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Risk factors of incisional hernia after laparoscopic colorectal surgery with periumbilical minilaparotomy incision: a propensity score matching analysis

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Purpose: Incisional hernia is one of the most common complications after abdominal surgery conducted through a midline incision. Considerable debate remains regarding the design, comorbidity, suture material, and method. We investigated the risk factors for incisional hernia after laparoscopic colorectal surgery in the presence of limited surgery-related factors.

Methods: A retrospective study was designed with 541 patients who underwent laparoscopic colorectal surgery performed by a single operator from January 2015 to December 2017. Due to open conversions, other abdominal operations, or follow-up loss, only 445 patients were included in the study. After propensity score matching, 266 patients were included. The study was based on diagnosis of incisional hernia on computed tomography at 6 and 12 months postoperatively.

Results: Of the 266 total patients, 133 underwent abdominal closure using PDS (Ethicon), while the remaining 133 underwent closure with Vicryl (Ethicon). Of these patients, nine were diagnosed with incisional hernia at the 12-month follow-up: six (4.5%) in the Vicryl group and three (2.3%) in the PDS group ($p = 0.309$). The incidence of incisional hernia was significantly increased in females (odds ratio [OR], 15.233; 95% confidence interval [CI], 1.905–121.799; $p = 0.010$), in patients with body mass index (BMI) of >25 kg/m^2 (OR, 4.740; 95% CI, 1.424–15.546; $p = 0.011$), and in patients with liver disease (OR, 19.899; 95% CI, 1.614–245.376; $p = 0.020$).

Conclusion: BMI of >25 kg/m^2, female, and liver disease were significant risk factors for incisional hernia after elective laparoscopic colorectal surgery performed through a transumbilical minilaparotomy incision.

Keywords: Incisional hernia, Colorectal surgery, Laparoscopy, Propensity score

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INTRODUCTION

Incisional hernia is one of the most frequent complications after abdominal surgery carried out through a midline incision; it is defined as protrusion of structures into the abdominal cavity through defects in the fascia of the abdominal wall [1,2]. This type of hernia has a frequency ranging from 5% to 20% depending on observation period and research method [3,4]. The occurrence of these kinds of hernias has a major impact on patient life and cost of associated medical care required for repair [5,6].

Risk factors associated with incisional hernia can be categorized as either patient-related or surgical-related factors. Patient-related factors include age, sex, obesity, and comorbidities (diabetes, hypertension, chronic lung disease, liver disease, im-

munosuppression status), while surgery-related factors include emergency surgery, bowel surgery, abdominal aortic aneurysm, peritonitis surgery, re-laparotomy, suture technique, and suture material [7]. Many procedures and methods that involve different suture materials, techniques, and combinations with a laparoscopic approach have been discussed; however, the risk factors for incisional hernia remain controversial depending on various factors, and there is lack of consensus on the best approach for preventing incisional hernia [8].

With development of minimally invasive colorectal surgery using laparoscopic procedures, a successful approach is a main incision of approximately 5 to 6 cm for specimen retrieval [9], and frequency of incisional hernia has significantly decreased [10]. However, there have been only few research on the risk factors for incisional hernia after laparoscopic colorectal surgery.

In this study, we investigated the influence of risk factors and suture material on development of incisional hernia in laparoscopic colorectal surgery in situations where surgery-related factors were limited as much as possible.

MATERIALS AND METHODS

Patients

All patients who underwent laparoscopic colorectal surgery by a single surgeon at Pusan National University Yangsan Hospital in Yangsan, Korea between January 2015 and December 2017 were considered for this study. The inclusion criteria were suitability for elective laparoscopic colorectal surgery (regardless of benign or malignant disease) and age of 15 to 90 years. The exclusion criteria were conversion to an open procedure, cooperation with another surgeon, and undergoing another major abdominal operation during the follow-up period.

