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Original Article

Robotic vs. laparoscopic distal gastrectomy for gastric cancer: A propensity score-matched retrospective comparative study at a single institution

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ABSTRACT

Background: Although robotic surgery is becoming more widespread worldwide, it is still in its infancy. This study aimed to confirm the safety and feasibility of the induction of robotic-assisted gastric surgery at a local hospital.

Methods: For five years, between 2016 and 2020, 42 laparoscopic and 71 robotic distal gastrectomies were performed at the same institution. Patients diagnosed with gastric cancer were retrieved from the database. Propensity score matching was performed based on covariates such as Age, Sex, BMI, the American Society of Anesthesiologists Physical Status, Tumor Location, pT, and pN. Clinicopathological characteristics, surgical performance, postoperative outcomes, and pathological data were retrospectively collected and compared by the Chi-square test, the Fisher's exact test, the Student's t-test, and the Mann−Whitney U test.

Results: Billroth II reconstruction was often selected for the robotic group more than the laparoscopic group (59.4% and 15.6%, respectively). In addition, the number of lymph nodes harvested after D2 dissection tended to be more significant in the robotic group than in the laparoscopic group (52.1 ± 7.6 and 29.1 ± 3.7, respectively; $p = 0.00934$). The mean operative time was 271.4 ± 10.5 min for the robotic group and 220.8 ± 12.3 min for the laparoscopic group ($p = 0.00005$). There were no differences in short-term clinical outcomes between the two groups.

Conclusions: Although a single-center, small comparative study, the results showed that the robotic surgery group was not inferior to the laparoscopic group in feasibility and safety. Moreover, robotic surgery enables harvesting a higher number of lymph nodes, which may be more advantageous than laparoscopic surgery. This study also showed that as the surgeon gains experience with robotic surgery, its operative time becomes significantly shorter.

1. Introduction

Gastric cancer, which affected more than 1 million people in 2018, is a significant burden on the healthcare system.[1] Incidence varies widely by continent, with the Far East having the highest incidence. Moreover, gastric cancer kills 50,000 people annually in Japan, making it the third deadliest cancer by the number of deaths.

Currently, treatment for gastric cancer includes anticancer drugs, surgery, and radiation therapy. Among these, surgical therapy is undeniably the most effective for gastric cancer. Radical gastrectomy with regional lymph node dissection is still considered the only curative treatment for gastric cancer.[2,3] In Japan, the demand for minimally invasive surgery has increased dramatically in recent years as the early gastric cancer diagnosis rate has exceeded 50%.[4] Minimally invasive surgery for gastric cancer has evolved rapidly. It has increased in popularity during the last two decades, mainly in the Far East and for patients with early-stage tumors.[5,6]

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Gastric surgery is one of the most relevant and developed fields of minimally invasive surgery.[7] In terms of minimally invasive surgery, there are laparoscopic and robotic surgeries, but their merits and demerits are still to be clarified.

While laparoscopic surgery has spread worldwide, robotic surgery is still in its infancy. Robotic-assisted gastrectomy (RAG) for gastric cancer was first reported in 2002.[8] According to Lim SH et al, the introduction of RAG has increased exponentially. However, this represents about 2% of all gastrectomies performed in Korea and only about 4% of all robotic surgeries performed annually.[9,10] Researchers and surgeons are focusing on applying advanced robotic technology to gastrectomy.

Our aim with this study is to examine our initial use of robotic distal gastrectomy and compare the surgical performance and postoperative outcomes of laparoscopic and robotic distal gastrectomy for gastric cancer.

2. Methods

2.1. Patients

A total of 136 patients underwent distal gastrectomy (DG) between 2016 and 2020 at Nanpuh Hospital, Japan. Invalid data such as open distal gastrectomy and lack of clinical data were excluded. Forty-two laparoscopic distal gastrectomies (LDG) and 71 robotic distal gastrectomies (RDG) for gastric cancer were included in the study. The clinicopathological characteristics, surgical performance, postoperative outcomes, and pathological data between these two groups of patients were retrospectively collected and compared.

Prior to the commencement of the study, all patients underwent a thorough screening process. This involved the implementation of a standard protocol that encompassed upper digestive endoscopy, along with gastric biopsy and computed tomography of the abdomen and chest. We ensured that all patients were thoroughly informed about the investigation and provided their written consent as well. Our actions were in strict accordance with the ethical committee of our hospital and fully compliant with the Helsinki Declaration.

