Routine pathologic evaluation of circular stapler anastomotic rings is not useful after resection for colorectal cancer: retrospective study and systematic review with meta-analysis

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Abstract

Background: Circular staplers are commonly used for reconstruction after radical resection for colorectal cancer. Pathological analysis of the anastomotic rings is common practice, although the benefits are unclear. The purpose of this study was to evaluate the usefulness of routine histopathological analysis of anastomotic rings in an original series and in a systematic review of the literature.

Method: The retrospective study was performed at two university-associated academic hospitals in Winnipeg, Canada, including patients investigated for colorectal cancers (within 30 cm of the anal verge) who underwent resection between 2007 and 2020. The systematic review involved Ovid MEDLINE, Embase, Scopus, and Web of Science databases, selecting for adult human studies involving analysis of anastomotic rings in elective colorectal cancer resections. The main outcome measure was the proportion of patients with cancer in the anastomotic ring specimens. The frequency of benign pathology findings and changes to patient management were also examined.

Results: Out of 673 eligible patients, 487 were included in the retrospective analysis. No patients had cancer within the anastomotic ring specimens. Twenty-five patients (5.1 per cent) had benign pathological findings within the anastomotic ring specimens, and patient management was never affected. In the systematic review, 27 articles were included in the final analysis out of 5848 records reviewed. The rate of cancer within anastomotic ring specimens was 0.34 per cent, and the rate of change in patient management was 0.19 per cent.

Conclusion: The likelihood of finding cancer within anastomotic rings is rare and their histopathological examination seldom changes patient management.

Introduction

End-to-end anastomosis (EEA) staplers are commonly used to restore intestinal continuity after resection for left-sided colorectal cancers. Firing of the EEA stapler creates two rings of tissue, often termed ‘donuts’ or ‘doughnuts.’ The proximal ring originates from the distalmost end of the bowel proximal to the specimen, whereas the distal ring originates from wherever on the rectal or colorectal stump the ‘spike’ of the stapler is punctured through. Intraoperative assessment of these rings by surgeons predicts an intact anastomosis. Additionally, many surgeons routinely send these anastomotic rings for histological analysis to provide supplementary pathological information to that of the main surgical specimen, although this practice incurs a cost and requires considerable time and effort on the part of a pathologist.

Previously, multiple studies in the literature have investigated the value of this examination, with results generally showing little utility to analysing EEA stapler anastomotic rings. Nonetheless, guidelines from the UK’s Royal College of Pathologists continue to recommend routine analysis of these tissue samples, and surgical guidelines on the subject are lacking. The purpose of this study was to retrospectively examine data at two institutions regarding the utility of histopathological analysis for anastomotic rings, and to comprehensively review the available literature on this practice. It was hypothesized that neither local nor systematic review data would support routine histopathological analysis of anastomotic rings.

Methods

Retrospective analysis

Study protocol

The retrospective chart review was approved by the University of Manitoba’s Health Research Ethics Board and St. Boniface Hospital.
Hospital’s Research Review Committee. The STROBE tool was used as a reporting guide15.

**Study participants**

All patients who underwent an elective anterior resection or low anterior resection (LAR) for colorectal cancer using a circular stapler anastomosis from February 2007 to December 2020 at St. Boniface Hospital and Victoria Hospital in Winnipeg, Manitoba, Canada were included. Both institutions are university-affiliated teaching centres with a high volume of patients referred for subspecialized surgical care. Patients were identified retrospectively based on billing codes of the hospitals’ colorectal surgery group, then reviewed for inclusion criteria. Data were collected through manual review of hospital electronic medical records and surgeons’ office charts. The timeframe was selected because it marked the onset of a significant volume of colorectal procedures using the EEA stapler at these institutions. Tumour location was reported based on preoperative MRI imaging or, if unavailable, preoperative endoscopy reports. Tumour location was defined based on distance from the anal verge, similar to previous studies13. The following were selected as exclusion criteria: tumour location less than 30 cm from the anal verge (to capture all cases where the EEA stapler would conceivably be used), benign disease, non-sphincter-preserving surgery, handsewn anastomosis, anastomotic rings discarded intraoperatively, and absent histological examination report for anastomotic rings. Anastomotic ring evaluation always occurred after fixation in a formalin solution. The following variables were collected for each patient: age, sex, height, weight, BMI, ASA grade, tumour stage, tumour height from anal verge, tumour size, tumour histology, tumour differentiation, presence of neoadjuvant treatment, surgical approach, intraoperative leak test results, anastomotic reconstruction method, surgical margins, and total mesorectal excision (TME) completeness. The TME completeness was evaluated by a trained pathologist in accordance with the methods described by Quirke et al.14.

