widespread consensus that serrated polyps represent a second minor pathway to cancer, likely accounting for 25% of sporadic nonfamilial colorectal cancers (6). There is an ever-increasing understanding of the genetic underpinnings of this neoplastic pathway. Serrated polyps represent a family of serrated subtypes that includes the long-recognized hyperplastic polyp, as well as other subtypes not previously recognized as a discrete lesion with future malignant potential or as part of this family. The family of serrated polyps includes three major polyp subtypes (7) (Table 1).

The hyperplastic polyp constitutes the majority of serrated polyps, accounting for over 70% of all serrated polyps (8). Histologically, it demonstrates a serrated epithelium without cytologic dysplasia. In other words, there is a sawtooth infolding of the crypt epithelium. As long thought, hyperplastic polyps are benign without future malignant potential. They are typically small subcentimeter lesions in a left-sided location. In one colonoscopic series, over 85% were less than 5 mm in size and over 70% were distal in location (8). They manifest with a variety of morphologies including sessile, flat, and pedunculated, although a flatter nature is most common. At both colonoscopy and CT colonography, they appear as a pliable sofer lesion that flattens with colonic distention (9,10).

The second major serrated polyp subtype is the SSP or SSA. This polyp is the main lesion in the serrated polyp family with malignant potential. Its existence was previously unknown, mistaken for a hyperplastic polyp. SSPs constitute over 20% of serrated lesions (8). There are subtle differences in the architecture of the crypt bases, with...
of adenomas and more in line with lesions of a hyperplastic lineage. Currently, there is debate over which is the preferred term.

The final polyp subtype is the traditional serrated adenoma (TSA). It has long been recognized as a rare discrete lesion with some future malignant potential (12). TSAs constitute a minority of serrated lesions; when all polyps are considered, they comprise less than 1% of colorectal polyps (8,13). As opposed to the difficulty in distinguishing between the SSP and hyperplastic polyp, the TSA is histologically distinct. Hypereosinophilic cells lining villiform projections are typical of these lesions, as well as an

SSPs having elongated or boot-shaped crypts that distinguish them from hyperplastic polyps (11). Often, there is no cytopathic dysplasia, which originally led to their misidentification as hyperplastic polyps without malignant potential. Dysplasia is infrequently seen in SSPs. As with hyperplastic polyps, SSPs exhibit a sawtooth epithelium.

**Sessile serrated polyp (SSP)** is perhaps the better term over the other term in common use for this lesion ([*sessile serrated adenoma (SSA)*]), as the moniker “adenoma” suggests that this lesion resides in the major adenoma-carcinoma pathway, which it does not. The histologic and genetic classification of this lesion is different from that of adenomas and more in line with lesions of a hyperplastic lineage. Currently, there is debate over which is the preferred term.

The final polyp subtype is the traditional serrated adenoma (TSA). It has long been recognized as a rare discrete lesion with some future malignant potential (12). TSAs constitute a minority of serrated lesions; when all polyps are considered, they comprise less than 1% of colorectal polyps (8,13). As opposed to the difficulty in distinguishing between the SSP and hyperplastic polyp, the TSA is histologically distinct. Hypereosinophilic cells lining villiform projections are typical of these lesions, as well as an

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Table 1: Serrated Polyp Family

<table>
<thead>
<tr>
<th>Serrated Polyp Subtype</th>
<th>Size*</th>
<th>Location</th>
<th>Morphology</th>
<th>Percentage of Serrated Polyps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperplastic polyp</td>
<td>Small or diminutive</td>
<td>Left colon</td>
<td>Flat</td>
<td>&gt;70%</td>
</tr>
<tr>
<td>Sessile serrated polyp (SSP)</td>
<td>Small to large</td>
<td>Right colon</td>
<td>Flat</td>
<td>&gt;20%</td>
</tr>
<tr>
<td>Traditional serrated adenoma (TSA)</td>
<td>Small to large</td>
<td>Entire colon</td>
<td>Sessile; when very large, mass with frond-like projections</td>
<td>Rare</td>
</tr>
</tbody>
</table>

Note.—Characteristics reflect typical presentations. For example, hyperplastic polyps are typically smaller and left sided but infrequently occur as large (>10 mm) cecal lesions.

