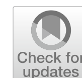
Techniques in Coloproctology (2025) 29:66
https://doi.org/10.1007/s10151-024-03091-2

ORIGINAL ARTICLE



Feasibility and usefulness of the elongation of ileocolic pedicle with extended ileal resection on secure anastomosis after laparoscopic restorative proctocolectomy: a retrospective observational study

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Received: 10 April 2023 / Accepted: 5 December 2024 / Published online: 14 February 2025
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Abstract

Purpose Tension-free ileal pouch–anal anastomosis (IPAA) in restorative proctocolectomy (RPC) for ulcerative colitis (UC) and familial adenomatous polyposis (FAP) is important for avoiding anastomotic complications. We have employed the elongation of ileocolic pedicle (ICP) with extended ileal resection as one of the mesenteric-lengthening techniques. In this study, we examined the feasibility and usefulness of our mesenteric-lengthening technique.

Methods This retrospective study enrolled 60 patients for whom laparoscopic RPC with IPAA was electively planned for UC and FAP from January 2009 to December 2022. In 41 patients ("conventional group"), the ileum was cut flush to the cecum without ileal resection, and in 19 patients ("experimental group"), the elongation of the ICP with extended ileal resection was conducted. The short-term outcomes were compared between the two groups, and the risk factor for anastomotic complications was examined.

Results The preoperative and intraoperative parameters did not differ between the two groups. However, the incidence of anastomosis-related complications (ARCs) was significantly lower in the experimental group than in the conventional group (0.0% versus 14.6%, respectively; $p=0.027$). Univariate analysis demonstrated that the elongation of the ICP with extended ileal resection was significantly correlated with ARCs ($p=0.027$ and $p=0.030$, respectively), although multivariate analysis did not show the independent factors.

Conclusion The lengthening technique using the elongation of the ICP with extended ileal resection is feasible and safe, and might be one choice for secure IPAA during the laparoscopic approach for RPC.

Keywords Mesenteric lengthening · Ileal J-pouch · Laparoscopic restorative proctocolectomy · Sacrifice of the intestine

Introduction

Restorative proctocolectomy (RPC) with ileal J-pouch–anal anastomosis (IPAA) is a standard surgical treatment for ulcerative colitis (UC) and familial adenomatous polyposis (FAP), and most patients who undergo IPAA have satisfactory functional and long-term outcomes [1–3]. With the advent of endoscopic surgery, many colorectal surgeons have been challenging laparoscopic RPC, which is reportedly safe and feasible for patients with UC and FAP [4, 5]. Even so, anastomosis-related complications (ARCs), such as anastomotic leakage, abscess and fistula formation around the pouch, bleeding, and anastomotic stricture, are still serious issues, which could worsen patients' quality of life and lead to pouchitis and pouch failure [6].

The main risk factors for ARCs have been considered to be anastomotic tension and ischemia of the pouch [7–11]. Therefore, several ileal mesenteric-lengthening techniques have been developed for tension-free anastomosis with preservation of adequate blood flow. The main techniques for creating additional mesenteric length are ligation of some of the vascular arcades of the mesentery and freeing of any peritoneal thickening or adhesions that disturb the stretch of the

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vessels [12–15]. Although division of ileocolic pedicle (ICP) or superior mesenteric pedicle (SMP) is effective for lengthening, careful attention is needed to preserve adequate blood flow of the pouch.

We have established an effective mesenteric-lengthening technique with the elongation of the ICP with extended ileal resection, which could certainly preserve the blood flow from ileocolic vessels. Even in upper gastrointestinal surgery, it was reported that sacrificing a small part of the jejunum was useful for tension-free esophagojejunostomy in total gastrectomy [16]. We herein describe our technique and investigated its feasibility and usefulness.