**Outcomes**

The primary outcome was the presence of cancer within the anastomotic ring specimens. Secondary outcomes included benign abnormalities within the anastomotic ring specimens and any changes in patient management specifically arising from the results of the anastomotic ring pathology. Pathology outcomes were evaluated based on the reporting of anastomotic ring specimens from institutional pathologists. All specimens were examined in accordance with best practices of the Canadian Association of Pathologists, using transverse sectioning of anastomotic ring specimens at regular intervals. Cancer staging was performed using the American Joint Committee on Cancer system based on the final surgical pathology. Patient medical records were examined to determine whether any change in clinical management (any additional surgery, chemotherapy, radiation, or other documented treatment modification) occurred based on anastomotic ring histopathology.

In 2020, the pathology department associated with the participating hospitals adopted a policy of reporting gross pathology results only for anastomotic rings where the tumour is less than 2 cm from the main specimen margin, a change from the previous practice of routine microscopic examination of all anastomotic rings. Patients who had only microscopic pathology results reported for their distal anastomotic ring were included in the study.

**Systematic review**

**Study protocol and design**

The systematic review protocol was registered in the international prospective register of systematic reviews (PROSPERO 2021, CRD42021275722). The systematic review was conducted according to guidelines enumerated in the Methodological Expectations of Cochrane Intervention Reviews and reported according to the PRISMA guidelines16,17. The research questions developed a priori were as follows. In adult patients undergoing elective colorectal resection for cancer, how often is cancer found in the anastomotic ring specimens?; how often is any other pathological abnormality found in the anastomotic ring specimens?; and how often does pathological analysis of anastomotic ring specimens alter patient management?

This research included all studies with adult patients (18 years or older) who underwent elective colorectal surgery for colorectal adenocarcinoma. For cohorts where some patients met the inclusion criteria and others did not (for example mix of children and adults), those where 80 per cent or more met the inclusion criteria were included in the analysis. Patients had to have undergone elective resection of their left colon or rectal cancer with curative intent, had their anastomosis constructed using a circular stapler, and had the tissue rings from the stapler sent for histopathological analysis. All practice settings were included. Patients who did not have sphincter-preserving surgery, had a handsewn reconstruction, or did not have anastomotic rings sent for pathological analysis were excluded. Trials of emergent operations and animal trials were also excluded.

A search strategy was designed in consultation with an independent health sciences information professional (Fig. S1). Database searches were conducted in MEDLINE (Ovid), Embase (Ovid), Cochrane Central (Ovid), Scopus, and Web of Science. A search of the grey literature was conducted, including American Society of Colon and Rectal Surgeons conference proceedings and unpublished/ongoing clinical trials identified from ClinicalTrials.gov. Literature was searched from 1975 (the year that a circular stapler was first described in the literature) until 23 September 202118. All retrieved records were imported into EndNote (X9, Thomson Reuters, Carlsbad, CA, USA) and deduplicated.

Citations were imported into Covidence (Covidence.org). Two reviewers independently screened citations for eligibility in duplicate using a two-stage approach. First, titles and abstracts were reviewed. Potentially relevant full-text articles were examined to determine whether they met inclusion criteria. The rationale for full-text article ineligibility was recorded. Conference abstracts were eligible for inclusion if the primary outcome was available from presented data and no full-text article based upon the data had been published to date. Data were extracted by two independent reviewers using a standardized pilot-tested form. Disagreements at all phases were resolved through consensus, or with assistance from a third party if consensus could not be achieved.

**Outcomes**

The primary outcome was the proportion of anastomotic rings where cancer was detected. Secondary outcomes were other pathological findings in the anastomotic rings and changes to patient management based on anastomotic ring pathology
(same comment as above). Studies were excluded if outcomes were unavailable from the full-length report or study abstract.

