Endoscopic Tattooing to Mark Distal Margin for Low Anterior Rectal and Select Sigmoid Resections

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Abstract
Obtaining a reliable distal margin during anterior colorectal resection can be difficult. In this study, endoscopic transmural tattoos were placed to mark the distal transection point in patients with distal colorectal neoplasms who undergo bowel resection. In the operating room, before surgery, sigmoidoscopy is performed with a 2-channel scope using CO₂ insufflation. Through channel 1, a biopsy forceps, marked 5 cm from its end, is inserted to the tumor’s distal edge; in channel 2, a sclerotherapy catheter is placed. The scope is then withdrawn and forceps inserted at the same rate until the mark is seen, next, via the needle catheter, 4 tattoos are placed at that level circumferentially. After rectal mobilization, visible external tattoos guide stapler placement. If no tattoo is seen, sigmoidoscopy is done and the tattoos used to guide stapler placement. In all 27 patients, the tattoos guided stapler placement; tattoos were seen via the abdomen in 26 and the stapler placed as per tattoos in 25. In 2 patients, repeat endoscopy was done and tattoos used to guide or confirm stapler placement. The margin was ≤1 cm from target in 74% while in 22% the margin was 2 to 3.5 cm off target (mean deviation from target margin = 0.33 cm). In conclusion, this method facilitates stapler placement and provides more reliable margins.

Keywords
endoscopic tattoo, rectal cancer, distal margin tattoo, rectal resection margin

Introduction
This report addresses the use of endoscopically placed tattoos to identify the rectal transection point for distal left-sided cancers. It can be difficult to precisely judge the length of the distal margin when placing a stapler after rectal mobilization. Thus, although a 5-cm margin is the goal for rectal cancers, the margin obtained is often notably shorter (1-3 cm).

With regard to open low anterior resection (LAR), it can be difficult to precisely palpate the tumor’s distal edge because of the bulk of the mesorectum. Tumor localization is also a challenge in patients who have received neoadjuvant chemoradiotherapy because the residual tumor may be small or absent. Also, it is difficult to choose the transection point in patients with small sigmoid lesions or flat polyp cancers that have been endoscopically removed. To deal with this problem, digital exam and proctoscopy or sigmoidoscopy are often performed to confirm that the stapler, already in place, is below the cancer. Unfortunately, these measures do not reveal the distal margin length. Distal margin selection is even more of an issue during laparoscopic-assisted LAR or sigmoidectomy because palpation of the bowel is not possible.

Colonoscopically placed submucosal tattoos have been used for more than 35 years to identify the site of small colonic tumors and polypectomy sites. The use of colonic tattoos has increased with the advent of minimally invasive methods. In the colon, tattoos are usually placed just distal to the lesion in order to reveal the tumor’s location to the surgeon. Tattoos are not commonly used to mark rectal cancers. The proximity of the tumor to the anus is one reason; proctoscopy or digital exam can always be carried out if problems arise. Furthermore, submucosal tattoos are difficult to see transabdominally because of the thick mesorectum that envelops the extraperitoneal rectum.

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The selection of the distal transection point is a critical decision when performing LAR. It is, perhaps, more useful to know where the rectum should be divided than to know where the tumor is. We propose the use of submucosal and transmural rectal wall tattoos, placed in the operating room prior to surgery via flexible sigmoidoscopy after measurement with an endoscopic ruler, to mark the distal margin of resection. The hypothesis is that more accurate margins will be obtained when the stapler position is determined by these “margin” tattoos, visualized either transabdominally or via sigmoidoscope. This is a preliminary report that describes the technique and the results of the first 27 cases.

Materials and Methods

This method was used on patients with colorectal neoplasms who underwent either a sphincter-saving rectal or rectosigmoid resection by a single surgeon between July 2009 and April 2012 at St. Luke’s Roosevelt Hospital in New York City. It is the surgeon’s practice to consent all bowel resection patients for intraoperative colonoscopy; thus, an endoscopy tower, colonoscope, and CO₂ insufflation unit are in the operating room for all large bowel resections. The data for these consecutive cases was prospectively collected and recorded in an institutional review board–approved database.