A retrospective study was conducted with 541 patients. We collected data on patient sex, age, diagnosis, type of performed colorectal operation, body mass index (BMI), medical history, history of previous surgeries, comorbidities, and suture material used to close the abdominal fascia by reviewing medical records from hospitalizations and outpatient visits. Diagnosis of a postoperative incisional hernia was made by a radiologist using computed tomography (CT) scans of the abdomen based on the presence of an abdominal wall gap, a defect in the proximity of the postoperative scar, or protrusion of abdominal contents [11] at approximately 6 months and 12 months after surgery as a routine follow-up schedule after colorectal surgery.

Surgical procedure

All patients underwent elective laparoscopic colorectal surgery. A 10-mm umbilical incision was created to insert a trocar for the laparoscope port, and then four trocars were inserted to perform appropriate colon or rectal resection based on the lesions or disease present. After dissection, a 5-cm minilaparotomy incision was made in the umbilical trocar site to remove the resected specimen. The wound was closed layer by layer; first, the midline fascia was closed using an interrupted suture method with intervals of about 0.5 cm (Fig. 1). Two types of suture materials were used to close the abdominal fascia: 1-0 PDS II (monofilament, polydioxanone; Ethicon, Cincinnati, OH, USA) and 1-0 Vicryl (multifilament, polyglactin 910; Ethicon). The subcutaneous layer and skin were closed sequentially.

Statistical analysis

The patients were divided into two groups based on incidence of an incisional hernia, and their risk factors were compared using statistical analysis. IBM SPSS version 24 (IBM Corp., Armonk, NY, USA), and R version 3.3.3 (R Foundation for Statistical Computing, Vienna, Austria) software were used for statistical analysis. A chi-square test was used for univariate analysis, while multivariate analysis was performed using a binary logistic regression model to identify independent risk factors for incisional hernia. In addition, the odds ratios (ORs) with 95% confidence intervals (CIs) were calculated. A p value of <0.05 was considered statistically significant. To minimize the effect of potential confounders on selection bias, propensity score matching (PSM) was performed to compensate for differences in baseline patient characteristics between the two groups, with covariates of sex, age, BMI, comorbidity, and previous surgical history. A 1:1 nearest neighbor matching algorithm using a caliper of 0.2 without

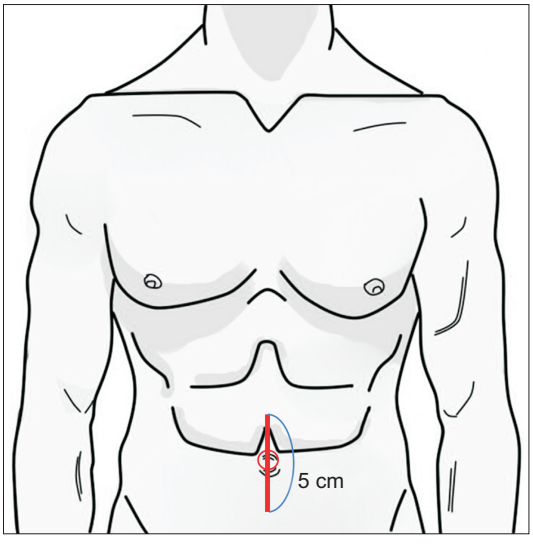

Fig. 1. Location of umbilical port and transumbilical minilaparotomy incision of laparoscopic colorectal surgery.