**Risk of bias**

Bias assessment was conducted by two independent reviewers using a modified Newcastle–Ottawa scale for assessing the quality of non-randomized studies in meta-analyses (Table S1). Discrepancies between reviewers were resolved by discussion and, if necessary, a third investigator (EH). Risk of bias was assessed with respect to the primary outcome of this systematic review only.

**Statistics**

Patient demographic information and outcomes of interest were analysed using basic descriptive statistics. All continuous data were normally distributed and are reported using mean and s.d. Categorical variables are reported using sample proportions. The analysis plan was determined a priori. A Freeman–Tukey transformation was used to calculate the weighted summary proportion of positive anastomotic rings, and changes to patient management. Meta-analysis data were subjected to calculations using both fixed and random-effects models and are reported as random-effects models in the text. Statistical heterogeneity was explored and quantified using the I² test.

Data were analysed using MedCalc version 20.026 (MedCalc Software, Ostend, Belgium).

**Results**

**Retrospective study**

A total of 673 patient records were evaluated for study inclusion, and 487 patients were identified as meeting the inclusion criteria (Fig. 1). Excluded patients were those who underwent permanent end colostomy, those without invasive malignancy, and those who did not have anastomotic rings sent for analysis based on factors such as palliative surgery or surgeon decision. Patient characteristics are listed in Table 1. All patients examined had a negative distal margin on the main surgical specimen. The completeness of TME was not reported in patients who had sigmoid colon cancers, or who had pathology reports from before routine description of this finding.

Table 2 shows the outcomes of interest for the microscopic pathological examination of anastomotic rings. A total of 14 proximal specimens and 21 distal specimens had a described pathological finding, across 25 total sets of anastomotic rings.

None of the patients examined had findings of cancer within the anastomotic ring specimens. Twenty-five (5.1 per cent) patients had benign pathology findings in the anastomotic rings, most commonly inflammatory changes, hyperplastic polyps, and adenomatous polyps without high-grade dysplasia. Included in this number were 0.8 per cent of patients who had a benign neoplastic process. None of the patients had changes in clinical management related to the findings of their anastomotic ring specimens.

**Systematic review and meta-analysis**

The electronic database search identified 5840 citations and manual searching identified eight citations. After duplicates were removed, 3730 records remained. Title and abstract screening determined that 246 studies were eligible for full-text review. Full-text review yielded a total of 27 articles meeting the specified inclusion criteria (Fig. S1). A total of 6861 patients were contained within these studies and 4368 of these patients had anastomotic rings sent for histopathological analysis. The effect of anastomotic ring findings on patient

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**Fig. 1** CONSORT flow diagram showing patient exclusions for retrospective study
management was reported for 3054 patients across 19 studies. Distal margin status was reported in 13 studies. The operation performed was described in 24 publications. Out of 3902 listed operations, there were 3860 anterior resections/LARs (with inconsistent or absent distinctions between these procedures among various studies), 14 subtotal colectomies, 12 left hemicolectomies, and 16 unspecified procedures.

Cancer was reported in anastomotic ring specimens for 11 patients, always in the distal ring. Two studies changed management according to negative donut histopathology when main specimen distal margins were positive. This management was contrary to other included studies and local practice. Post hoc sensitivity analysis was performed with and without these studies’ data censored to determine their effect on overall change in management rates. One author reported that patient management was affected in two of these patients after final pathology was reviewed, with both undergoing subsequent abdominopereineal resection. Both patients had no residual cancer in the final specimen, though one suffered a locoregional recurrence 23 months later. Furthermore, in that same publication, 14 patients with a distal margin that was either positive or 1 mm or less had a negative anastomotic ring specimen used to confirm the decision against further surgery. Among other studies, none of the patients with cancer in the anastomotic ring specimens had treatment altered based on these findings. Six patients had positive margins on their main surgical specimen that determined their treatment course. Two had extensive metastatic disease either before surgery or soon after surgery, and one was felt to have a separate synchronous adenocarcinoma in the distal anastomotic ring that was resected by the EEA stapler firing. Another study did not report any cancer within anastomotic ring specimens but did describe an algorithm using anastomotic ring status for patients with a positive distal resection margin of the main colorectal cancer specimen.