Comprehensive patient-related information was meticulously gathered, covering a range of crucial factors such as age, sex, BMI, the American Society of Anesthesiologists Physical Status (ASA-PS), tumor location, pathological findings, as well as surgical outcomes, which incorporated type of reconstructions, blood loss, blood transfusion, operative time, open conversion, lymph node dissection, number of lymph nodes harvested after D2 dissection, and short-term clinical outcomes such as time to first oral feeding, surgery-related complications, reoperation, mortality and postoperative length of stay.

Tumor location was precisely categorized as either the middle or lower third, and the type of lymph node removal was determined based on the lymph node classification provided by the Japanese Gastric Cancer Association.[11] Tumors were classified according to the 7th edition of the AJCC/TNM tumor staging.[12]

2.2. Operative technique

2.2.1. Setup for robotic distal gastrectomy

In RDG, all robotic surgeries were performed using the da Vinci Xi system (Intuitive Surgical, Sunnyvale, CA, USA). The preparation process for RDG surgery closely resembles that of LDG surgery, except for using robotic ports and instruments. The patient was placed in the supine and reverse Trendelenburg position, with each leg elevated approximately 13°, and abducted while under general anesthesia. An 8-mm trocar was inserted through the

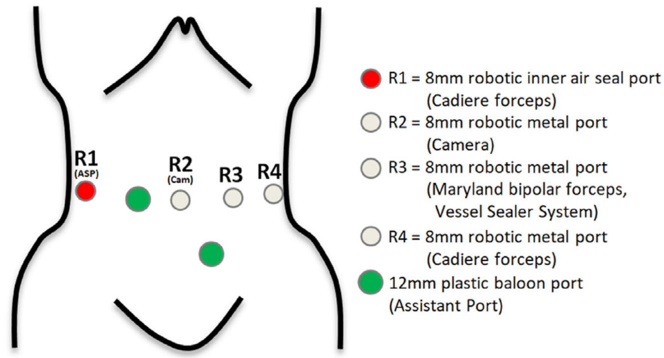

Fig. 1. Port positioning and instrument installation for robotic distal gastrectomy.

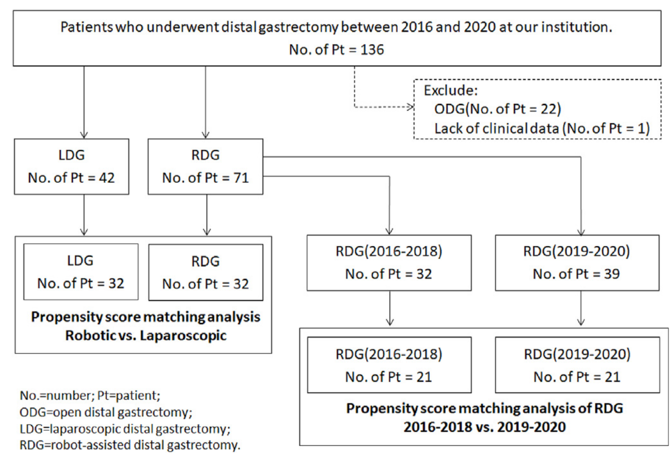

Fig. 2. Flowchart of patient data collected in the study.

transumbilical incision for the camera port. Once the pneumoperitoneum was established, three 8-mm trocars were inserted for the robotic arms. One was placed in the right lumbar, and two were placed in the left (Fig. 1). Two 12-mm ports for an assistant were also inserted in the right lumbar and Umbilical region down left from the umbilicus for surgical gauze, suctioning, or removal of the

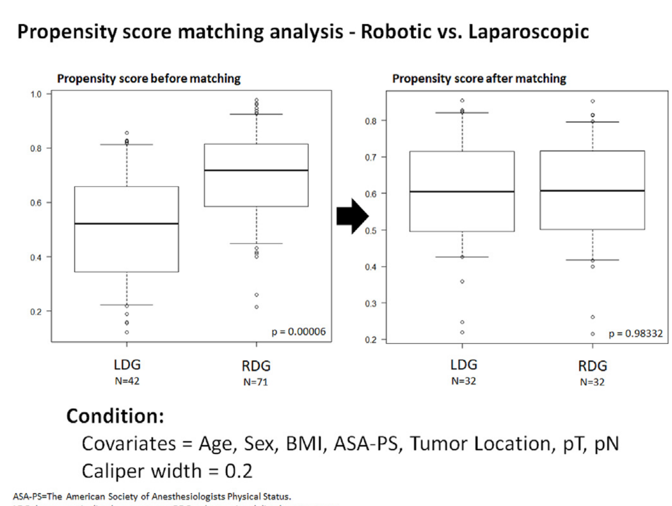

Fig. 3. Propensity score analysis before and after pair-matching (Robotic vs. Laparoscopic).