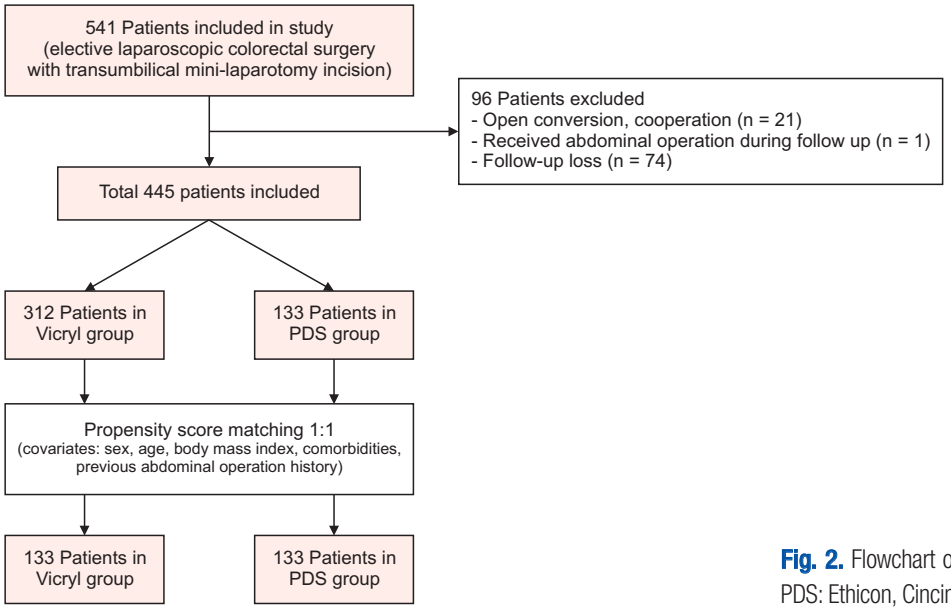

Fig. 2. Flowchart of patients. Vicryl and PDS: Ethicon, Cincinnati, OH, USA.

replacement was used to match the propensity scores. No covariate exhibited a large imbalance (|d| > 0.25), so we confirmed that the sample was statistically well matched. This procedure was conducted using the SPSS PS matching plugin designed by felixthoemmes and wliao229 (https://sourceforge.net/projects/psmspss/).

RESULTS

Patient characteristics

Out of 541 patients, 21 underwent open conversion due to cooperation with other departments or laparoscopic difficulty during surgery; one underwent abdominal surgery with a midline incision during the follow-up period, and 74 did not complete the follow-up schedule. Before PSM, of the 445 total patients, the abdominal midline fascia was closed using Vicryl in 312 and with PDS in 133. The male-to-female ratio was 170 (54.5%) vs. 142 (45.5%) in the Vicryl group and 92 (69.2%) vs. 41 (30.8%) in the PDS group, and the proportion of women in the PDS group was statistically higher (p = 0.004). To minimize the effect of potential confounders on selection bias, PSM was performed with covariates of sex, age (at 65 years), BMI (at 25 kg/m^2), comorbidities (cardiovascular disease, cerebrovascular accident, liver disease, chronic kidney disease, hypertension, and diabetes), and previous abdominal operations. As a result, 133 people were selected for each group, a total of 266 people (Fig. 2).

After PSM, the male-to-female ratio was 94 (70.7%) to 39 (29.3%) in the Vicryl group and 92 (69.2%) to 41 (30.8%) in the PDS group (p = 0.789). In Asia and the Pacific region, a BMI of 25 kg/m^2 or higher is considered obese [12]; 92 patients in the Vicryl group (69.2%) had a BMI of <25 kg/m^2, while 90 in the PDS group (67.7%) were not obese (p = 0.792). The mean BMI values of each group were 24.09 and 23.82 kg/m^2 (p = 0.479), respectively. The mean age was 64.82 years in the Vicryl group and 65.38 years in the PDS group (p = 0.657). The number of patients aged 65 years or older (Korean Geriatrics Society definition of elderly) was similar at 72 (54.1%) and 74 (55.6%) in the groups (p = 0.805), respectively. There was no statistically significant difference in type of colorectal surgery or comorbidities; 26 patients with a history of previous abdominal surgery were in the Vicryl group (19.5%), while 27 patients (20.3%) with prior surgery belonged to the PDS group (p = 0.878) (Table 1).