Materials and methods

This retrospective study enrolled 60 patients for whom laparoscopic RPC with IPAA was electively planned for UC and FAP from January 2009 to December 2022 in the Department of Surgery, Saga University Hospital and the Department of Surgery and Oncology, Kyushu University Hospital. It was planned for 41 consecutive patients to receive IPAA using the terminal ileum from January 2009 to November 2014 ("conventional group"). In one patient from the conventional group, IPAA could not be created, because the pouch could not reach the anal canal despite the division of the ICP, and pouch ischemia developed; a permanent ileostomy was therefore created. After that patient, for the purpose of preservation of blood flow, the mesenteric-lengthening technique with the elongation of the ICP with extended ileal resection was performed in 19 consecutive patients ("experimental group") from December 2014 to December 2022. In the conventional group, four expert surgeons (including the first author) performed surgery, and in the experimental group, the first author completed surgeries as a leading surgeon. The demographics of the patients were obtained from a prospectively maintained comprehensive database and the patients' medical records. Complications that occurred within 30 days of surgery were evaluated according to the Clavien–Dindo classification [17]. ARCs included anastomotic leakage (clinical and radiological leakage), anastomotic stricture (requiring multiple dilation and/or a surgical approach), fistula formation, anastomotic bleeding (requiring endoscopic or surgical hemostasis), and intraoperative abandonment. This research adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist [18] (Appendix).

Surgical technique

Laparoscopic procedure

All laparoscopic procedures were conducted according to our previous report [19]. In summary, after mobilization of the entire colon and rectum, the rectum was transected using an endoscopic linear stapler at the level of the anal canal. Next, the mesentery from the sigmoid colon to the right colon was divided with a LigaSure™ bipolar vessel sealer (Medtronic, Minneapolis, MN, USA) with preservation of the ICP. The entire large bowel and ileum were delivered through the enlarged navel small incision.

Mesenteric lengthening, creation of ileal J-pouch, and anastomosis

In all cases, a reach test was performed in which the planned apex of the J-pouch could go beyond the symphysis pubis with minimal tension prior to creation of the J-pouch. In the conventional group, the terminal ileum was cut flush to the cecum, and the apex was set at 13 cm from the oral side of the terminal ileum. When the apex could not go beyond the symphysis pubis, scoring of the mesenteric peritoneum and/or division of the SMP or ICP were performed (Fig. 1a). In the experimental group, about 5 cm of the terminal ileum was resected with preservation of the marginal arcade connecting the ileocolic vessels, resulting in the elongation of the ICP equivalent to the length of the resected ileum (Fig. 1b). When the apex could not go beyond the symphysis pubis, scoring of the mesenteric peritoneum and/or division of the SMP were performed. In each patient, a 13 cm ileal J-pouch was created with multiple firings of the linear stapler. Stapled or hand-sewn IPAA with rectal mucosectomy was carried out according to the patient's clinical situation.

Statistical analyses

All statistical analyses were performed using JMP version 16 (SAS Institute, Cary, NC, USA). For descriptive analysis, continuous variables were compared between the groups using the Mann–Whitney *U* test, while the chi-squared test and analysis of variance were used for comparison of categorical variables. For univariate analysis, simple logistic regression analysis was used. Multiple logistic regression analysis with Firth correction was performed to identify factors that were independently associated with ARCs. A p-value of < 0.05 was considered statistically significant.

Results

Patient characteristics

The patient characteristics are shown in Table 1. Patient age, sex, disease, body mass index, preoperative steroid use, serum albumin level, prognostic nutritional index, and American Society of Anesthesiologists physical status did