*Diminutive = ≤5 mm, small = 6–9 mm, large = ≥10 mm.
element of cytologic dysplasia. A defining characteristic is the presence of ectopic crypt formation, with loss of attachment to the muscularis mucosa (14). These lesions tend to be morphologically more protuberant, often pedunculated.

The carcinogenesis pathway for serrated lesions with malignant potential (ie, SSPs and TSAs) is characterized by mutations in BRAF for SSPs and in BRAF or KRAS for TSAs. There are subsequent changes in the cell-signaling RAS-RAF-MEK pathway and adaptive changes in the cell to induce cell senescence (and early cell death). Multiple epigenetic methylation events occur to silence various genes, including DNA mismatch repair genes such as MLH1, MSH, and MLH2 for SSPs.

These events typically lead to “microsatellite instability high” (MSI-H) cancers. Microsatellite-stable lesions can result for SSPs with affected genes such as MGMT. TSAs are microsatellite stable (6,15). In contrast, cancers mediated through adenomas and the traditional major pathway do not demonstrate microsatellite instability (MSI) but demonstrate chromosomal instability, where portions of the chromosome are duplicated or deleted.

The time course of transformation from benign serrated lesion to cancer is unknown but is thought to be extended over many years, possibly longer than that of the adenoma-carcinoma sequence. This is supported by the statistic where the mean age of patients harboring SSPs is approximately 15 years less than the mean age of patients with MSI cancers (16).

**Clinical Presentation of the SSP**

Among serrated polyps, the main lesion of interest is the SSP, given its prevalence, malignant potential, and subtle presentation. TSAs also hold some malignant potential but are rare in prevalence and are generally easy to detect when present due to their often more polyoid or pedunculated morphology (17). Information regarding the presentation of SSPs at colonoscopy has rapidly accumulated in recent years once there was widespread consensus regarding the existence and significance of these lesions.

Gastroenterologists now realize that they had previously been missing these often flat lesions. SSPs were likely the source of various disquieting observations, such as the lack of protective effect of colonoscopy for right-sided cancers or for the development of presumably “fast” interval cancers despite adequate structural screening with colonoscopy (18). The presentation of SSPs at colonoscopy is now well established and holds implications for CT colonography detection of these important lesions.

SSPs are typically flat in morphology. Although they can protrude into the lumen for a more sessile (ie, dome-shaped) or pedunculated appearance, they are often only minimally raised from the colonic mucosal surface (Fig 2). At colonoscopy, there are only minor color and textural differences in the visual appearance between the polyp and adjacent normal mucosa, which can make detection of these lesions very difficult. Use of advanced techniques such as chromoendoscopy may improve detection to highlight these visual differences (19), whereas narrow band imaging techniques may not be helpful (20). Ultimately, knowledge of lesion appearance and increased scrutiny have helped in improving detection (21).

Besides a flat nature, SSPs tend to be larger lesions, often greater than 10 mm in size. They are located primarily in the proximal colon (ie, cecum, ascending colon, transverse colon) (21,22). Finally, these lesions often secrete a mucin coat—composed of various mucoproteins—that adheres to the surface of these lesions (23) (Fig 2). The presence of mucus is often used by the gastroenterologist to help detect these lesions (21).

From the colonoscopy experience, it is logical to surmise that these lesions would be difficult to detect and potentially invisible at CT colonography. The minimally raised surface of these polyps without the ability to see visual color and textural...
differences in the mucosa at CT colonography would argue against detection. In fact, gastroenterologists have stated that CT colonography would be unable to demonstrate these lesions and have pointed to this as an argument against using CT colonography in colorectal cancer screening (24). However, it is important to realize that CT colonography can indeed allow detection of these lesions despite their often flat morphology.