Risk factors of incisional hernia: univariate analysis

Of the 266 total patients, five were diagnosed at 6 months postoperatively and nine by 12 months after surgery. At 12 months, six (4.5%) and three patients (2.3%) in the respective Vicryl and PDS groups had an incisional hernia, but this difference was not statistically significant (p = 0.309). By sex, one of 186 males (0.5%) and 4 of 80 females (5.0%) were diagnosed with an incisional hernia at 6 months postoperatively, and this difference was statistically significant (p = 0.014). At 12 months, there was no additional occurrence of incisional hernia in males, but four additional females were diagnosed, a total of eight patients (10.0%) with as incisional hernia (p < 0.001). According to analysis based on BMI of >25 kg/m^2, which is the obesity standard in Asia and the Pacific region [12], 84 people were obese. At 6 months, four patients in the obese group (4.8%) and one patient in the non-obese group (0.5%) were diagnosed with incisional hernia (p = 0.019). At 12 months, seven patients in the obese group (8.3%) and

Table 1. Comparison of characteristics before and after propensity score matching

Characteristic	Before matching			After matching		
	Vicryl group	PDS group	*p* value	Vicryl group	PDS group	*p* value
No. of patietns	312	133		133	133	
Sex			0.004			0.789
Male	170 (54.5)	92 (69.2)		94 (70.7)	92 (69.2)	
Female	142 (45.5)	41 (30.8)		39 (29.3)	41 (30.8)	
BMI (kg/m^2)	24.08 ± 3.08	23.83 ± 3.09	0.416	23.88 ± 2.98	23.83 ± 3.09	0.435
>25	104 (33.3)	43 (32.3)	0.837	41 (30.8)	43 (32.3)	0.792
≤25	208 (66.7)	90 (67.7)		92 (69.2)	90 (67.7)	
Age (yr)	64.20 ± 11.49	65.38 ± 11.02	0.322	64.82 ± 12.46	65.38 ± 11.02	0.689
>65	168 (53.8)	74 (55.6)	0.728	79 (59.4)	74 (55.6)	0.535
≤65	144 (46.2)	59 (44.4)		54 (40.6)	59 (44.4)	
Operation type			0.867			0.825
RHC	88 (28.2)	33 (24.8)		28 (21.1)	33 (24.8)	
LHC	13 (4.2)	5 (3.8)		3 (2.3)	5 (3.8)	
LAR	103 (33.0)	42 (31.6)		48 (36.1)	42 (31.6)	
AR	103 (33.0)	51 (38.3)		51 (38.3)	51 (38.3)	
TC	5 (1.6)	2 (1.5)		3 (2.3)	2 (1.5)	
Comorbidity						
CVD	29 (9.3)	9 (6.8)	0.382	8 (6.0)	9 (6.8)	0.802
CVA	15 (4.8)	6 (4.5)	0.893	6 (4.5)	6 (4.5)	>0.999
Liver disease	3 (1.0)	4 (3.0)	0.112	3 (2.3)	4 (3.0)	0.702
CKD	3 (1.0)	1 (0.8)	0.830	0 (0)	1 (0.8)	0.316
Hypertension	129 (41.3)	53 (39.8)	0.769	49 (36.8)	53 (39.8)	0.614
Diabetes	79 (25.3)	27 (20.3)	0.255	25 (18.8)	27 (20.3)	0.757
History of previous abdominal operation	88 (28.2)	27 (20.3)	0.081	26 (19.5)	27 (20.3)	0.878

Values are presented as number only, number (%), or mean ± standard deviation.
BMI, body mass index; RHC, right hemicolectomy; LHC, left hemicolectomy; LAR, low anterior resection; AR, anterior resection; TC, total colectomy; CVD, cardiovascular disease; CVA, cerebrovascular accident; CKD, chronic kidney disease.

two in the nonobese group (1.1%) were diagnosed with incisional hernia (p = 0.002). Age of patients and type of colorectal operation did not demonstrate an association with incisional hernia (p = 0.904 and p = 0.091, respectively). Two of seven patients (28.6%) with liver disease had incisional hernia at the 12-month examination, which was a significant statistical association (p < 0.001). Previous abdominal operation history showed no significant association with incisional hernia (p = 0.061) (Table 2).