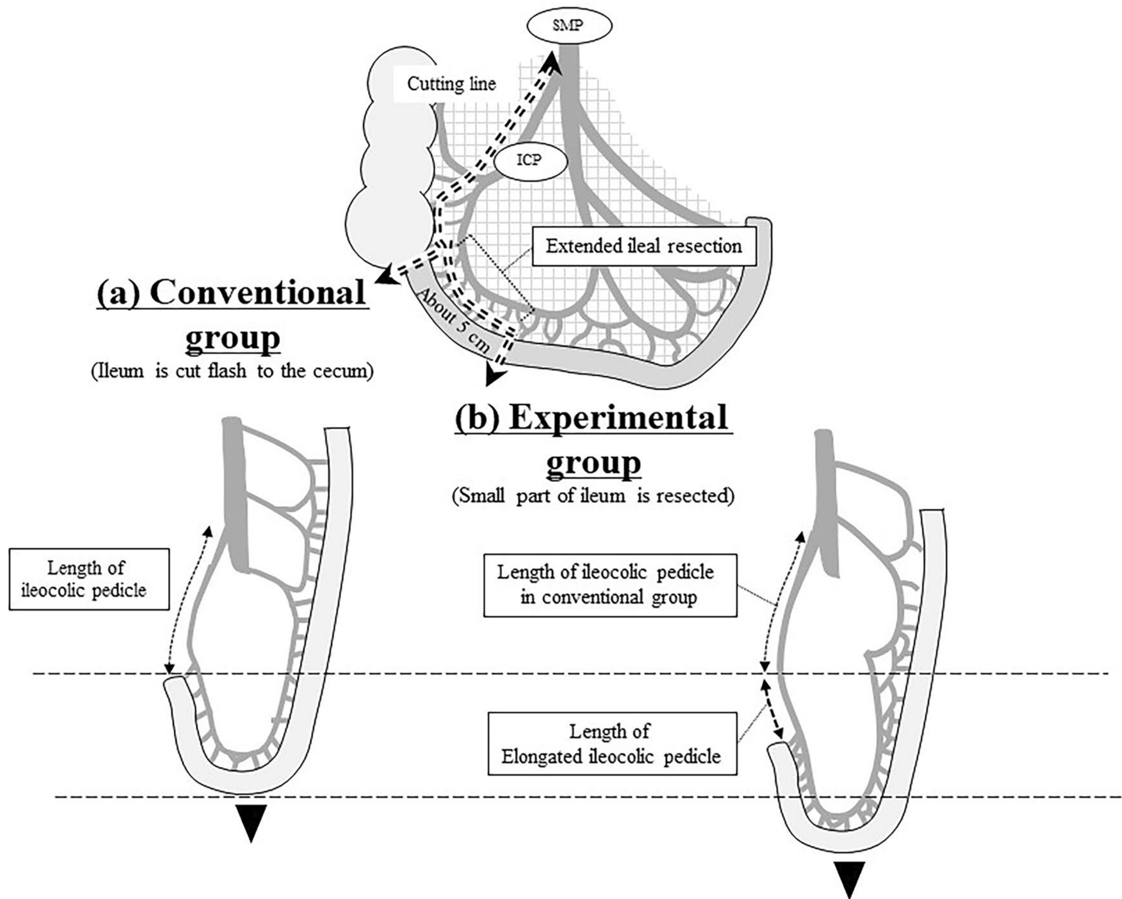

Fig. 1 Schematic diagram showing the elongation of the ileocolic pedicle with extended ileal resection. **a** Cutting line of the mesentery. In the conventional group, the terminal ileum was cut flush to the cecum. In the experimental group, about 5 cm (less than 10 cm) of the terminal ileum was resected with conservation of the marginal arcade connecting the ileocolic vessels using a LigaSure™. **b** Completion of the experimental group. As a result, the elongation of the ileocolic pedicle could be obtained. *SMP* superior mesenteric pedicle, *ICP* ileocolic pedicle

Table 1 Patient characteristics in both groups

		Conventional group $n=41$	Experimental group $n=19$	p-Value
Age (years)	Median (range)	38.4 (14–78)	46.8 (16–75)	0.059
Sex	Male/female	24/17	11/8	0.963
Disease	UC/FAP	29/12	16/3	0.248
BMI (kg/m^2)	Mean (range)	21.6 (15.4–29.9)	20.9 (15.0–28.2)	0.484
Steroid use	Yes/no	18/23	8/11	0.896
Serum albumin (g/dl)	Mean (range)	3.8 (1.9–4.8)	3.6 (1.7–4.6)	0.361
PNI	Mean (range)	45.0 (28.0–63.0)	43.0 (27.0–54.3)	0.404
Surgical history	Yes/no	0/41	1/18	0.126
ASA-PS	1/2/3	16/24/1	7/11/1	0.858

UC ulcerative colitis, *FAP* familial adenomatous polyposis, *BMI* body mass index, *PNI* prognostic nutritional index, *ASA-PS* American Society of Anesthesiologists physical status

not significantly differ between the conventional group and experimental group.

Short-term outcomes

The surgical parameters and postoperative outcomes of both groups are shown in Table 2. The type of operation (one- or two-staged), anastomotic type (hand-sewn or stapled), operation time, blood loss volume, and postoperative stay did not differ significantly between the two groups. Although there was no significant difference in the incidence of Clavien–Dindo grade 3 postoperative complications, the incidence of ARCs was significantly lower in the experimental group than in the conventional group (0.0% versus 14.6%, respectively; $p = 0.027$).