Meta-analysis demonstrated an overall pooled frequency of 0.34 per cent (95 per cent c.i. 0.19 to 0.53, 27 studies, 4368 participants, \( I^2 = 0 \) per cent; Fig. 2). Anastomotic rings resulted in changed patient management in 0.19 per cent (95 per cent c.i. 0.066 to 0.37, 27 studies, 4368 participants, \( I^2 = 0 \) per cent). In sensitivity analysis taking a more liberal definition of altered patient management by including patients from publications with non-standard treatment regimens (negative donut with positive distal resection margin led to no surgery), there was a 0.72 per cent (95 per cent c.i. 0.66 to 0.88, 27 studies, 4368 participants, \( I^2 = 0 \) per cent) frequency of altered patient management.

Finally, pooled analysis identified non-malignant anastomotic ring findings in a total of 74 patients (1.7 per cent). The most common pathologies included non-specific inflammatory

### Table 1 Retrospective study patient characteristics

| Patient demographics | \( n = 487 \) |
|----------------------|-------------|
| Age (years)          | 62.5 ± 12.2 |
| Sex ratio (M:F)      | 314 (64.5%):173 (35.5%) |
| BMI (kg/m²)          | 28.0 ± 5.6 |
| ASA grade            | 2.2 ± 0.6 |
| Previous abdominal surgery | 253 (51.9%) |
| IBD/polyposis syndrome/Lynch syndrome | 4 (0.8) |
| Family history of colorectal cancer | 87 (17.9) |
| Neoadjuvant therapy | 260 (53.3) |

### Tumour characteristics

| Pathological T category | \( n = 487 \) |
|-------------------------|-------------|
| 0                       | 44 (9.0)    |
| 1                       | 125 (25.6)  |
| 2                       | 120 (24.6)  |
| 3                       | 175 (35.9)  |
| 4                       | 22 (4.5)    |

| Tumour location         | \( n = 487 \) |
|-------------------------|-------------|
| Low rectum (≥6 cm)      | 73 (15.0)   |
| Middle rectum (6–12 cm) | 232 (47.6)  |
| Upper rectum (12–15 cm) | 65 (13.3)   |
| Sigmoid                 | 65 (13.3)   |
| Repeat surgery, location unclear | 3 (0.6) |

| Histology               | \( n = 487 \) |
|-------------------------|-------------|
| Adenocarcinoma          | 484 (99.4)  |
| Neuroendocrine tumour   | 2 (0.4)     |
| Gastrointestinal stromal tumour | 1 (0.2) |

### Surgery details

| Surgical approach         | \( n = 487 \) |
|---------------------------|-------------|
| Open                      | 313 (64.3)  |
| Laparoscopic              | 148 (30.4)  |
| Converted                 | 26 (5.3)    |
| Multi-visceral organ reconstruction | 76 (15.6) |

| Distal margin status      | \( n = 487 \) |
|---------------------------|-------------|
| Negative                  | 487 (100.0) |
| Positive                  | 0 (0.0)     |

| TME completeness          | \( n = 487 \) |
|---------------------------|-------------|
| Total recorded            | 198         |
| Complete                  | 154 (77.8)  |
| Nearly complete           | 38 (19.2)   |
| Incomplete                | 6 (3.0)     |

### Table 2 Retrospective study anastomotic ring findings

| Pathological exam | \( n = 487 \) |
|-------------------|-------------|
| Microscopic for distal proximal | 479 (98.4) |
| Gross for proximal, microscopic for distal | 8 (1.6) |

| Proximal ring pathology findings | \( n = 487 \) |
|---------------------------------|-------------|
| Absent                          | 465 (95.5) |
| Present                         | 14 (2.9)   |
| Microscopic examination          | 8 (1.6)    |

| Distal ring pathology findings | \( n = 487 \) |
|--------------------------------|-------------|
| Absent                          | 466 (95.7) |
| Present                         | 21 (4.3)   |

| Pathological findings | \( n = 487 \) |
|-----------------------|-------------|
| Total                 | 25          |
| Cancer                | 0           |
| Radiation changes     | 11          |
| Diverticula           | 8           |
| Tubular adenoma without | 2        |
| HGD                   | 1           |
| Ulceration            | 1           |
| Ischaemia             | 1           |
| HGD                   | 1           |
| Hyperplastic polyp    | 1           |

Values are \( n \) (%) unless otherwise indicated. IBD, inflammatory bowel disease; TME, total mesorectal excision.
change, hyperplastic polyps, and adenomatous polyps without high-grade dysplasia. These findings did not alter patient management in any instance.