Risk factors of incisional hernia: multivariate analysis

Multivariate analysis identified female sex (OR, 15.233; 95% CI, 1.905–121.799; p = 0.010), BMI of >25 kg/m^2 (OR, 4.704; 95% CI, 1.424–15.546; p = 0.011), and liver disease (OR, 19.899; 95% CI, 1.614–245.376; p = 0.020) as independent risk factors for incisional hernia after laparoscopic colorectal surgery at 12-month follow-up (Table 3).

DISCUSSION

The incidence of incisional hernia after surgery has varied depending on study method and follow-up duration; it is about 12% for major open abdominal surgeries and about 3% for major laparoscopic surgeries [10]. Although the incidence has been

Table 2. Incisional hernia rate in 6-month and 12-month follow-up

Parameter	Incisional hernia at 6 months		Incisional hernia at 12 months	
	No. (%)	*p* value	No. (%)	*p* value
Material		0.176		0.309
Vicryl	4/133 (3.0)		6/133 (4.5)	
PDS	1/133 (0.8)		3/133 (2.3)	
Sex		0.014		<0.001
Male	1/186 (0.5)		1/186 (0.5)	
Female	4/80 (5.0)		8/80 (10.0)	
BMI (kg/m^2)		0.019		0.002
>25	4/84 (4.8)		7/84 (8.3)	
≤25	1/182 (0.5)		2/182 (1.1)	
Age (yr)		0.910		0.904
>65	3/153 (2.0)		5/153 (3.3)	
≤65	2/113 (1.8)		4/113 (3.5)	
Operation type		0.284		0.091
RHC	3/61 (4.9)		5/61 (8.2)	
LHC	0/8 (0)		0/8 (0)	
LAR	0/90 (0)		0/90 (0)	
AR	2/102 (2.0)		4/102 (3.9)	
TC	0/5 (0)		0/5 (0)	
Comorbidity				
CVD	0/17 (0)	0.555	0/17 (0)	0.425
CVA	0/12 (0)	0.624	0/12 (0)	0.507
Liver disease	1/7 (14.3)	0.014	2/7 (28.6)	<0.001
CKD	0/1 (0)	0.890	0/1 (0)	0.851
Hypertension	2/102 (2.0)	0.939	5/102 (4.9)	0.280
Diabetes	0/52 (0.0)	0.266	1/52 (1.9)	0.516
History of previous abdominal operation	2/53 (3.8)	0.257	4/53 (7.5)	0.061

BMI, body mass index; RHC, right hemicolectomy; LHC, left hemicolectomy; LAR, low anterior resection; AR, anterior resection; TC, total colectomy; CVD, cardiovascular disease; CVA, cerebrovascular accident; CKD, chronic kidney disease.
Vicryl and PDS: Ethicon, Cincinnati, OH, USA.

reduced by development of advanced surgical techniques and instruments, much research has been performed to reduce patient discomfort and health care costs due to incisional hernia. Meta-analysis studies of incisional hernia with wound infection, wound dehiscence, suture methods, and suture material have indicated that use of a monofilament suture is more efficient than multifilament suture material at reducing incidence of incisional hernia, but there was no difference in wound infection, and slowly-absorbable suture material had no relation with incidence of incisional hernia but did increase the risk of wound dehiscence [13]. On the other hand, a guideline for abdominal wall closure was published by the European Hernia Society published in 2015, recommended the avoidance of fast-absorbable sutures and suggested the use of slowly-absorbable monofilament sutures [14]. However, these studies are based on meta-analysis including even from the 1970s, incision length, suturing materials and methods were not controlled well, update is necessary in the current era of laparoscopic surgery. To our knowledge, this is the first report about risk factors of incisional hernia in situation of laparoscopic colorectal surgery, using same suture technique, performed by