Risk factors for the occurrence of ARCs

Table 3 shows the results of univariate and multivariate analysis for the occurrence of ARCs. Univariate analysis revealed that type of anastomosis and additional elongation of the ICP were significantly associated with the incidence of anastomotic complications ($p = 0.030$ and $p = 0.027$, respectively). However, in multivariate logistic regression analysis with Firth correction, both factors were not significantly associated with the occurrence of anastomotic complications.

Discussion

The elongation of the ICP with extended ileal resection could have potential advantages for tension-free IPAA. First, this procedure could make division of the ICP unneeded for lengthening the pouch mesentery. Consequently, two-way reliable blood flow with adequate mesenteric length could be provided. Second, the longest mesentery, which is advantageous for secure IPAA as the apex, is located at about 19 cm (15–20 cm) from the ileocecal valve, as seen in a cadaver study by Smith et al. [20]. Sacrificing a small part of the ileum (about 5 cm) could make the apex be located close to the greater mesentery without elongation of the pouch size.

In 1995, Goes et al. [21] reported a lengthening technique with preservation of the marginal arcade from the middle colic artery to the ileal branches and division of the ileocolic artery, which could provide good elongation, as seen in a study using cadavers [22], and be clinically useful [23]. As shown in Fig. 1b, the final form of the mesentery of the J-pouch attained by our technique seems to imitate that attained by the technique of Goes et al. Although the technique used by Goes et al. must be planned at least prior

Table 2 Surgical parameters and postoperative outcomes in both groups

		Conventional group $n = 41$	Experimental group $n = 19$	p-Value
Operation plan	One-staged/two-staged	8/33	2/17	0.369
Type of anastomosis	Hand-sewn/stapled	33/8	18/1	0.120
Operating time (min)	Median (range)	598 (380–862)	553 (392–850)	0.306
Blood loss (ml)	Median (range)	200 (0–1185)	135 (0–900)	0.487
Conversion to laparotomy		0 (0%)	0 (0%)	–
Postoperative complication (> grade 3*)	Total	9 (22.0%)	1 (5.3%)	0.079
	Anastomotic breakdown	1	0	
	Pelvic abscess	1	0	
	Intraabdominal abscess	2	1	
	Bowel obstruction	4	0	
	Peristomal abscess	1	0	
	Anastomotic bleeding	2	0	
Anastomosis-related complication	Total	6 (14.6%)	0 (0%)	0.027
	Stricture	3	0	
	Breakdown	1	0	
	Nonreaching	1	0	
	Bleeding	1	0	
Reoperation (within 30 days from operation day)		0 (0%)	0 (0%)	–
Hospital stay (days)	Median (range)	19.5 (9–112)	20 (13–35)	0.591
Readmission (within 30 days from discharge)		0 (0%)	0 (0%)	–

*According to Clavien–Dindo classification

Table 3 Univariate and multivariate analysis of the risk factor for ARCs

	Univariate analysis OR (95% CI)	*p*-Value	Multivariate analysis OR (95% CI)	*p*-Value
Age	1.0004 (0.9521–1.0513)	0.706		
Sex				
Male/female	2.0317 (0.4123–10.0125)	0.381	1.2201 (0.2675–2.31956)	1.000
Disease				
UC/FAP	0.8125 (0.1405–4.6998)	0.817	0.8144 (0.2675–2.3194)	0.902
BMI (kg/m^2)	1.0604 (0.8501–1.3228)	0.916		
Preoperative steroid use				
Yes/no	1.0222 (0.2079–5.0251)	0.978	0.7581 (0.2541–2.2457)	0.874
Serum albumin (g/dl)	0.7378 (0.2246–2.4232)	0.604		
PNI	0.9265 (1.0334–1.0793)	0.147		
ASA-PS				
1–2/3	0.8533 (0.2281–10.2094)	1.000		
Previous operation				
Yes/no	1.5275 (0.1241–6.9421)	1.000		
Operation plan				
One-staged/two-staged	0.8148 (0.0872–7.6167)	0.858		
Type of anastomosis				
Hand-sewn/stapled	0.125 (0.01882–0.8020)	0.030	0.44710 (0.1965–1.1257)	0.086
Lengthening technique				
Experimental/conventional	0.3434 (0.0298–1.0297)	0.027	0.4253 (0.0366–1.3548)	0.104
Operating time (min)	1.0008 (0.9935–1.0081)	0.833		
Blood loss (ml)	1.0001 (0.9971–1.0043)	0.963		

UC ulcerative colitis, *FAP* familial adenomatous polyposis, *BMI* body mass index, *PNI* prognostic nutritional index, *ASA-PS* American Society of Anesthesiologists physical status

to colectomy, our technique can be applied even after the laparoscopic procedure. However, our technique required resection of a small part of ileum, which is unnecessary in technique of Goes et al.

