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Review article

Colonic Endoscopic Tattooing and Its Impact on Colorectal Surgery: More Than Just a Mark

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Abstract

Introduction: Endoscopic tattooing of colorectal lesions has evolved from a simple marking technique into an essential tool for preoperative localization in colorectal surgery. Since its introduction in 1958, its utility has been particularly demonstrated in minimally invasive surgeries, where tactile feedback is limited. **Objective:** To review the role of endoscopic tattooing and its surgical implementation, as well as the outcomes achieved, to facilitate lesion identification, ensure adequate oncologic margins, and reduce operative times. **Methods:** A comprehensive literature review was conducted, highlighting current indications, techniques, and recommendations for endoscopic tattooing. Guidelines from the American Society for Gastrointestinal Endoscopy (ASGE) regarding its use in the colorectal context were also analyzed. **Results:** Evidence supports the use of endoscopic tattooing in the transverse, descending, and sigmoid colon, improving intraoperative localization and reducing the risk of incorrect resections. For the right colon, anatomical landmarks are recommended as an alternative. In the rectum, tattooing is debated due to the risk of lymphatic ink absorption and potential overstaging in imaging studies. **Conclusions:** Endoscopic tattooing is a cost-effective and precise method for lesion localization, directly impacting surgical planning, confidence in resection margins, and oncologic outcomes. Implementing standardized guidelines on its use is crucial to maximize its benefits in colorectal surgery.

Keywords

Endoscopy, tattooing, colon, surgery.

INTRODUCTION

The concept of *tattooing colon polyps* was introduced in 1958 by Sauntry and Knudtson[(1)], who used Lausanne Brilliant Blue to mark colonic lesions. Subsequently, Knoernschild[(2)] reported on 190 patients who underwent endoscopic tattooing. In 1975, Ponsky and King highlighted the value of endoscopic tattooing for the intraoperative localization of colonic lesions, promoting its implementation[(3)].

For over three decades, endoscopic tattooing, via the injection of India ink, has been established as an essential tool for the preoperative localization of tumors in colorectal resections. This technique allows for the precise identification of lesions during surgical procedures or follow-up colonoscopies and is particularly valuable in minimally invasive surgery due to the limited tactile feedback, which makes detecting and locating small lesions in the colon difficult.

Although colonoscopy is the gold standard for detecting colorectal cancer, the accuracy in pinpointing the exact tumor location shows significant variation. Endoscopic orientation is hampered by the lack of reliable anatomical landmarks between the anal verge and the ileocecal valve, leading to accuracy rates ranging from 59.7% to 98.3%, dropping to as low as 37.5% for transverse colon tumors[(4,5)].

Complete resectability of colorectal cancer is crucial for achieving an oncological cure, and multiple clinical trials have shown comparable oncological outcomes between laparoscopic and open resections[6]. Inaccurate localization of a lesion during laparoscopy can have critical consequences, including blind resections, removal of incorrect segments, unexpected modifications to the surgical plan, or the need for a permanent stoma[7].

To overcome these barriers, various localization techniques have been described, with colonoscopic tattooing being the predominant one. However, alternatives also exist, such as colonoscopic metal clips, intraoperative ultrasound, and preoperative computed tomography colonography, albeit with varying results regarding accuracy, safety, cost, and availability. Despite the popularity of colonoscopic tattooing, a superior technique has not yet been established in Colombia, nor are there standardized guidelines to consistently guide endoscopists[8].

This article reviews errors in tumor localization in patients with colorectal cancer who were preoperatively evaluated for curative-intent surgery and synthesizes the available evidence on risk factors associated with localization errors and adverse events during the procedure. This review aims to provide a solid scientific basis for developing guidelines to optimize the practice of endoscopic tattooing in the Colombian context, thereby strengthening the accuracy of lesion localization and improving surgical outcomes for patients with colorectal cancer.

IMPORTANCE OF ACCURATE TUMOR LOCALIZATION

Colonoscopy is a fundamental tool for the preoperative localization of colorectal lesions; however, most tumors are described in relation to anatomical reference points, such as the ileocecal valve, the hepatic flexure, and the splenic flexure. Complementing this orientation, endoscopists also use the inserted length of the colonoscope as an indirect measure of tumor position. Nevertheless, these methods have limitations, especially in patients with colonic redundancy, which distorts the anatomy and reduces the accuracy of anatomical measurements. Lack of precision in tumor localization leads to laparoscopic resections of incorrect segments, resulting in conversions to laparotomies, additional resections, and consequently, increased patient morbidity as well as higher costs for the healthcare system (**Figure 1**)[7].