Patients underwent a standard bowel preparation. After anesthetic induction the patient is placed in the modified lithotomy position. A digital rectal examination is done to assess the bowel prep and, for distal lesions, the tumor’s location. If stool is noted, the rectum is irrigated. Next, a 2-channel colonoscope is inserted and CO₂ gas insufflation is done. An exam of the rectum and distal sigmoid is done and the lesion identified. Scope torque is applied until the tumor is in the 6 o’clock position on the endoscopic monitor. With the scope distal to the lesion, the measuring device is passed via a working channel into the rectum. The “ruler” for the first 17 cases was a standard biopsy forceps onto which a thin piece of easily seen tape was placed 3 to 5 cm (margin determined by surgeon) from the forceps tip. The ruler for the last 10 cases was the same biopsy forceps with black circumferential marks (marking pen) 3, 4, and 5 cm from the forceps tip. The biopsy forceps is advanced to the lesion’s distal edge and then held steady (alternately, the adjacent normal mucosa is gently grasped with the forceps). The scope is then slowly withdrawn while the biopsy forceps is simultaneously inserted at the same rate until the mark on the forceps is seen. The goal is to keep the forceps tip at the tumor’s distal edge. Next, a sclerotherapy catheter, primed with india ink (or other dye), is passed via the scope’s second channel and a tattoo made at the level of the mark. Both submucosal and deep, hopefully transmural, injections are made with 1 cm³ of dye at each location. This requires a purposefully deep injection. A submucosal tattoo is also needed so the site can be identified endoscopically. After the first tattoo, the “ruler” is withdrawn and 3 more tattoos are placed around the bowel circumference at the same level. The scope is then removed and the operation begun.

During and after rectal mobilization the mesorectal and antimesenteric surfaces of the rectum are inspected for tattoos. If the tattoos are clearly seen, the mesorectum and rectum are divided at that level.

If the surgeon is not confident of the margin, perhaps because the tattoos are light or very broad, a repeat sigmoidoscopy is done after a linear stapler is placed across the rectum at the level of the tattoo. From the endoscopist’s viewpoint, the rectal lumen abruptly ends at the stapler’s edge. If the tattoos are not visible or if only the distal edge of the tattoo(s) is seen, it can be assumed the stapler is well below the tumor. If full tattoos are seen distal to the occluded rectum, the stapler needs to be moved further distally. Having identified the point of distal transection, after removing the colonoscope, the mesorectum and rectum are divided at that level.

If the tattoos are not visible transabdominally after rectal mobilization the sigmoidoscope is reinserted and the tattoos identified. The tattoo’s external location is revealed either by transillumination or by using an operative instrument to indent the rectal wall until the correct spot is found as verified by the endoscopist. The surgeon then places a marking suture on the rectal wall at that level. The scope is then withdrawn after which the mesorectum and rectum are divided at the chosen level. After resection the specimen is opened, the tumor inspected, and the unstretched distal margin measured.

The following data were noted and recorded: distance from the anal verge to the distal edge of the tumor site, intraoperative sigmoidoscopy, tattooing, the target and actual distal margin (as measured immediately postresection), and final pathology results were collected prospectively. The visibility of the tattoos from the abdominal field was noted as was the need for repeat sigmoidoscopy at the time of stapler placement. Information regarding demographics, neoplasm type and location, operation performed, complications, and clinical short-term outcome was obtained.

Results

This distal margin tattooing method has been used in 27 patients with colorectal neoplasms. In all cases, the sigmoidoscopy and tattooing was carried out in the operating room prior to the start of the surgery. The mean age of the patients was 55 ± 16.4 years (16 males, 11 females). The operations performed were the following: LAR, 12 patients; rectosigmoid/anterior resection, 7 patients; sigmoid resection, 6 patients; total abdominal colectomy,
The surgical methods used were as follows: laparoscopic-assisted, 15 patients (55.6%); hand-assisted, 11 patients (40.7%); open, 1 patient (3.7%). There were 2 conversions to open methods (7.7%). Transanal circular double stapled anastomoses were made in 25 patients; 6 were proximally diverted. Two patients underwent a Hartmann’s procedure with colostomy. The mean surgery length was 333 minutes. Median number of days until first flatus occurred was 2.0 ± 0.75 days after surgery; the first bowel movement was noted 3.0 ± 0.9 days postoperation. The median length of stay was 5.0 ± 6.2 days. The complications were as follows: anastomotic leak requiring reoperation and proximal diversion, 1 patient; congestive heart failure and pneumonia, 1; wound infection 1; ileus, 1; and urinary retention, 2. There were no deaths or sigmoidoscopy/tattooing related complications.

Of note, in the series there were 6 patients with invasive sessile polyp cancers that had been previously removed via colonoscopy. Bowel resections were done in these patients because of the 5% to 15% chance that one or more mesenteric lymph nodes will contain cancer. Four rectal cancer patients received long course neoadjuvant chemoradiation. Analysis of the final pathology results, in regards to the colorectal mucosal evaluation, revealed 18 adenocarcinomas, 1 adenoma, and in 8 patients no residual cancer in the bowel wall (all 6 polyp cancer patients and 2 preoperative chemoradiation patients who had a complete response). In 1 of the 6 polyp cancer patients an involved lymph node was found. The final cancer stage breakdown for the 26 biopsy proven cancers was as follows: Tx, N-0, M-0, 2 patients (complete responders to radiation therapy/chemotherapy); stage 1, 8 patients (including 5 polyp cancer with no residual cancer on resection), stage 2, 5 patients; stage 3, 10 patients; stage 4, 1 patient.