In this study, the majority of IPAA (85%) was performed by hand-sewn anastomosis, and hand-sewn IPAA was greater in the experimental group. Possible reasons are that hand-sewn IPAA was adopted in patients with neoplastic disease and severe proctitis in our institutions and that surgery for ulcerative-colitis-associated cancer has increased these days [24]. Univariate analysis demonstrated that stapled IPAA might be one of the risk factors for ARCs compared with hand-sewn IPAA, although both stapled and hand-sewn IPAAs have been reported to have comparable complication rates, functional outcomes, and quality of life [25]. In contrast, multivariate analysis showed no significant factor. The possibility that a confounding effect was caused by small sample size cannot be ruled out.

Several points require further discussion. First, although our technique was consecutively applied in the experimental group, our technique is not necessary for all cases. Actually, in most patients in the conventional group, IPAA was safely created. Our technique should be taken into account when the apex of pouch is hard to reach. Second, our technique cannot be applied for patients with a malignant tumor at the right colon requiring lymph node dissection along the ICP. Third, the effect of resection of the terminal ileum on long-term nutritional status is still unknown, especially in juvenile patients, although the length of the resected ileum is short in our technique.

This study has two main limitations. First, it was a retrospective study with a very small sample size, which might cause several confounders and possible statistical error. Moreover, our lengthening technique was significant only in univariate analysis, but not significant in multivariate analysis. Therefore, the results might not be definite. Second, the cohort was divided into an earlier and later study period, and the quality of surgery and skill of the surgeons undeniably improved over time.

In conclusion, the elongation of the ICP with extended ileal resection is feasible and safe, and might be one choice for secure IPAA. We hope that this preliminary study will encourage an analysis of a larger patient population, including the patients' metabolic status.

Appendix

STROBE Statement—checklist of items that should be included in reports of observational studies.

	Item number	Recommendation	Page number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract.	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found.	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported.	5
Objectives	3	State specific objectives, including any prespecified hypotheses.	6
Methods			
Study design	4	Present key elements of study design early in the paper.	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection.	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. *Case–control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls. *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants.	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed. *Case–control study*—For matched studies, give matching criteria and the number of controls per case.	No
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	No
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group.	*8*
Bias	9	Describe any efforts to address potential sources of bias.	8
Study size	10	Explain how the study size was arrived at.	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why.	8

	Item number	Recommendation	Page number
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding.	8
		(*b*) Describe any methods used to examine subgroups and interactions.	8
		(*c*) Explain how missing data were addressed.	6
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed. *Case–control study*—If applicable, explain how matching of cases and controls was addressed. *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy.	No
		(*e*) Describe any sensitivity analyses.	No
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analyzed.	6
		(b) Give reasons for nonparticipation at each stage.	No
		(c) Consider use of a flow diagram.	No
Descriptive data	14*	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders.	9
		(b) Indicate number of participants with missing data for each variable of interest.	6
		(c) *Cohort study*—Summarize follow-up time (e.g., average and total amount).	No
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time.	*9*
		Case–control study—Report numbers in each exposure category, or summary measures of exposure.	No
		Cross-sectional study—Report numbers of outcome events or summary measures.	No

*Give information separately for cases and controls in case–control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobestatement.org.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s10151-024-03091-2.

Acknowledgements The authors thank Dr. Atsushi Kawaguchi of the Center for Comprehensive Community Medicine at the Faculty of Medicine of Saga University for his valued assistance in the statistical analyses of this study.

Author contributions T.M. contributed to the study conception and design and drafted the manuscript. Y.M., S.T., T.F., K.O., and F.T. contributed to the data acquisition, analysis, and interpretation. M.N. and H.N. critically reviewed the manuscript. All authors approved the final manuscript.

Data availability The datasets analyzed during this study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures in this study were conducted in accordance with the ethical standards of the responsible committee on human study and with the Helsinki Declaration and later revision. The study protocol was approved by the Ethics Committee of the Faculty of Medicine at Saga University (2019–09-Jinsoku-03) and Kyushu University (29–292).

Informed consent All patients consented to the use of their data in this study.

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