In this context, a reliable method for accurate tumor localization is indispensable to ensure adequate margins during the laparoscopic resection of colorectal tumors, minimizing surgical complications. Historically, other methods have been used, such as barium enemas, clip placement, computed tomography (CT) scans, CT colonography, intraoperative colonoscopy with markers, and proctoscopy with sutures[8]. However, each technique has limitations: barium enemas have reduced effectiveness in visualizing small or flat tumors[9], while intraoperative colonoscopy, despite its high potential for determining location, prolongs operative time, requires advanced skills, and increases postoperative complications due to bowel distension. Endoscopic clips are often ineffective due to their low visibility in the laparoscopic context and the possibility of migration.

The available evidence strongly supports the use of permanent endoscopic tattoos as the most effective method for ensuring accurate intraoperative localization of colorectal lesions[10].

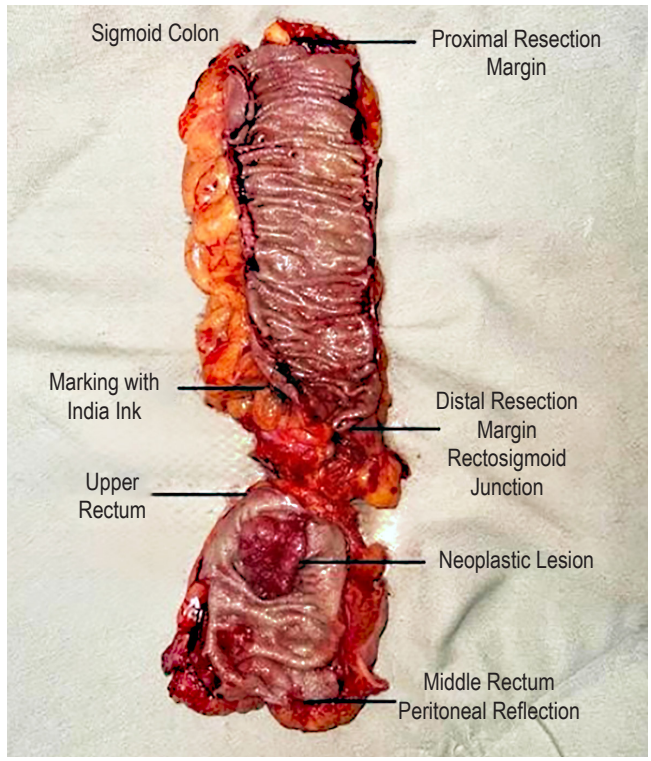

Figure 1. Lack of precision in tumor localization in the colon, leading to a new laparoscopic colon resection. Image property of the authors.

INDICATIONS FOR ENDOSCOPIC TATTOOING

The American Society for Gastrointestinal Endoscopy (ASGE) recommends tattooing during colonoscopy for those lesions that may require localization in future endoscopic or surgical procedures. This includes confirmed or suspected malignant lesions, polypectomy sites, endoscopic mucosal resection or endoscopic submucosal dissection, difficult-to-locate polyps, and dysplastic areas. Lesions located in the cecum, adjacent to the ileocecal valve, or in the lower rectum do not require tattooing due to their easy identification[11]. We propose the following objectives:

- To facilitate surgical localization: Endoscopic tattooing enables the precise identification of lesions during surgical resection, increasing patient safety and reducing surgical time spent locating the lesion (**Figure 2**).
- To enable clinical monitoring: It is used to monitor the patient after a polypectomy, allowing for long-term follow-up of treated areas and early detection of recurrences (**Figure 3**).