The tattoos were seen via the abdominal field after rectal mobilization in 26 patients. In 2 cases, repeat sigmoidoscopy was carried out at the time of stapler placement to ensure the stapler was placed at the desired level; in 1 case, the tattoos were not seen transabdominally and in 1 case the tattoos were feint. In the latter case the endoscopy was repeated after the stapler was placed.

Table 1. Location of Tumor Distal Edge From Anal Verge and Distal Margin Data (Desired and Mean Actual).

<table>
<thead>
<tr>
<th>Distance From Anal Verge (CM)</th>
<th>Number of Patients</th>
<th>Distal Margin Goal</th>
<th>Actual Distal Margin in cm (Target, Mean Actual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤5</td>
<td>0</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>5-10</td>
<td>7</td>
<td>5 cm, 3;</td>
<td>5.43;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 cm, 3;</td>
<td>4.35;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 cm, 1</td>
<td>2.27</td>
</tr>
<tr>
<td>10.1-15</td>
<td>10</td>
<td>5 cm, 7;</td>
<td>5.55;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 cm, 3</td>
<td>4.38</td>
</tr>
<tr>
<td>&gt;15</td>
<td>10</td>
<td>5 cm, 10</td>
<td>5.60</td>
</tr>
</tbody>
</table>

The breakdown of the patients as regards distance of the tumor from the anal verge as well as the desired distal margin is provided in Table 1. The majority of the tumors (17) were located in the middle (5-10 cm from the anal verge) or proximal rectum (10.1-15 cm from the anal verge). There were no tumors in the distal rectum. Ten tumors were located in the rectosigmoid or sigmoid colon. With 1 exception, the target distal margin was 4 or 5 cm. The target margin and actual distal margin (as measured in the operating room after resection) for all patients is shown in Figure 1. The actual mean fresh distal margin for the study population was 5.0 ± 1.6 cm; however, when measured in the pathology lab (up to 1 day postresection) it was 4.0 ± 1.8 cm. In 20 patients, the actual fresh margin was within 1 cm of the target (74%); however, in 6 (22%) the difference was 2 cm or more (2 cm in 3 patients; 2.5 cm in 1, 3-3.5 cm in 2). In 9 patients, the actual margin was shorter than the target (1 cm less in 8 patients, 2 cm less in 1 patient), in 12 patients, the margin was longer, and in 5 the margin was correct (Figure 1). Of note, for the 5 patients whose actual margins were 2 cm or greater than the target margin the distance of the tumor’s distal edge from the anal verge was between 15 and 20 cm.

Discussion

Most surgeons choose the distal transection point by estimation after palpating the tumor (manually or with laparoscopic graspers). The distal margins obtained this way are rarely precise. The difficulties associated with distal margin selection were discussed in the introduction. Using distal margin tattoos in this small series, in 74% of patients the margin was within 1.0 cm of the goal; in 89% the margin was within 2 cm of the target distance. Of note, for the patients with actual margins shorter than the target, the shortfall was only 1 cm except for a single patient whose margin was off by 2 cm. It is the opinion of the authors that these results are closer to target and more consistent than results obtained with the standard “dead reckoning” method. Importantly, using the distal tattoo method there were no very short margins (less than 2 cm). Admittedly, sigmoidoscopy and tattooing add time to the procedure; however, time is saved later because there is...
no need to go through the process of finding the tumors distal edge and choosing the point of transection. Instead, after mobilization, the mesorectum and rectum are simply divided at the level of the tattoos. Furthermore, in the patients who require repeat sigmoidoscopy prior to rectal division, the exam should be brief because all that is required is to determine the relationship between the stapler and the tattoos (at, below, or above).

The few patients in whom tattoos had been placed at the level of the tumor preoperatively by the gastroenterologist were tattooed at the distal margin in the operating room in the usual way. In these cases, both the tattoo close to the lesion and distal tattoos were seen. In this situation, if both sets of tattoo are not seen transabdominally then a sigmoidoscopy is recommended to verify stapler position prior to firing because it is possible that the visible tattoo is at the level of the tumor. Of note, this method can be used for distal cancers if a sphincter saving operation is to be done, however, the target margin must be less than 5 cm. If a double stapled anastomosis is planned, the margin tattoos must be placed proximal to the sphincter.