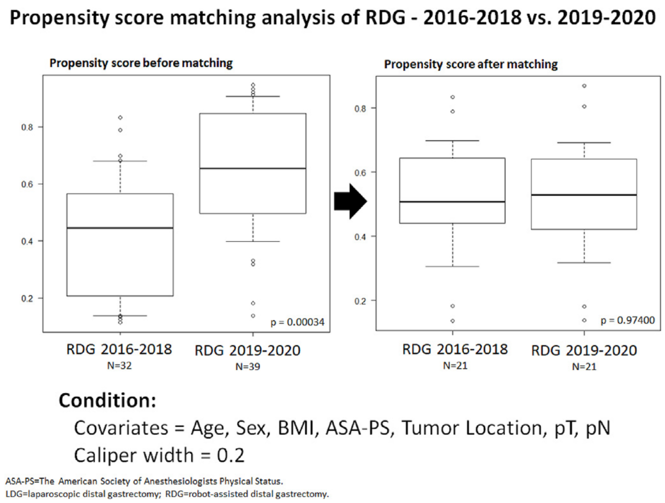

Fig. 4. Propensity score analysis before and after pair-matching (2016–2018 vs. 2019–2020).

small resected tissue during operations. During the surgery, an air seal port and Cadiere forceps were held in the patient's first robotic arm on the right side. On the left side, a Maryland bipolar forceps, a Cadiere forceps and Vessel Sealer system were held in the third and fourth arms, respectively.

2.2.2. *The procedures of distal gastrectomy*

All gastrectomies were performed according to the standard of radical gastrectomy based on the Japanese Gastric Cancer treatment guidelines.[13] The procedures employed during RDG are not different from those of LDG except for articulating robotic instruments. The LDG surgical technique involves placing four trocars two 12-mm trocars, and two 5-mm trocars in the usual positions. In cases where Billroth-I reconstruction was feasible, a Delta-shaped anastomosis was utilized. When it was not possible, either Billroth-II or Roux-en-Y reconstruction was employed. Following the reconstruction, a single abdominal drainage tube was inserted into the left subphrenic cavity.

2.3. *Data validation and statistical analysis*

Fig. 2 shows the flow chart of patient data collected in this study. One hundred thirty-six patients were retrieved, including 71 patients who underwent robotic distal gastrectomy. Propensity score matching (PSM) was performed to reduce bias between two groups based on covariates such as Age, Sex, BMI, ASA-PS, Tumor Location, pT, and pN. After A 1:1 nearest-neighbor matching algorithm with an optimal caliper width of 0.20 without replacement, 32 pairs were generated (64 patients) for the comparison between LDG and RDG. Furthermore, we also compared RDG performed between the first period (2016–2018) and the second period (2019–2020) to analyze time-related changes in surgical outcomes of RDG. The first and second periods groups comprised 32 and 39 cases, respectively, and 21 pairs (42 patients) were generated after PSM. Figs. 3 and 4 shows the propensity score between the two groups for each

Table 1
Summary of patients and disease characteristics before and after matching (LDG vs. RDG).