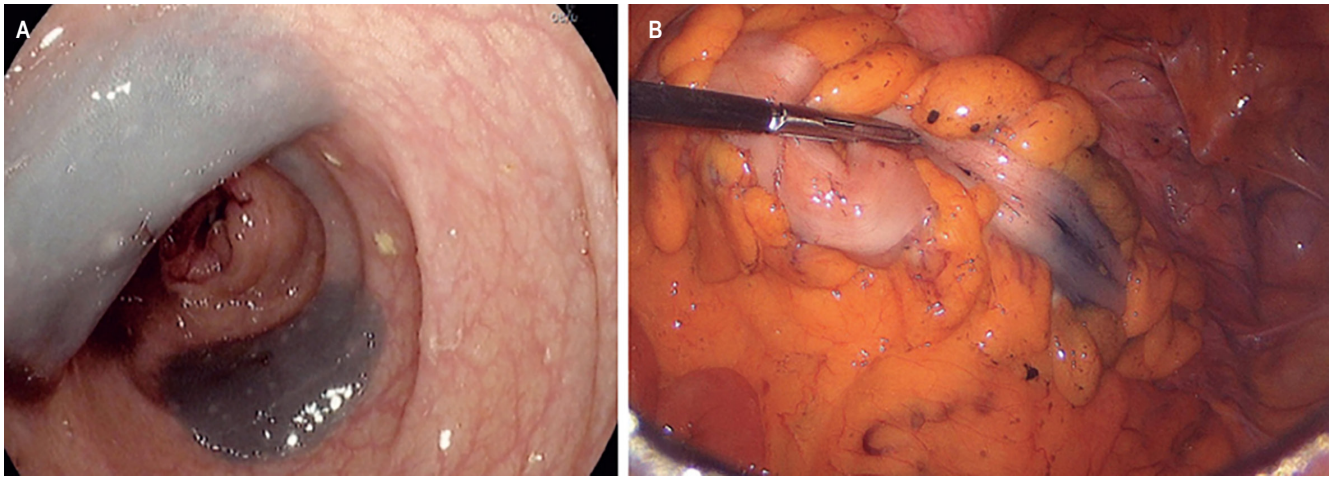

Figure 2. Endoscopic tattooing of the colon. **A.** Endoluminal marking distal to the lesion in two contralateral segments. **B.** Marking with India ink tattoo on the colon, allowing for its laparoscopic identification. Images property of the authors.