**Lesional Contrast Material Coating of SSPs at CT Colonography**

The explanation of how CT colonography can demonstrate these lesions despite a flat morphology is related to a serendipitous interaction between the oral tagging agents administered as part of the CT colonography bowel preparation and the mucin film elaborated by these lesions. The original purpose of the oral contrast agents was to tag any residual stool particles or colonic fluid left behind after catharsis. As stated earlier, SSPs produce an adherent mucin coat comprised of various mucoproteins. It appears that the tagging agents given as part of the bowel preparation mix with this film to create an adherent coat of contrast material (Fig 3). The remainder of the colonic mucosa (without adherent mucin) remains free of contrast material outlining its surface.

**This contrast material coat phenomenon** is leveraged at CT colonography to highlight a potential flat lesion. This is a similar situation to that in colonoscopy, where the mucin coat or rim of bubbles or debris is used to indicate a potential SSP (21). Although flat polyps can be seen without this adherent coat on the basis of the morphology alone (Fig 3), the presence of a contrast material coat substantially increases the likelihood of detection, as well as the diagnostic confidence of the reader. In one study, the odds ratio for detection was elevated by 40 when the adherent contrast material was present on an SSP as opposed to when it was not (25).

It is theorized that the dilute 2% wt/vol barium sulfate of the tagging protocol creates this contrast material coat (26). It is important to recognize that the phenomenon of lesional contrast material coating has been documented with a specific CT colonography bowel regimen, which includes a dry osmotic cathartic agent followed by a dual tagging protocol of dilute 2% wt/vol barium sulfate and a water-soluble iodine agent (iohexol or diatrizoate) (26) (Table 2). Potentially, the components in the bowel preparation are synergistic to promote this phenomenon. From the barium enema era, it has been known that an interaction exists between the residual magnesium cations in the colonic mucus with the barium sulfate that promotes barium coat-

**Serrated Polyp Detection in a Large-Scale CT Colonography Screening Program**

The experience with detecting serrated polyps at CT colonography is maturing. The University of Wisconsin series reported their experience in a large-scale screening program (25). In an average-risk asymptomatic population of over 8000 adults, a prevalence of 3.1% for nondiminutive (≥6 mm) serrated polyps was seen. This correlates well with the prevalence seen at colonoscopy.

Although colonoscopic series report much higher prevalence ranging from 12% to 21%, this rate includes serrated lesions of all sizes, which are comprised predominantly of diminutive polyps (≤5 mm) (28–30). When lesions of importance such as large (≥10 mm) SSPs are considered, the rates are equivalent. For example, Lash et al (22) demonstrated a prevalence of 1.2% for these lesions in a large colonoscopic series (n = 179 111), echoing the prevalence at screening CT colonography of 1.4% for SSPs greater than or equal to 10 mm (25).

In the Wisconsin series (25), the majority of serrated lesions (≥6 mm) were hyperplastic at 58.9% followed by SSPs at 36.8%. TSAs were rare, constituting 4.3% of serrated lesions. In this series, SSPs had an average size of 10.6 mm ± 5.1; 51.1% were large polyps. There was a high percentage of flat morphology, and the majority (91.2%) resided in the proximal colon (defined as the cecum, ascending colon, and transverse colon) (Fig 4). Thus, the findings of serrated lesions at CT colonography mirrored the presentation of these lesions at colonoscopy.