	Before PSM			After PSM		
	LDG (n = 42)	RDG (n = 71)	p-value	LDG (n = 32)	RDG (n = 32)	p-value
Age						
Mean ± SEM	70.2 ± 1.8	64.3 ± 1.4	0.01108 *	69.1 ± 2.0	67.6 ± 1.6	0.57189
Median(IQR)	73.0 (61.0–81.0)	67.0 (59.0–73.0)		71.0 (60.0–79.5)	70.0 (64.0–74.0)	
Sex						
Male	31 (73.8%)	41 (57.7%)	0.08613	23 (71.9%)	21 (65.6%)	0.58964
Female	11 (26.2%)	30 (42.3%)		9 (28.1%)	11 (34.4%)	
BMI						
Mean ± SEM	22.899 ± 0.611	23.380 ± 0.402	0.49453	23.408 ± 0.737	23.735 ± 0.606	0.73321
Median(IQR)	22.630 (20.670–25.360)	23.390 (20.850–25.850)		23.160 (21.475–26.330)	23.820 (21.330–25.845)	
ASA-PS						
I	3 (7.1%)	16 (22.5%)	0.0043 **	3 (9.4%)	1 (3.1%)	0.41023
II	34 (81.0%)	54 (76.1%)		28 (87.5%)	30 (93.8%)	
	5 (11.9%)	1 (1.4%)		1 (3.1%)	1 (3.1%)	
Tumor Location						
Middle third	30 (71.4%)	45 (63.4%)	0.3815	24 (75.0%)	22 (68.8%)	0.57818
Lower third	12 (28.6%)	26 (36.6%)		8 (25.0%)	10 (31.3%)	
Tumor size(cm)						
Mean ± SEM	34.7 ± 2.6	30.9 ± 2.1	0.26705	34.4 ± 3.1	34.9 ± 3.5	0.91549
Median(IQR)	33.0 (24.0–40.0)	27.0 (17.3–42.3)		33.0 (22.5–39.0)	31.0 (18.0–45.5)	
pStage						
I	33 (78.6%)	50 (70.4%)	0.46081	26 (81.3%)	22 (68.8%)	0.32914
II	4 (9.5%)	15 (21.1%)		3 (9.4%)	8 (25.0%)	
III	5 (11.9%)	6 (8.5%)		3 (9.4%)	2 (6.3%)	
pT						
T1	27 (64.3%)	49 (69.0%)	0.73956	23 (71.9%)	22 (68.8%)	0.73864
T2	7 (16.7%)	6 (8.5%)		3 (9.4%)	3 (9.4%)	
T3	5 (11.9%)	12 (16.9%)		5 (15.6%)	5 (15.6%)	
T4	3 (7.1%)	4 (5.6%)		1 (3.1%)	2 (6.3%)	
pN						
N0	33 (78.6%)	51 (71.8%)	0.48258	26 (81.3%)	25 (78.1%)	0.72348
N1	4 (9.5%)	10 (14.1%)		3 (9.4%)	3 (9.4%)	
N2	3 (7.1%)	8 (11.3%)		2 (6.3%)	2 (6.3%)	
N3	2 (4.8%)	2 (2.8%)		1 (3.1%)	2 (6.3%)	

PSM=Propensity score matching; LDG = laparoscopic distal gastrectomy; RDG = robot-assisted distal gastrectomy.
*P < 0.05 indicates statistical significance (**P < 0.01, and ***P < 0.001).

Table 2
Summary of surgical outcomes before and after matching (LDG vs. RDG).

	Before PSM			After PSM		
	LDG (n = 42)	RDG (n = 71)	p-value	LDG (n = 32)	RDG (n = 32)	p-value
Type of reconstruction						
Billroth-I	25 (59.5%)	28 (39.4%)	0.0004 ***	21 (65.6%)	12 (37.5%)	0.00083 ***
Billroth-II	9 (21.4%)	40 (56.3%)		5 (15.6%)	19 (59.4%)	
Roux-en-Y	8 (19.0%)	3 (4.2%)		6 (18.8%)	1 (3.1%)	
Blood loss(ml)						
Mean ± SEM	55.6 ± 10.8	50.3 ± 6.6	0.96194	54.2 ± 11.4	56.3 ± 11.8	0.94088
Median(IQR)	30.0 (15.0–70.0)	30.0 (20.0–60.0)		35.0 (10.0–70.0)	30.0 (17.5–67.5)	
Blood transfusion	2 (4.8)	1 (1.4)	0.55423	2 (6.3)	1 (3.1)	1.00000
Operative time(min)						
Mean ± SEM	220.9 ± 9.9	269.3 ± 6.6	0.00005 ***	220.8 ± 12.3	271.4 ± 10.5	0.00259 **
Median(IQR)	218.0 (185.0–242.0)	262.0 (236.0–304.5)		215.5 (184.0–239.5)	262.5 (237.0–312.0)	
Open Conversion	none	none	–	none	none	–
Lymph node dissection						
D1	6 (14.3%)	16 (22.5%)	0.444	4 (12.5%)	8 (25.0%)	0.41497
D1+	17 (40.5%)	30 (42.3%)		13 (40.6%)	10 (31.3%)	
D2	19 (45.2%)	25 (35.2%)		15 (46.9%)	14 (43.8%)	
Number of lymph nodes harvested after D2 dissection						
Mean ± SEM	30.4 ± 3.3	42.2 ± 5.0	0.07072	29.1 ± 3.7	52.1 ± 7.6	0.00934 **
Median(IQR)	30.0 (19.3–40.3)	37.0 (26.8–47.0)		30.0 (16.8–40.3)	44.5 (35.0–58.0)	

PSM=Propensity score matching; LDG = laparoscopic distal gastrectomy; RDG = robot-assisted distal gastrectomy.
*P < 0.05 indicates statistical significance (**P < 0.01, and ***P < 0.001).

comparison that was balanced after PSM. Categorical variables were compared using the Chi-square test or the Fisher's exact test. Quantitative variables were compared using the Student's t-test or the Mann–Whitney U test depending on the result of Kolmogorov–Smirnov Test. P < 0.05 was considered statistically significant. All statistical analyses were calculated with R Statistical Software (version 4.2.2; R Foundation for Statistical Computing, Vienna, Austria) and StatFlex (version 7; Artech Co. Ltd., Fukuoka, Japan).