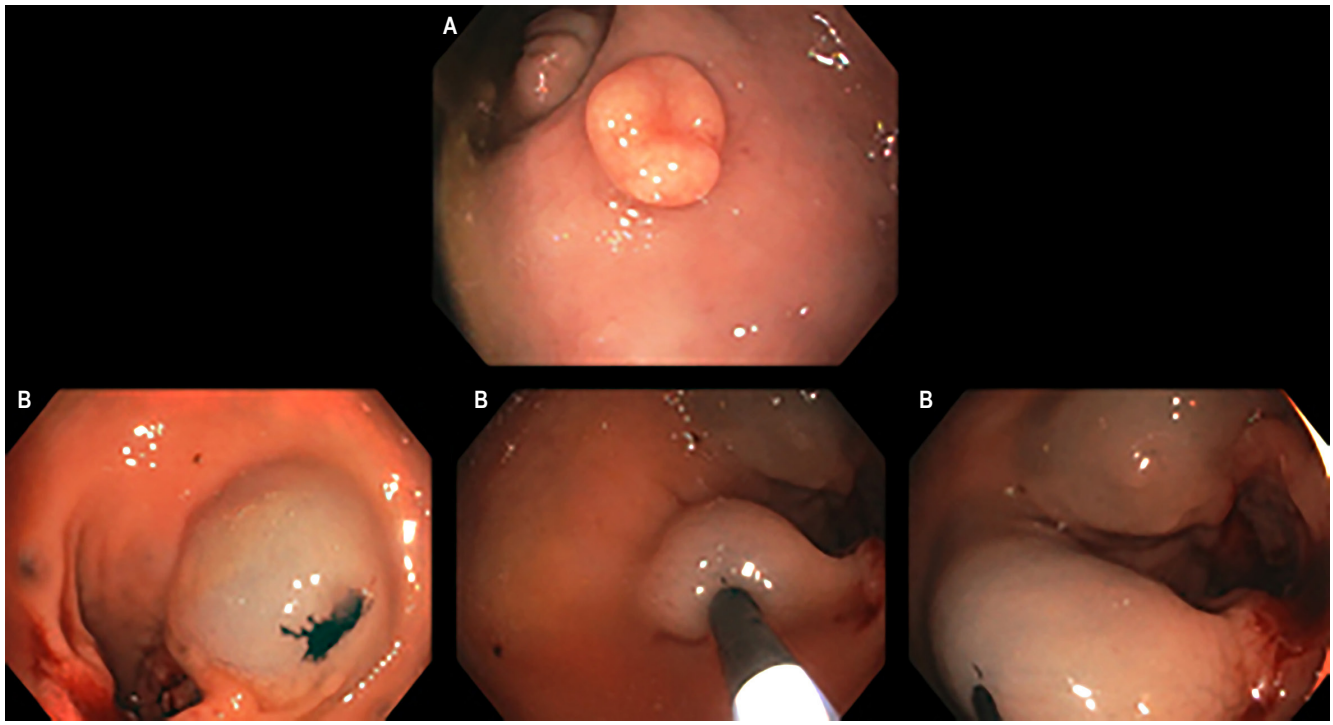

Figure 3. Subepithelial lesion of 15 x 15 x 5 mm in the upper rectum, fixed and with central ulceration, with high suspicion of rectal neuroendocrine tumor. **A.** Identification and characterization of the lesion in the upper rectum. **B.** Marking with India ink distal to the lesion on two contralateral sides (quadrants), allowing for easy identification for subsequent clinical monitoring and future resection. Images courtesy of Dr. Carlos Martínez - HOMIC.

PREOPERATIVE ENDOSCOPIC TATTOOING

Studies show an 88% success rate in the accurate localization of tumors through endoscopic tattooing, achieving adequate resection margins and lymph node harvest[12]. A prospective comparative study by Arteaga-González et al. found that tumor visualization was successful in 100% of patients in the preoperative tattoo group, compared to 80.8% in the non-tattoo group[9]. They also demonstrated shorter surgical time and less blood loss, with no related complications, while in the non-tattoo group, imprecise tumor visualization led to unnecessary resection of healthy colon and inadequate resection margins. It was concluded that preoperative endoscopic tattooing is a safe, effective, and superior method for the intraoperative localization of tumors, with lower rates of positive resection margins, in addition to highlighting its cost-effectiveness[13].

The international Delphi consensus has provided guidelines on the proper use of endoscopic tattooing, including its indications and technique[14]. Current research, such as trials by Barquero et al., among others, continues to evaluate the accuracy of tattooing and its technical variations, reinforcing evidence-based practice in modern endoscopy[15].

EFFECTS OF A WELL-EXECUTED COLORECTAL TATTOO ON THE MULTIDISCIPLINARY CARE TEAM

- Safety for the endoscopist and the surgeon.
- Confirmation of the type of resection to be performed (preoperative assessment).
- Prevention of incorrect trocar placement at the time of intraoperative identification.
- Reduction in the conversion rate from laparoscopic surgery to open surgery.

THE BEST SUBSTANCE FOR TATTOOING

The ASGE currently recommends a sterile carbon particle suspension as the ideal agent for endoscopic tattooing due to its high permanence, safety, and ease of implementation, essential characteristics for ensuring surgical localization. Other agents, such as India ink, methylene blue, and indigo carmine, have limitations, such as lesser permanence, potential infection risks, and complex preparation processes. The introduction of a sterile, biocompatible suspension based on carbon particles (such as Spot®, GI Supply, United States) has optimized the safety and accessibility of the procedure, though it is not yet available in our setting[16].

Studies conducted by Hammond et al. explored the efficacy of different compounds, including methylene blue, indigo carmine, indocyanine green, and India ink, in canine models, and demonstrated that India ink stood out for its prolonged permanence and low tissue reactivity[17]. Based on these studies, it was established that India ink provided the best long-term visibility, with tattoos evaluated up to ten years later without significant loss of intensity[18]. Its efficacy was confirmed in the surgical context, with a 97% intraoperative visibility rate in laparoscopic procedures, establishing it as the preferred substance for the accurate identification of lesions[19].

THE OPTIMAL PREOPERATIVE TIMING FOR ENDOSCOPIC TATTOOING

Although preliminary recommendations exist, the evidence establishing the optimal timing remains limited. In a prospective study, Conaghan et al.[20] identified variability in tattooing practices prior to laparoscopic colorectal surgery and highlighted the absence of a standardized protocol to guide this decision. Feingold et al.[12] suggest that performing the tattoo during the diagnostic colonoscopy allows for a permanent and lasting mark, ensuring the lesion is easily identifiable in future interventions.