**Risk of bias**
Risk-of-bias findings with respect to the primary outcome are summarized in Fig. 3 and presented in detail in Table S1. All included publications were observational in nature. Only three studies had low risk of bias across all domains. The remainder had unclear or high risk of bias, most commonly related to representativeness of the cohort to the general population.

**Discussion**
In this retrospective study involving 487 patients undergoing circular stapler reconstruction after radical resection for colorectal cancer, there were no instances of cancer in the anastomotic ring specimens. Benign findings were present in 5.1 per cent of anastomotic rings (including benign neoplastic findings in 0.8 per cent of specimens) and did not change clinical management for any patients. This is the largest set of patient data on this topic to date, further supporting the notion that routine anastomotic ring histopathological analysis is an unnecessary practice. Additionally, it provides a uniquely Canadian patient cohort, which has not previously been specifically studied for this outcome. The proportion of patients who underwent laparoscopic surgery (30 per cent) is greater than in many other studies of this topic. The systematic literature review included 27 studies reporting anastomotic ring histopathological data on 6861 patients and found a very low frequency of cancer occurrences in the specimens, with most cases accompanied by positive main specimen margins. On pooled analysis, findings of cancer within the anastomotic ring specimens occurred in only 0.34 per cent of
patients. The frequency with which these results affected patient management were even lower at 0.19 per cent.

Previously, another study also conducted a systematic review of anastomotic ring pathology, which included eight studies, 1754 patients, and concluded that the practice of routine pathological analysis of anastomotic rings should be re-evaluated. In comparison, the systematic review presented here used a more comprehensive search strategy and retrieved a larger number of studies. Studies reporting anastomotic ring histopathological findings that were not specifically designed to address the question of their usefulness were identified, thus increasing the pool of patients available for meta-analysis and increasing the statistical power of the data.

Interestingly, the systematic review identified two studies that described practices inconsistent with conventional rectal cancer practice. In both, the authors interpreted negative anastomotic rings as reassuring in the context of a positive main specimen distal margin, a practice that many rectal cancer surgeons would avoid. These two studies were excluded from the main analysis for determination of patient management change, as this practice was incongruent with standard of care and the remainder of the included studies. For practitioners who operate in settings where negative anastomotic rings are used as a negative distal margin, routine histopathological analysis of anastomotic rings might be marginally more useful; however, this practice is not commonplace. Anastomotic rings do not necessarily include a complete circumferential specimen of the bowel and therefore cannot be taken to reliably represent an additional resection margin. In particular, if a circular stapler’s ‘spike’ is not brought out directly through the proximal end of the colorectal stump, little or none of the distal ring will represent an additional distal margin.

While the present study does not support the use of routine histopathological analysis of circular stapler anastomotic rings after resection of colorectal malignancy, there may be exceptions where directed analysis is prudent. In cases where the surgeon has a compelling clinical reason to believe that the anastomotic ring might have some meaningful finding, histopathological analysis could be considered selectively. Otherwise, the cost of pathological analysis has been reported in several studies, including figures up to $643 USD (€631)9–11,13. Alleviating the burden of the pathologist’s time and effort as well as expenses for healthcare systems would be immensely beneficial.

This study has several limitations. One drawback of both the local study and systematic review is the retrospective nature of the data and absence of a comparator patient group. Without randomization, patients who had anastomotic rings submitted for pathology may have been subject to selection bias. Additionally, the local study involved high-volume colorectal surgeons, whose patient population and outcomes may not be reflective of all surgeons who use EEA staplers; however, a prospective randomized clinical trial addressing this topic is unlikely to occur and is also unlikely to provide new information due to the low frequency of events. Another limitation, unique to the systematic review, is the overall quality of the included studies. Most had at least an unclear risk of bias due to poor methods reporting. While meta-analyses can increase power and precision, they cannot eliminate any biases that exist in pooled data. Another limitation is that several studies did not report whether anastomotic ring findings changed patient management; however, of those six studies that did not comment on changes to management, none reported anastomotic rings that were positive for cancer on histopathology. Last, the rate of patient management change may have been overestimated in the meta-analysis due to reporting bias where studies with positive findings might be more likely to describe this outcome.