3. Results

After PSM, there was no statistically significant difference in the summary of patients and disease characteristics between the LDG and RDG groups (Table 1). Table 2 shows surgical outcomes. Billroth-II (B-II) was performed more in RDG group when compared to LDG group with a significant difference (59.4% vs. 15.6%, p = 0.00083), the mean of operative time was significantly longer in RDG group (271.4 ± 10.5 vs. 220.8 ± 12.3, p = 0.00259; Fig. 5), and a more significant number of lymph nodes harvested after D2 dissection was retrieved in the RDG group (52.1 ± 7.6 vs. 29.1 ± 3.7, p = 0.00934; Fig. 6). Both groups were similar in blood loss, blood transfusion, and open conversion. As shown in Table 3, no significant differences were found in short-term clinical outcomes.

As a result of the comparison of RDG performed in the first period and the second period group to analyze the time-related changes, there was no statistically significant difference in the summary of patients and disease characteristics between the first and the second period group after PSM (Table 4). In surgical outcomes (Table 5), Billroth-II (B-II) was performed more with a significant difference in the second period group compared to the first period group (71.4% vs. 33.3%, p = 0.04678), the mean of operative time was significantly shorter in the second period group (244.9.±9.8 vs. 302.5 ± 12.8,

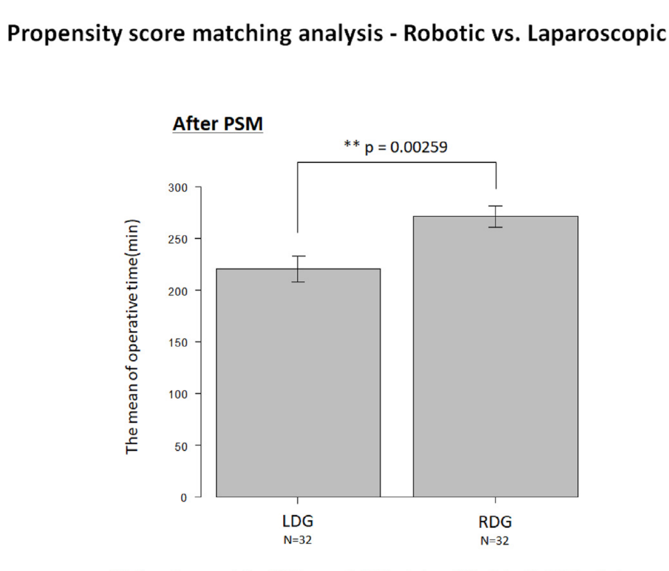

Fig. 5. Comparison of operative time between LDG and RDG after PSM.

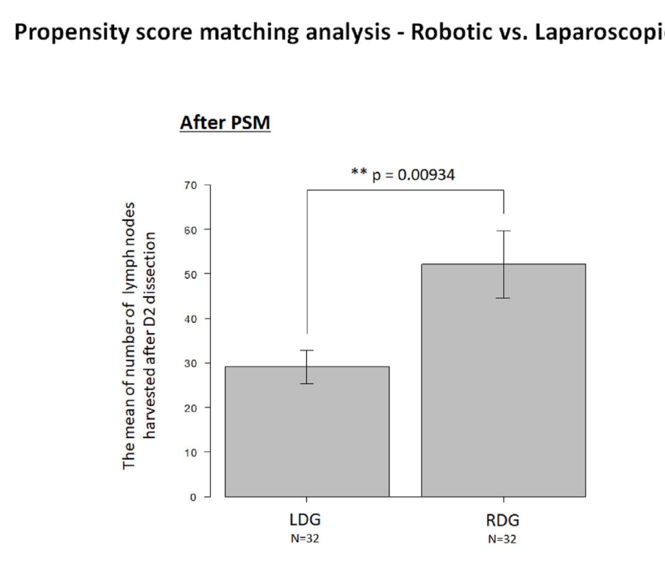

Fig. 6. Comparison of the number of lymph nodes harvested after D2 dissection between LDG and RDG after PSM.