Another alternative is to perform the tattoo the day before the planned laparoscopic colorectal resection, taking advantage of the preoperative bowel preparation to maximize the tattoo's visibility and accuracy. Based on this strategy, we recommend performing a routine tattoo on all suspicious lesions during the initial diagnostic colonoscopy and considering, in specific cases, repeating the tattoo the day before surgery to ensure optimal localization.

Despite these recommendations, future research should evaluate cost factors, the relationship with clinical outcomes, and the impact on operative safety and efficiency to establish clear guidelines that optimize both the effectiveness and feasibility of the procedure.

TECHNIQUE FOR PERFORMING AN ADEQUATE ENDOSCOPIC TATTOO

The ASGE recommends creating a submucosal bleb (wheal) by injecting saline solution before applying the tattooing agent (1 to 2 mL of saline solution) (**Figure 4A**). This technique helps ensure precise injection of the India ink (0.6 to 1 mL) into the submucosal plane, and a saline flush after the ink injection is also recommended (**Figure 4B**), to minimize the risk of transmural injection and significantly reduce associated complications, such as peritonitis and submucosal fibrosis, which can hinder future endoscopic interventions[19]. There are no recommendations to dilute India ink, and we suggest instilling it in its pure form under the volumes described. Furthermore, it is recommended to insert the injector at a 45° angle relative to the mucosa to optimize submucosal application and minimize the risk of intraperito-

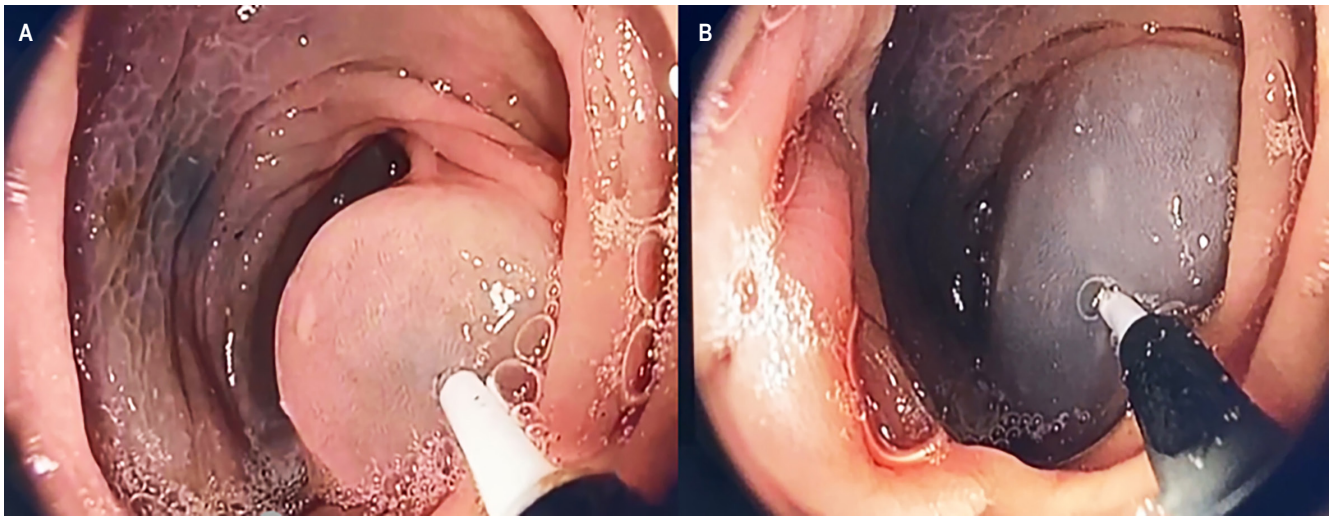

Figure 4. Technique for performing an adequate endoscopic tattoo. **A.** Submucosal bleb or wheal via injection of saline solution. **B.** Injection of India ink into the preformed bleb. Images courtesy of Dr. Nairo J. Senejoa – HOMIC.

neal spillage, which could induce inflammation and confuse the localization of the target tissue. The two-step technique demonstrated excellent lesion visualization (98%) and a lower complication rate (1.8%)[21].

LOCATION AND TECHNIQUE FOR TATTOO CONFIGURATION

Placing the tattoo at least 3 cm distal to the lesion is recommended, using two injections (marks) on opposite sides of the lumen to ensure its intraoperative visibility. We consider that more than two injections do not provide a significant difference during intraoperative tattoo identification, acknowledging the possibility that a single mark may not be prominent enough or may end up on the mesenteric side of the colon (**Figure 5**).