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Disclosure

The authors declare no conflict of interest.

Supplementary material

Supplementary material is available at BJS Open online.

Data availability

The data that support the finding of this study are available from the corresponding author, EH, upon reasonable request.

References

1. Kyzer S, Gordon PH. Experience with the use of the circular stapler in rectal surgery. Dis Colon Rectum 1992;35:696–706
2. Mason C, Przybyl K, Brelsford K. Histopathological assessment of ‘doughnuts’ after anterior resection. A regional survey and single institution audit. Colorectal Dis 2014;16:151–152
3. Davids J, Cherng N, Sturrock P et al. Time to toss the donuts? A pilot study of EEA stapler anastomotic ring pathology in rectal cancer cases. Dis Colon Rectum 2014;57:e330
4. Dixon S, Barrow H, Hughes J. Doughnut bother! Histopathological examination of anastomotic doughnuts following colorectal anastomosis does not change patient management. Surg Exp Pathol. 2020;3:1–4
5. Haq I, Shakeel O, Amjad A, Ullah F, Ali H, Jamal A et al. Benefits of outcomes of the microscopic examination of anastomotic donuts after colorectal resection for oncological purposes: a medical record-based study. Cureus 2020;12:e7932
6. Iqbal MR, Deputy M, Bailey S, Lawes D. Routine ‘doughnut’ histology after anterior resection: does it add any clinical benefit? Colorectal Dis 2017;19:97
7. Jain P, Saad A, Bowley D, Karandikar S. Should we analyse the doughnuts after stapled restorative surgery for low rectal cancer? Colorectal Dis 2012;14:9
8. Miiri B, Joondan Z, Kelly M. Routine histological examination of ‘doughnuts’ following anterior resection for rectal cancers: is it a fruitless exercise? Brit J Surg 2004;91:3
9. Morgan A, Dawson PM, Smith JJ. Histological examination of circular stapled ‘doughnuts’: questionable routine practice? Surgeon 2006;4:75–77
10. Ng CW, Lieske B, Tan KK. Routine histological sampling of doughnuts post oncologic anterior resection is not necessary. Int J Colorectal Dis 2014;29:843–845
11. Pollyblank AM, Kirwan C, Bigby HS, Dixon AR. Is routine histological reporting of doughnuts justified after anterior resection for colorectal cancer? Colorectal Dis 2001;3:198–200
12. Speake WJ, Abercrombie JF. Should ‘doughnut’ histology be routinely performed following anterior resection for rectal cancer? Ann R Coll Surg Eng 2003;85:26–27
13. Sugrue J, Dagbert F, Park J, Mareck S, Frasad LM, Chaudhry V et al. No clinical benefit from routine histologic examination of stapler doughnuts at low anterior resection for rectal cancer. Surgery 2017;162:147–151
14. Loughrey MB, Quirke P. Shepherd NA. Standards and datasets for reporting cancers: Dataset for histopathological reporting of colorectal cancer, September 2018. Royal College of Pathologists, 2018
15. Von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The strengthening of the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet 2007;370:1453–1457
16. Chandler J, Churchill R, Higgins J, Lasserson T, Tovey D. Methodological standards for the conduct of New Cochrane Intervention Reviews (MECIR), 2013
17. Liberati A, Douglas G, Altman J, Mulrow C, Gøtzsche PC, Ioannidis JPA et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol 2009;62:e1–e43
18. Fain SN, Patin CS, Morgenstern L. Use of a mechanical suturing apparatus in low colorectal anastomosis. Arch Surg 1975;110:1079–1082
19. Lewis-Lloyd C, Adiamah A, Pettitt E, Crooks C, Humes D. Risk of post-operative venous thromboembolism after surgery for colorectal malignancy: a systematic review and meta-analysis. Dis Colon Rectum 2021;64:484–496