Table 3
Summary of short-term clinical outcomes before and after matching (LDG vs. RDG).

	Before PSM			After PSM		
	LDG (n = 42)	RDG (n = 71)	p-value	LDG (n = 32)	RDG (n = 32)	p-value
Time to first oral feeding(day)						
Mean ± SEM	4.6 ± 0.8	3.6 ± 0.1	0.07089	4.8 ± 1.1	3.5 ± 0.1	0.25547
Median(IQR)	4.0 (3.0–4.0)	3.0 (3.0–4.0)		3.5 (3.0–4.0)	3.0 (3.0–4.0)	
Surgery-related complications						
Postoperative ileus	0 (0.0%)	1 (1.4%)	0.42884	0 (0.0%)	0 (0.0%)	0.38499
Postoperative bleeding	0 (0.0%)	1 (1.4%)		0 (0.0%)	1 (3.1%)	
Postoperative bleeding anastomotic ulcer	0 (0.0%)	1 (1.4%)		0 (0.0%)	1 (3.1%)	
Postoperative wound infection	0 (0.0%)	2 (2.8%)		0 (0.0%)	2 (6.3%)	
Postoperative intra-abdominal abscess	2 (4.8%)	3 (4.2%)		2 (6.3%)	1 (3.1%)	
Postoperative anastomotic stenosis	1 (2.4%)	0 (0.0%)		0 (0.0%)	0 (0.0%)	
Postoperative pancreatic fistula	1 (2.4%)	0 (0.0%)		1 (3.1%)	0 (0.0%)	
Upper gastrointestinal bleeding	1 (2.4%)	0 (0.0%)		1 (3.1%)	0 (0.0%)	
Reoperations	none	none	–	none	none	–
Mortality	none	none	–	none	none	–
Postoperative length of stay(day)						
Mean ± SEM	14.6 ± 1.3	13.0 ± 0.7	0.45391	14.4 ± 1.6	13.3 ± 1.3	0.69399
Median(IQR)	11.5 (11.0–16.0)	12.0 (10.0–13.8)		11.0 (10.5–13.5)	11.5 (10.0–13.5)	

PSM=Propensity score matching; LDG = laparoscopic distal gastrectomy; RDG = robot-assisted distal gastrectomy.
*P < 0.05 indicates statistical significance (**P < 0.01, and ***P < 0.001).

p = 0.00092; Fig. 7), and there was no D2 lymph node dissection performed in the first period group. No significant differences were found in short-term clinical outcomes (Table 6).

4. Discussion

The effectiveness and superiority of laparoscopic surgery in clinical practice have been demonstrated by studies over the past several decades.[14] Another clear thing is that performing gastric cancer surgery laparoscopically is highly challenging. In particular, skill is required for lymph node number 6, 8, and 11 dissection and suture procedures in anastomotic operations.[15,16] Therefore, robotic surgery was introduced to reduce the difficulty of operation while retaining the good points of laparoscopic surgery.

With the development of technology, robotic surgery has become widely performed in the field of urology,[17] gynecology,[18]

Table 4
Summary of patients and disease characteristics before and after matching (RDG 2016–2018 vs. RDG 2019–2020).