Documenting the exact location of the tattoo in the endoscopic report, accompanied by photographs, is essential to ensure standardization and improve the accuracy of surgical lesion identification[7]. This distance of 2 to 5 cm prevents the risk of tattoo dispersion towards the lesion (**Figure 6A**), decreases the possibility of submucosal fibrosis, and helps maintain the integrity of oncological margins, thereby avoiding complications that could compromise the patient's treatment in future procedures (**Figure 6B**)[10].

It is crucial to specify that marking or tattooing the colon to identify a lesion or plan a preoperative resection is recommended only for the transverse, descending, and sigmoid colon segments. For the cecum and ascending colon, the routine use of endoscopic tattoos is not advised. The location of tumors in these segments is usually defined in relation to precise anatomical references, such as the ileocecal valve, the appendiceal orifice, and the hepatic shadow. These references allow for reliable localization based on the approximate distance of the lesion in centimeters, as well as the contralateral position of the lesion on the colonic wall. However, for some special cases where localization in the ascending colon is unclear for the endoscopist, endoscopic tattooing can be considered as an additional strategy to ensure accurate lesion identification during subsequent surgical interventions.

ENDOSCOPIC TATTOOING FOR RECTAL TUMORS

The tattooing of rectal tumors remains a topic of debate. Traditionally, rectal polyps and tumors are not tattooed due to their proximity to the anus, which facilitates localization via proctoscopy or digital examination. Furthermore, the visualization of submucosal tattoos is complex in the rectum due to the density of the mesorectum, which can hinder their identification[10]. The rectum's own anatomical landmarks, such as the valves of Houston, can facilitate localization without the need for marking.

Another reason to avoid tattooing rectal tumors is the risk of dye absorption by local lymph nodes, which could lead to overstaging of rectal tumors on magnetic resonance imaging. Likewise, spillage of the tattoo into the mesorectal plane complicates surgical resections, whether open or laparoscopic, by distorting the anatomical planes necessary to complete a total mesorectal excision.

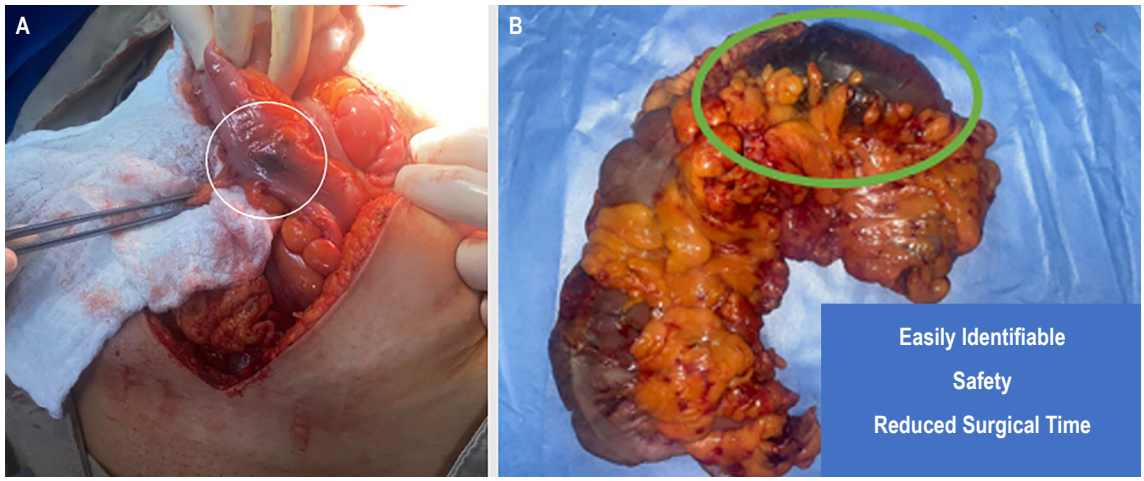

Figure 5. Appropriate identification of endoscopic tattoo. **A.** Identification of the endoscopic tattoo in open surgery. **B.** Identification of the endoscopic tattoo on a surgical specimen. Images property of the authors.