Table 3. Multivariate analysis of risk factors for incisional hernia at 12-month follow-up

Risk factor	OR (95% CI)	*p* value
Female sex	15.233 (1.905–121.799)	0.010
BMI of >25 kg/m^2	4.704 (1.424–15.546)	0.011
Liver disease	19.899 (1.614–245.376)	0.020
Suture material, PDS	0.523 (0.113–2.418)	0.407
Hypertension	3.019 (0.892–10.224)	0.076
Diabetes	0.473 (0.108–2.063)	0.319

OR, odds ratio; CI, confidence interval; BMI, body mass index.
PDS: Ethicon, Cincinnati, OH, USA.

single surgeon.

PDS and Vicryl are suture materials that have been safely used to close the abdominal wall for a long time. PDS 1-0 is a monofilament suture that is completely absorbed into the body in about 6 to 8 months, while Vicryl 1-0 is a multistrand-braided suture that is absorbed by the body after about 2 months. The breaking strength retention of PDS at 4 weeks is 70%, whereas it is 25% for Vicryl. Thus, some studies have assumed that use of long-lasting PDS suture material with its higher tensile strength could reduce the incidence of incisional hernia and is relatively resistant to infection [15–17]. Multiple studies have included a meta-analysis, which suggested that use of a long-lasting monofilament suture material lowered the incidence of incisional hernia compared to short-lasting multifilament suture material; in addition, a low incidence of incisional hernia was shown when using an interrupted manner compared to a running suture technique [18]. However, another study found that using slowly or rapidly absorbable suture material in a continuous or interrupted closure method did not affect the incidence of incisional hernia, but monofilament suture material showed a lower incidence of incisional hernia than did multifilament suture material [13]. Our analysis showed a decrease in incidence (4.5% vs. 2.3%, respectively), according to the guideline by European Hernia Society in 2015 [14], but statistical significance could not be confirmed ($p = 0.309$). The small number of patients included in the study and the shorter length of incision than that used in conventional open abdominal surgery are believed to have caused the relatively low incidence of incisional hernia. Studies that have compared slowly-absorbable materials and rapidly absorbable materials used in elective and midline laparotomy have reported that slowly-absorbable material can significantly reduce the risk of incisional hernia, with an OR of 0.65. Since many incisional hernias occur after more than one year postoperatively [18], further observation is needed to clarify the findings of this study.

Among the risk factors of incisional hernia, patient sex remains controversial. In this study, women had a significantly higher risk of hernia occurrence than males; however, some studies have named male sex as a risk factor for incisional hernia [7,19], and some report that sex was not statistically significant [20]. Further investigation is needed; in this study, the mean BMI was 23.8 kg/m^2 in males and 24.4 kg/m^2 in females. The slightly higher BMI in male patients might have had an effect.

Many studies have confirmed obesity to be a major risk factor for occurrence of incisional hernia. In the current study, BMI of >25 kg/m^2 significantly increased the risk of incisional hernia upon univariate and multivariate analyses. However, when the patient group was divided at a BMI of 23 kg/m^2 based on the overweight criteria for Asia and the Pacific region [12], there was no statistically significant difference ($p = 0.368$) based on a 12-month survey. Another study showed that BMI of >24.4 kg/m^2 is a predictive factor of incisional hernia [21], while BMI of >30 kg/m^2 can interfere with wound healing and increase the incidence of incisional hernia. These findings indicate that special care should be considered in obese patients [18,22].

The incidence of incisional hernia in patients with liver cirrhosis and ascites is high at about 20% to 40% [23]. The prevalence is high in these patients due to the elevated abdominal pressure caused by ascites and to weakness in the muscles and fascia of the abdominal wall caused by liver disease and malnutrition [24]. Because of the high risk and high recurrence rate after hernia repair surgery, as long as no complications occur, a "watch and wait" strategy typically is applied before resorting to surgery [25]. This study also showed a statistically significant prevalence in the patient group with liver disease, indicating that careful attention should be paid to selecting candidates for hernia repair surgery in this group. Although underlying diseases such as hypertension and diabetes are reported as risk factors for incisional hernia, the results reported vary based on the research method [26]. Our univariate and multivariate analysis showed that both hypertension and diabetes are not significant risk factors for incisional hernia, but further studies on the severity and duration of incisional hernia and the surgical wound healing process are expected to be helpful.