It is of concern that 5 patients had margins that were 2 to 3.5 cm greater than intended; in all 5 the lesions were located 15 to 20 cm from the anus. The authors believe there is a greater tendency for a long margin when this technique is used in the proximal rectum and sigmoid colon because the bowel is not straight in these segments. If a straight (rigid) ruler is used to measure across a curved segment of bowel, it is likely the margin obtained will be longer than desired because the ruler “bridges” the curve. Because of this tendency, the authors are now purposefully placing the tattoos 1 to 2 cm proximal to the level suggested by the ruler whenever the ruler bridges a curved segment of the bowel. There is another potential reason for a longer than planned margin in cases where the tumor is located in the sigmoid colon. In this situation, the 5-cm distal margin tattoos may be located in the distal rectosigmoid colon in which case the blood supply to the distal bowel, after division of the inferior mesenteric artery proximally, may be questionable. In this situation, the surgeon may intentionally (and correctly) choose a longer distal margin to ensure that the remaining distal bowel has an adequate blood supply.

Another potential source of error is that the ruler’s tip may not stay at the lesion’s distal edge when the scope is withdrawn and the ruler extended. If the rates of withdrawal and insertion are not the same then the ruler tip may migrate and result in an incorrect measurement. It is easier to keep the ruler’s tip in position if the lesion remains in view during the measurement. However, in the upper rectum and more proximally, the ruler is likely to traverse a curve that will put the lesion out of sight and increase the chances of ruler tip migration and an inaccurate margin.

Later in the series, to ensure that the ruler stayed in position, the normal bowel wall next to the tumor’s distal edge was grasped with the biopsy forceps prior to pulling the scope back and inserting the ruler. This method works best for mid and distal lesions that remain in view with the ruler extended. When measuring across a curve, however, traction may inadvertently be applied to the forceps which may pull the tumor bearing segment distally resulting in a
longer margin than desired. Thus, care must be taken not to pull on the ruler as the scope is withdrawn.

As noted, to obtain a visible tattoo on the external surface of the rectum and mesorectum the injection must be transmural. This requires a purposefully deep injection. A submucosal tattoo is also needed so the site can be identified endoscopically. In this series the tattoo was visible externally in 96% of patients. Of note, the external tattoo was 2 to 3 cm in diameter in some cases which made it difficult to obtain a precise margin because of the width of the mark. Currently, injections are limited to 1 cm³/site to avoid very broad tattoos. Of note, in patients with a very thick and broad mesorectum the tattoos may not be visible. In this case, a repeat sigmoidoscopy is needed before stapling to identify the transection point. In this series, 2 of 27 patients required a second sigmoidoscopy. In one case, the tattoos were not visible externally while in the second case one tattoo was visible but was faint. In the latter case a sigmoidsclerosing was done after stapler placement to verify correct positioning. Of note, in some cases staining of the tissue beyond the mesorectum was noted. There were no complications associated with the tattoos.

When measuring, the ruler should run parallel to the bowel wall in the tumor-bearing quadrant to avoid “bridging” across the gas-filled lumen to another point along the circumference and a shorter than desired margin; thus, the scope must be positioned so the tumor is at the 6 o’clock position on the monitor. Multiple tattoos are made to increase the odds that a tattoo will be seen externally. Ideally, the tattoos are the same distance from the tumor; however, it is difficult to select the spot directly opposite or adjacent to the first tattoo, thus, the last 3 tattoos may be more proximal or distal than desired. This introduces another source of error. Ideally, if it is visible, the stapler is placed at the site of the first tattoo (anterior, posterior, left, or right).

It is critical that CO₂ gas be used for insufflation during the endoscopy to avoid colonic distension that impairs abdominal exposure. Unlike air, CO₂ is rapidly absorbed by the bowel mucosa and excreted via the lungs; within 15 minutes the colon diameter returns to its original size.¹¹,¹²

Finally, although this method calls for a 2-channel scope that is not universally available, it can be adapted to a 1-channel scope by using a marked sclerotherapy catheter as the ruler. Once the mark is seen on the catheter after scope withdrawal and catheter advancement, the scope is held steady and the mark’s position noted after which the sclerotherapy catheter is pulled back and the bowel tattooed.

In summary, despite the pitfalls, the authors believe this tattooing method yields more accurate distal margins than can be obtained using standard methods. Confidence that the margin obtained will be oncologically adequate removes the uncertainty that otherwise often accompanies this part of the operation.

**Authors’ Note**

Part of this study was presented as a poster at the SAGES Annual Meeting, March 30 to April 2, 2011, San Antonio, Texas.

**Declaration of Conflicting Interests**

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