**Optimizing Interpretation of SSPs at CT Colonography and Avoiding Pitfalls**

There is general consensus that serrated polyps, specifically SSPs, are subtle lesions at screening that can be more easily missed. However, sound interpretative approaches applied to optimal
Figure 3. Lesional contrast material coat of SSP at screening CT colonography. (a, b) Supine (a) and prone (b) axial two-dimensional (2D) CT colonography images show adherent contrast material (arrowheads), which aids in detection. Note how the contrast material outlines the lesion but not the normal colonic mucosa (magnified inset). (c) Three-dimensional (3D) endoluminal view shows that this flat lesion is more obvious and appears sessile, as the reconstruction is a combination of the polyp and the contrast material, while the colonoscopic image (inset) shows the lesion's true flat nature (arrowhead). (d) Axial 2D CT colonography image in another patient shows a polyp without a contrast material coat (arrowhead), which is much more difficult to see and is characterized by a subtle undulation. (e) Sagittal 2D reconstruction better shows the lesion (arrowhead). (f) Colonoscopic image confirms the lesion.
The interpretative process at CT colonography involves two basic recurring tasks. The first is detection, where focal structures projecting into the colonic lumen that potentially could represent a soft-tissue polyp are identified. This detection task is typically accomplished by examining the supine and prone datasets from both a 2D and 3D perspective.

The 2D examination involves interactively scrolling through the stack of thin-section CT colonography images, tracing the colon from...

**Table 2: University of Wisconsin CT Colonography Bowel Preparation**

<table>
<thead>
<tr>
<th>Time</th>
<th>Preparation</th>
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<tbody>
<tr>
<td>After midnight</td>
<td>Liquid diet only</td>
</tr>
<tr>
<td>11:00 AM</td>
<td>Bisacodyl tablets (X2)</td>
</tr>
<tr>
<td>3:00–5:00 PM</td>
<td>Magnesium citrate (one bottle, 296 mL)</td>
</tr>
<tr>
<td>6:00–8:00 PM</td>
<td>Magnesium citrate (one bottle, 296 mL)*</td>
</tr>
<tr>
<td>9:00–11:00 PM</td>
<td>Iohexol (60 mL)</td>
</tr>
</tbody>
</table>

*Both agents are taken at the same time, approximately 3 hours after the first bottle of magnesium citrate.

**Figure 4.** Typical SSP detected at CT colonography screening in a 67-year-old average-risk man. (a, b) Supine (a) and prone (b) axial 2D images show a representative lesion (arrowhead). The SSP is large, flat, and located in the ascending colon. Note the adherent film of contrast material on the lesion. (c) Three-dimensional image shows a more bulky-appearing lesion, an appearance created by the film of contrast material on the lesion at 2D CT colonography. (d) Colonoscopic image shows the subtle nature of the lesion (arrowheads). The overlying mucin and contrast material help detection here as well.
the rectum back to the cecum for any potential polyp candidates. The search algorithm involves distinguishing and excluding haustral folds projecting into the lumen from more focal soft-tissue structures that could represent true soft-tissue polyps (Fig 5). For the 3D examination, the detection task can be undertaken from a variety of formats, including an endoluminal fly-through and band, unfolded cube, and perspective filet views (Fig 6). The endoluminal fly-through is perhaps the most frequently used 3D perspective. Often, the fly-through is bidirectional—rectum to cecum and cecum back to rectum—for both the supine and prone datasets. The 3D perspective allows a complementary approach to detecting potential polyps that can be difficult to detect from a 2D perspective. Similarly, polyps that are difficult to see at 3D examination are often the ones easier to detect at 2D examination. There is general consensus that the most accurate readers use both methods to detect potential polyps. The detection task creates a list of potential polyps that then need to be confirmed or characterized.

The second task is perhaps the most important step in interpretation and determines the true expertise in CT colonography. Here, the potential polyps from the detection step are evaluated to determine if they meet criteria for a true soft-tissue polyp or if they represent a pseudopolyp related to stool or another cause. This task requires a strong background in CT interpretation and cross-sectional skill set with additional CT colonography-specific knowledge. On the source 2D images (ie, thin-section supine and prone CT colonography images), a real soft-tissue polyp must demonstrate two basic characteristics: (a) a fixed location on both views and (b) a soft-tissue attenuation core. Often, a true polyp will exhibit an overlying adherent contrast material coat as well (Fig 7).