Diagnostic method for incisional hernia is also important. It was reported that as much as 30% of incisional hernia cases are missed when the diagnosis was based solely on physical findings [27]. In this study, of the 445 patients surveyed through outpatient follow-up, the number diagnosed with incisional hernia through radiological examination was 16 (3.6%); eight of these patients had symptoms of a mass protruding through the abdominal wall while in a standing position or in a situation of increased abdominal pressure [11]. The remaining eight patients were not aware of the symptoms of incisional hernia, and only one of these 16 patients underwent a repair operation after the follow-up period. Even if a defect of the abdominal fascia is confirmed on CT, it can be asymptomatic, although symptoms

can develop as the defect worsens, and additional care might be needed.

During our chart reviews, we noted that the surgeon used PDS to close abdominal fascia of some thin patients. A few patients complained about dots on the umbilicus or pain in the suture line, which likely resulted from the longer lasting and larger size of the tie-knot compared to those for Vicryl (data not shown). In this study, the abdominal fascia was closed in an interrupted manner, and pain can be avoided using the continuous suture method. Monofilament knotless suture materials with good tensile strength, like Stratafix (Ethicon) or V-loc (Covidien, Minneapolis, MN, USA), have been developed [28] and can reduce iatrogenic errors as they are easier to handle compared to existing material. Further studies on incisional hernia occurrence and incision site wound pain are necessary.

Conventional laparoscopic colorectal surgery involves resected specimen extraction using a transumbilical midline minilaparotomy incision in the same general manner as we used in this study. However, the incidence of incisional hernia was lower in these patients compared to those treated with a midline incision when specimen removal was performed through muscle splitting, a Pfannelstiel incision, or a stoma site [29]. In a study of incisional hernia after laparoscopic gastrectomy, the incidence at a transumbilical minilaparotomy incision was significantly higher than that with an upper midline or right upper quadrant incision [30]. During laparoscopic colorectal surgery in patients at high risk for incisional hernia, a minilaparotomy incision elsewhere, such as at the site of a stoma instead of a transumbilical incision, might help reduce the incidence of incisional hernia.

This study has some limitations. Only patients from a single institution and operated on by a single surgeon were investigated. Our patient groups were relatively small, and the incision length was relatively short. Consequently, the incidence of incisional hernia in our sample was low. For accurate analysis, more cases and additional studies are needed. This study is limited by its retrospective study design and the possibility of selection bias. We believe that additional prospective randomized controlled studies on controllable surgery-related factors can be performed using a complementary study design.

In conclusion, the incidence of incisional hernia after elective laparoscopic colorectal surgery with a transumbilical minilaparotomy incision was significantly higher in patients with BMI of >25 kg/m^2, female sex, and liver disease. The incidence of incisional hernia did not significantly differ when using long-lasting monofilament suture material compared with short-lasting multifilament suture material under conditions with limited surgery-related factors.

NOTES

Ethical statements

This study was approved by the Institutional Review Board Pusan National University Yangsan Hospital (No. 05-2021-038). The study was conducted according to the tenets of the Declaration of Helsinki and its revisions. Due to the retrospective design of this study, the requirement for obtaining patient consent was waived.

Authors' contributions

Conceptualization: YK, GMS
Formal analysis, Investigation, Methodology: All authors
Project administration: GMS
Writing–original draft: YK, KHK, GMS
Writing–review & editing: All authors
All authors read and approved the final manuscript.

Conflict of interest

All authors have no conflicts of interest to declare.

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