	Before PSM			After PSM		
	RDG 2016–2018 (n = 32)	RDG 2019–2020 (n = 39)	p-value	RDG 2016–2018 (n = 21)	RDG 2019–2020 (n = 21)	p-value
Age						
Mean ± SEM	59.2 ± 2.1	68.5 ± 1.6	0.0011 **	61.9 ± 2.5	64.8 ± 2.4	0.41234
Median(IQR)	60.5 (49.5–68.5)	70.0 (65.0–74.0)		66.0 (56.0–68.3)	66.0 (62.8–70.8)	
Sex						
Male	19 (59.4%)	22 (56.4%)	0.80132	13 (61.9%)	12 (57.1%)	0.75325
Female	13 (40.6%)	17 (43.6%)		8 (38.1%)	9 (42.9%)	
BMI						
Mean ± SEM	23.540 ± 0.708	23.248 ± 0.452	0.72026	22.734 ± 0.773	23.256 ± 0.677	0.61417
Median(IQR)	23.475 (20.780–25.985)	23.390 (21.023–25.455)		23.190 (20.440–25.750)	22.980 (20.890–25.580)	
ASA-PS						
I	9 (28.1%)	7 (17.9%)	0.45867	7 (33.3%)	4 (19.0%)	0.29241
II	22 (68.8%)	32 (82.1%)		14 (66.7%)	17 (81.0%)	
III	1 (3.1%)	0 (0.0%)		0 (0.0%)	0 (0.0%)	
Tumor Location						
Middle third	20 (62.5%)	25 (64.1%)	0.88908	14 (66.7%)	14 (66.7%)	1.00000
Lower third	12 (37.5%)	14 (35.9%)		7 (33.3%)	7 (33.3%)	
Tumor size(cm)						
Mean ± SEM	28.4 ± 2.7	32.9 ± 3.2	0.30455	29.1 ± 3.1	37.4 ± 4.9	0.1639
Median(IQR)	25.0 (17.0–39.0)	28.0 (17.3–44.5)		27.0 (15.8–41.3)	32.0 (22.3–46.5)	
pStage						
I	26 (81.3%)	24 (61.5%)	0.08322	16 (76.2%)	16 (76.2%)	0.86545
II	4 (12.5%)	11 (28.2%)		3 (14.3%)	5 (23.8%)	
III	2 (6.3%)	4 (10.3%)		2 (9.5%)	0 (0.0%)	
pT						
T1	24 (75.0%)	25 (64.1%)	0.3215	15 (71.4%)	16 (76.2%)	0.85686
T2	2 (6.3%)	4 (10.3%)		1 (4.8%)	0 (0.0%)	
T3	5 (15.6%)	7 (17.9%)		5 (23.8%)	4 (19.0%)	
T4	1 (3.1%)	3 (7.7%)		0 (0.0%)	1 (4.8%)	
pN						
N0	28 (87.5)	23 (59.0)	0.01054 *	17 (81.0)	18 (85.7)	0.60019
N1	2 (6.3)	8 (20.5)		2 (9.5)	3 (14.3)	
N2	1 (3.1)	7 (17.9)		1 (4.8)	0 (0.0)	
N3	1 (3.1)	1 (2.6)		1 (4.8)	0 (0.0)	

PSM=Propensity score matching; LDG = laparoscopic distal gastrectomy; RDG = robot-assisted distal gastrectomy.
*P < 0.05 indicates statistical significance (**P < 0.01, and ***P < 0.001).

Table 5
Summary of surgical outcomes before and after matching (RDG 2016–2018 vs. RDG 2019–2020).

	Before PSM			After PSM		
	RDG 2016–2018 (n = 32)	RDG 2019–2020 (n = 39)	p-value	RDG 2016–2018 (n = 21)	RDG 2019–2020 (n = 21)	p-value
Type of reconstruction						
Billroth-I	19 (59.4%)	9 (23.1%)	0.0033 **	12 (57.1%)	5 (23.8%)	0.04678 *
Billroth-II	11 (34.4%)	29 (74.4%)		7 (33.3%)	15 (71.4%)	
Roux-en-Y	2 (6.3%)	1 (2.6%)		2 (9.5%)	1 (4.8%)	
Blood loss(ml)						
Mean ± SEM	58.4 ± 10.1	43.7 ± 8.7	0.05039	57.0 ± 13.9	37.9 ± 7.1	0.22458
Median(IQR)	34.0 (25.0–67.5)	20.0 (15.0–50.0)		30.0 (25.0–56.3)	30.0 (13.8–50.0)	
Blood transfusion	0 (0.0)	1 (2.6)	1.00000	0 (0.0)	1 (4.8)	1.00000
Operative time(min)						
Mean ± SEM	301.8 ± 9.4	242.7 ± 6.9	0.00000 ***	302.5 ± 12.8	244.9 ± 9.8	0.00092 ***
Median(IQR)	293.5 (260.5–329.5)	245.0 (211.0–264.5)		290.0 (254.0–333.3)	252.0 (220.5–263.8)	
Open Conversion	none	none	–	none	none	–
Lymph node dissection						
D1	7 (21.9%)	9 (23.1%)	0.00000 ***	4 (19.0%)	5 (23.8%)	0.00000 ***
D1+	25 (78.1%)	5 (12.8%)		17 (81.0%)	2 (9.5%)	
D2	0 (0.0%)	25 (64.1%)		0 (0.0%)	14 (66.7%)	
Number of lymph nodes harvested after D2 dissection						
Mean ± SEM	none	42.2 ± 5.0	–	none	47.4 ± 8.2	–
Median(IQR)	none	37.0 (26.8–47.0)		none	37.5 (34.0–48.0)	

PSM=Propensity score matching; LDG = laparoscopic distal gastrectomy; RDG = robot-assisted distal gastrectomy.
*P < 0.05 indicates statistical significance (**P < 0.01, and ***P < 0.001).