The criteria to confirm a true polyp can be difficult to determine, as the underlying colon can shift and rotate between patient positionings, requiring skills to use colonic landmarks (eg, distance from a bend in the colon, a straig diverticulum, or the ileocecal valve) to confirm the location of the polyp on both views. In addition, beam hardening and the low-dose nature of CT colonography can create artifacts and may change the true soft-tissue appearance (see the “Pitfalls” section). With optimal technique and interpretative skills, for polyps in general, sensitivities in the 90%–93% range at the 10-mm size threshold and 78%–89% at the smaller 6-mm threshold (with specificities of 86%–96% and 80%–89%, respectively) have been reported in large prospective trials (32,33).

For SSPs, there are important caveats to recognize to optimize the CT colonography interpretative process at both 2D and 3D examination. For detection, SSPs tend to be flat in morphology and thus harder to perceive than polyps with sessile or pedunculated morphology. Inspecting the colon for a minimally raised plaque of soft tissue from the mucosal surface (ie, a flat polyp) from a stack of thousands of thin-section CT images would be a daunting and difficult endeavor. However, this is often not necessary due to the phenomenon of adherent contrast material coating of SSPs. The colon does not need to be scrutinized for a subtle plaque-like lesion that minimally projects into the lumen but simply needs to be scanned for obvious focal plaques of contrast material, particularly if they are located on a nondependent wall (Fig 3).
Identified contrast material plaques should be examined to determine that they reside in the same location on both series, as opposed to tagged stool, which often moves between the series to a dependent location. If a contrast material plaque is fixed in location, it should be placed on a list for further characterization. Although these plaques may still represent tagged stool that is adherent to the wall, the suspicion for a coated flat polyp is raised for further evaluation. Importantly, this search strategy is easily employed without much mental effort. At 3D examination, these plaques of contrast material are easily seen, as they often appear sessile in morphology, as they are a combination of both the polyp and the contrast material (Fig 3).

Finally, the reader should pay particular attention to the cecum and ascending colon, given the proximal right-sided propensity for SSPs, as opposed to a more distal location where these lesions are more rare. It is helpful to prioritize attention to the proximal colon to decrease the possibility of missing these lesions.

For confirmation, the minimal soft-tissue profile of SSPs somewhat alters the standard characterizing process, but confident decisions can be made. The process of determining the fixed location of the polyp candidate between supine and prone positioning remains unchanged, as described earlier. However, the determination of a homogeneous soft-tissue core is less important, which is fortuitous because the low-dose nature of CT colonography and beam hardening often affect the appearance of these thin-profile lesions, leading to a heterogeneous appearance with fatty/streaky areas.

To confirm that a contrast material plaque represents a coated flat polyp, it must demonstrate an advancing border undermining the contrast material plaque (Fig 8). The border represents the boundary between the flat polyp minimally projecting from the colon mucosa (or haustral fold) and the overlying adherent contrast material. The flat polyp may appear soft tissue in attenuation but often can be of lower/fatty attenuation due to the low-dose technique of CT colonography and beam hardening, as stated earlier (Fig 8).

It is often helpful to toggle between the polyp window (width, 2000 HU; level, 0 HU) and soft-tissue window (width, 400 HU; level, 50 HU) when making this determination. In addition, when interactively scrolling through the 2D dataset, these abnormalities often become more apparent, with a crinkling/wrinkled appearance of soft tissue commonly seen underneath the contrast material coat. If these findings cannot be demonstrated on both views, then the contrast material plaque represents adherent tagged stool (Fig 8). In our experience, all instances where we have sent examinations to colonoscopy for confirmation where there was an adherent plaque of contrast material (ie, same location on both positions), but without any hint of underlying thickening, have resulted in a lack of confirmation of a true flat polyp.