20. Freeman MF, Tukey JW. Transformations related to the angular and the square root. Ann Math Stat 1950;21:607–611
21. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med 2002;21:1539–1558
22. Colombo PL, Foglieni CL, Morone C. Analysis of recurrence following curative low anterior resection and stapled anastomoses for carcinoma of the middle third and lower rectum. Dis Colon Rectum 1987;30:457–464
23. Cong JC, Shen CS, Ma MX, Xia ZX, Liu DS, Zhang FY. Laparoscopic intersphincteric resection for low rectal cancer: comparison of stapled and manual coloanal anastomosis. Colorectal Dis 2014;16:353–358
24. De Palma GD, Luglio G, Staibano S, Bucci L, Esposito D, Maione F et al. Perioperative characterization of anastomotic doughnuts with high-resolution probe-based confocal laser endomicroscopy in colorectal cancer surgery: a feasibility study. Surg Endosc 2014;28:2072–2077
25. Ferdaus AM, Hossain MS, Islam SH, Islam T, Islam FA, Islam MS et al. The role of histological assessment of distal doughnut in low anterior resection for low rectal cancer. Mymensinig Med J 2020;29:73–77
26. Gertsch P, Baer HU, Kraft R, Maddern GJ, Altermatt HJ. Malignant cells are collected on circular staplers. Dis Colon Rectum 1992;35:238–241
27. Keranmu A, Liu HN, Wu YC, Liu TT, Li C, Guo TA et al. A negative-doughnut distal resection margin less than 5 mm does not affect prognosis in rectal cancer. J Surg Oncol 2018;118:536–543
28. McAnera OJ, Heald RJ, Lockhart-Mummery HE. Operative and functional results of total mesorectal excision with ultra-low anterior resection margin for rectal cancer: is it safe? Ann Diagn Pathol 2011;15:117–121
29. Morlote DM, Alexis JB. Is the routine microscopic examination of proximal and distal resection margins in colorectal cancer surgery justified? Ann Diagn Pathol 2016;20:35–37
30. Rubbini M, Vettorello GF, Guerrera C, Mari C, De Anna D, Mascoli F et al. A prospective study of local recurrence after resection and low stapled anastomosis in 183 patients with rectal cancer. Dis Colon Rectum 1990;33:117–121
31. Rutkowski A, Nowacki MP, Chwalinski M, Oledzki J, Bednarczyk M, Liszka-Dalecki P et al. Acceptance of a 5-mm distal bowel resection margin for rectal cancer: is it safe? Colorectal Dis 2012;14:71–78
32. Skouras C, Tang E, Jamil N, Baumstarck K, Vinton V. An evaluation of the quality of surgical resections for colorectal cancer—a district general hospital experience. Colorectal Dis 2014;16:170
33. Terzi C, Ünek T, Sağol O, Yılmaz T, Füzün M, Sökmen S et al. Is rectal washout necessary in anterior resection for rectal cancer? A prospective clinical study. World J Surg 2006;30:233–241
34. Varma JS, Chan AC, Li MK, Li AK. Low anterior resection of the rectum using a double stapling technique. Br J Surg 1990;77:888–890
35. Vernava AM III, Moran M, Rothenberger DA, Wong WD. A prospective evaluation of distal margins in carcinoma of the rectum. Surg Gynecol Obstet 1992;175:333–336
36. Vilela IF, Barroso MH, Sanchez AS, Hernandez GH, Jimenez ND, Sanchez EP. Utility of routine histological examination of stapler doughnuts at low anterior resection for rectal cancer. Colorectal Dis 2018;20:126
37. Wlodarczyk J, Gaur K, Mertz K, Wickham C, Mirza KL, Hsieh C et al. Do or doughnut: a systematic review and pooled analysis on the utility of pathological evaluation of the anastomotic doughnut in oncological colorectal operations. Colorectal Dis 2022;24:8–15
38. Bujko K, Rutkowski A, Chang GJ, Michalski W, Chmielik E, Kusnierz J. Is the 1-cm rule of distal bowel resection margin in rectal cancer based on clinical evidence? A systematic review. Ann Surg Oncol 2012;19:801–808