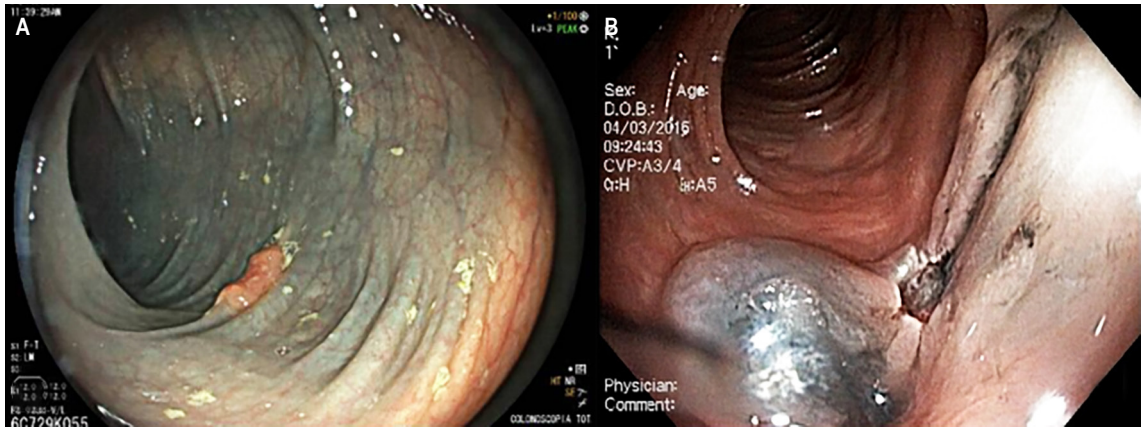

Figure 6. Tattoo dispersion towards the lesion. **A.** Occurs when a distance of 2 to 5 cm distal to the lesion suspicious for malignancy in the colon is not ensured. **B.** A distal distance from the resected lesion is not guaranteed, making a second endoscopic procedure technically more difficult if the margins are not R0 due to the submucosal fibrosis generated. Images property of the authors.

However, a retrospective study by Keller et al.[22] demonstrates benefits in using tattoos for rectal tumors in situations where immediate surgical management is not initially planned. They found that between 5% and 8% of apparently benign polyps removed during colonoscopy contained invasive carcinoma. In the absence of a tattoo, the precise identification of the resected polyp's location for adequate follow-up becomes difficult. Furthermore, endoscopists often face challenges in predicting the malignant potential of polyps. In this context, tattooing helped to accurately locate critical areas and facilitated the planning of resection margins for polyps with high-grade dysplasia.

The implications of not locating a rectal polyp accurately can be significant: inappropriate use of neoadjuvant therapy, unnecessarily extensive resections, or the creation of unnecessary or permanent stomas. Therefore, tattooing can be a useful tool in certain situations, such as for rectal polypectomies, incomplete resections, or before initiating neoadjuvant therapy. Nevertheless, the evidence is limited, highlighting the need for further studies to clearly define the benefits and risks of this practice compared to traditional localization methods.

TATTOOING IN THE CONTEXT OF MULTIPLE LESIONS

In cases where multiple synchronous lesions or tumors are identified in the colon, there are currently no specific guidelines on the optimal tattooing technique. In this context, we similarly recommend tattooing at a position at least 2 to 5 cm distal to both the most proximal and the most

distal lesion. This technique allows the surgeon to clearly distinguish between the anatomical margins required for resection, minimizing the possibility of confusion caused by multiple tattoos and visual saturation of the surgical field. Implementing an orderly tattooing method for multiple lesions contributes to improved surgical precision and oncological outcomes, underscoring the importance of a standardized protocol in these cases.

CONCLUSIONS

Endoscopic colon tattooing has transcended being a simple marking to become an essential tool in the planning and execution of colorectal surgery, with a direct impact on surgical precision, patient safety, and the optimization of oncological resection margins. Evidence supports the use of tattooing in the colon, reducing the need for additional interventions. Although the use of tattooing in the rectum remains a topic of discussion due to its anatomical proximity to identifiable structures, it can be beneficial in specific situations. The absence of standardized guidelines for determining the ideal timing of endoscopic tattooing and the need for protocols for identifying multiple lesions underscores the urgency for additional research to establish clear directives. Systematically applied endoscopic tattooing, aligned with oncological needs, provides greater security for both the surgeon and the endoscopist, impacting clinical outcomes and the survival of patients with colorectal cancer. Finally, it is important to highlight that with the advent of immunotherapy and the potential for complete endoscopic and radiological response, these patients should also undergo endoscopic tattooing for follow-up purposes.

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