Although it is clear that an adherent contrast material coat is key for detection and confirmation of flat serrated polyps, flat lesions without an adherent contrast material coat can be prospectively identified as well (Fig 3). However, it
requires careful attention and scrutiny to detect these lesions, and ultimately the overall confidence that the lesion is real is lessened. The 3D view is especially important for initial detection of flat lesions without a contrast material coating. In our experience, prior screening examinations can be helpful for comparison. Often, when the finding is real, the lesion can be seen in retrospect.

**Pitfalls**

Many pitfalls of interpretation are obviated with a fundamental knowledge of CT principles and strong cross-sectional imaging experience (34). As mentioned earlier, the determination of a fixed location within the bowel can be difficult at times, related to the lack of regular internal landmarks and movement of the colon between supine and prone positioning, particularly for those segments on a mesentery. Without a strong basis in CT, the decision for “moving stool” could be made, when in fact the serrated polyp candidate is real and fixed in position, while the underlying colon is shifting within the abdomen (Fig 9).

Furthermore, it is important to recognize two situations that may not be obvious or intuitive without prior CT colonography experience. First, when the patient changes from the supine to the prone position, there is a characteristic counterclockwise rotation of the retroperitoneal portions of the ascending colon and cecum of up to 90° (despite the lack of a mesentery in these regions) (35,36) (Fig 10). Owing to this rotation, a polyp may appear to move to a dependent location between the supine and prone series and be erroneously characterized as stool. It is important to use any landmarks to internally pinpoint the location of the polyp relative to these cues (Fig 10).

Second, there is often an apparent change of position of the polyp related to the haustral fold between supine and prone positioning, which is thought to represent some sliding of redundant mucosa over the fold (Fig 11). Again, this phenomenon is important to recognize to prevent an error of classification as a pseudopolyp.

Suboptimal examination technique leads to other common pitfalls. One is related to bowel preparation. As stated earlier, the main factor regarding detection of flat SSPs involves surface contrast material coating of the polyp. Thus, any residual adherent barium on normal colonic mucosa can pose problems for SSP detection by obscuring the presence of a contrast material coat.

Barium can adhere on colonic mucosa in two clinical situations. The first is related to the patient’s hydration status during the bowel preparation. Because magnesium citrate is an osmotic cathartic, it works by drawing fluid into the colonic lumen due to its high osmolarity. If the patient is relatively dehydrated, this cathartic does not work optimally and adherent barium remains on the wall (Fig 12). Adequate hydration during bowel preparation should be emphasized to the patient to prevent this situation.

Figure 7. Confirmation of a suspected polyp. (a, b) Supine (a) and prone (b) axial 2D CT colonography images show that the suspected polyp (arrowhead) fulfills required criteria. The polyp remains fixed in location along the posterior rectal wall on both views. If it were stool, the polyp candidate should fall dependently to the anterior wall with prone imaging. Note the homogeneous attenuation on both views similar to that of adjacent muscle, signifying a soft-tissue nature. An adherent contrast material coat increases confidence in this candidate as a real lesion. (c) Three-dimensional endoluminal image shows sessile morphology. (d) Colonoscopic image confirms a lobulated polyp. Histologic analysis demonstrated an SSP. (Reprinted, with permission, from reference 31.)
Figure 8. Coated flat polyp versus tagged adherent stool. (a, b) Diagrams show a coated polyp (a) and a plaque of tagged stool (b). For a true polyp, there is an advancing border of soft tissue undermining the plaque (red line), whereas the tagged stool extends to the mucosal surface of the colonic wall with a concave smooth border (yellow line). (c, d) Supine (c) and prone (d) axial 2D CT colonography images show a flat coated SSP (red circles) in the ascending colon. Note the soft tissue undermining the contrast material coat (magnified inset). (e) Colonoscopic image confirms the flat SSP. (f) Supine 2D CT colonography image in another patient shows that the advancing border of the flat polyp underneath the contrast material coat (red circles) may not appear soft tissue due to beam hardening (magnified inset). (g) Colonoscopic image shows the flat SSP. (h) CT colonography image in another patient shows stool, which has a smooth curving border with the mucosal surface of the colon. No undermining advancing border is seen.
Second, if the patient reverses the order of the tagging solutions, so that the iodinated agent is taken before the barium as opposed to the standard order (barium before the iodinated agent), it can lead to a smooth coating of the colon (Fig 12). Both of these processes predominantly affect the right colon, which is a detriment given the propensity of SSPs for a right-sided location. Similarly, too much residual tagged fluid can also be a detriment where the contrast material coat is obscured. Identification of a flat serrated lesion is then primarily based on its minimally raised profile, which can be difficult. This is typically more of an issue with wet polyethylene-based preparations.

Other pitfalls are related to technical difficulties that lead to inability to evaluate the polyp candidate in both positions. If one series is collapsed or blurred by motion so that the contrast material plaque is clearly evaluated on only one series, this decreases the confidence if a possible SSP is real. Even if the colon is only minimally decompressed, the normal thickening of the colon wall makes it difficult to assess for abnormalities underneath the contrast material coat. It is important that the colon—particularly the right colon (ie, cecum and ascending colon)—be optimally distended to prevent this pitfall. In cases with poor distention, a third decubitus view is indicated (37).

**Characteristic Appearance of TSAs**

Unlike SSPs, TSAs are more easily detected and can manifest with a range of more bulky morphologies of a sessile or pedunculated nature. They are less often flat. When these lesions grow to very large sizes, one presentation has been fairly characteristic for this uncommon lesion. When larger than 20–30 mm, these lesions have a frond-like appearance at 2D imaging with deep interstices filled with contrast material (Fig 13).

Like all polyps, they are fixed in location at one point in the colon; however, these lesions can change shape between supine and prone series due to the frond-like appendages. Interestingly, these frond-like areas are not well appreciated at colonoscopy, where the lesions look more macrolobulated (Fig 13). Although this appearance is fairly characteristic when TSAs are large, it is not completely specific, as other polyp types such as villous adenomas can have a similar presentation. As with any polyp, histologic type is determined at pathologic review.
Figure 10. Cecal rotation pitfall. (a) Diagram shows the characteristic counterclockwise rotation of the cecum between supine and prone positioning. Note the relationship of the coated polyp to the appendiceal orifice, which is unchanged, confirming a fixed location on the colonic wall. (b, c) Supine (b) and prone (c) axial 2D CT colonography images in a patient with a coated SSP in the cecum show this phenomenon. Again, note the fixed relationship between the coated polyp (arrowhead) and the appendiceal orifice (arrow). (d) Colonoscopic image confirms an SSP ringed by mucin. (Fig 10d reprinted, with permission, from reference 25.)

Figure 11. Apparent polyp movement on fold. (a, b) Supine (a) and prone (b) axial 2D CT colonography images show a change in position of a polyp (arrowhead) in relation to a haustral fold. The polyp projects off the fold on the supine image and resides in the crook between the fold and colonic wall on the prone image. This is a characteristic occurrence, presumably due to some redundancy in the mucosa in relation to the fold. It is important not to erroneously conclude movement related to sliding tagged stool. (c) Colonoscopic image confirms a polyp with mucin, which was an SSP at histologic analysis.

Conclusion
Serrated polyps are a recently recognized polyp precursor to cancer. Like adenomas, a small percentage of these benign lesions grow and can transform to cancer over many years. Their removal disrupts the pathway to cancer, and screening can therefore decrease the future incidence of colorectal cancer.
SSPs (previously mistaken for hyperplastic polyps) are a subtype with future malignant potential that are typically flat in morphology and right-sided in location. Despite their subtle nature, these lesions can be detected at CT colonography with high sensitivity and specificity due to the phenomenon of an adherent contrast material coat with a specific CT colonography bowel preparation. Adjusting interpretative strategies and recognizing certain pitfalls further improve the chances of accurate detection.

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