general surgery,[19] and robotic surgery have become an attractive option for surgeons. Robotic surgery is classified as laparoscopic surgery, but the operation is more straightforward and intuitive. The forceps used in the robot have a high degree of freedom and provide smooth movement in situations where precise movement is required in a narrow surgical field or in the vicinity of vital organs. A high-performance camera that projects three-dimensional images makes it possible to see anatomy that could not be captured by the naked eye, helping to improve safety and radical cancer resection. Many studies have shown the feasibility and safety of robotic gastric surgery, but a clear superiority over laparoscopy has not yet been demonstrated.[20–24] No substantial reductions in time to first bowel movement or time to first oral nutritional intake. No substantial reduction in hospital stay has been reported after robotic surgery compared to laparoscopic surgery. Our study also failed to prove the superiority of the robotic surgery group in short-term clinical outcomes. Why can't we show the superiority of robotic surgery? Perhaps it is because laparoscopic surgery is already at a sufficiently high clinical level. There are several studies comparing the difference in clinical efficacy between laparoscopic and open surgery.[25–28] They all showed that laparoscopic surgery is superior in terms of blood loss, frequency of postoperative complications, and length of hospital stay without compromising the curative resection rate for cancer. It would be challenging to show data surpassing such a high level of laparoscopic surgery.

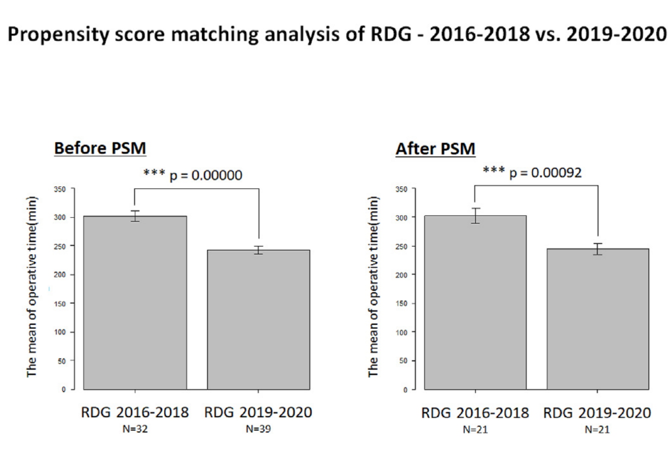

Fig. 7. Comparison of operative time between RDG performed in 2016–2018 and 2019–2020 before and after PSM.

In nearly every instance, it has been observed that RDG requires a longer operative time, despite any minor deviations that may exist (Fig. 5). Increased exposure to insufflation and the associated increase in anesthesia time are major concerns but are rarely published. However, previous studies of LDG in the elderly have shown that increased operative time has no detrimental effect with respect to surgical outcomes.[29] Therefore, increased operative time should not have such a direct impact on the patient's vital system. One of the problems with operative time in the robotic surgery group is docking time. Although docking time is an essential factor that increases operative time, with the use of new robotic surgical systems, the new robotic surgical systems are expected to shorten the time. Our study also showed that operative time had shortened as a surgeon experienced more (Fig. 7). Multiple studies have reported that the da Vinci Xi robotic platform is easier to use and install in rectal and renal patients.[30,31]

Needless to say, lymph node dissection is important in gastric cancer surgery. It is because lymph node dissection and pathological examination to determine the site and number of metastases can be used to estimate the stage of the disease and prevent recurrence.[32] Dissection of lymph nodes 8 and 11 is considered a difficult operation in laparoscopic surgery.[33–35] In laparoscopic surgery, forceps are mostly limited to a linear structure, and in terms of mobility, they can only rotate about an axis or move in a pinching motion. It makes it difficult to strip lymphatics while avoiding important blood vessels, or to make a patricidal approach to organs that should be avoided, such as the pancreas. Robotic surgery facilitates the use of articulated forceps to approach lymph nodes that may be located deeper within the narrow surgical field. The lymphatic dissection around the common hepatic artery and splenic artery, which is particularly problematic, is less stressful with robotic surgery compared to laparoscopic surgery.[36] Our study also suggested that more lymph nodes can be dissected by robotic surgery than by laparoscopic surgery and that more precise and

Table 6
Summary of short-term clinical outcomes before and after matching (RDG 2016–2018 vs. RDG 2019–2020).

	Before PSM			After PSM		
	RDG 2016–2018 (n = 32)	RDG 2019–2020 (n = 39)	p-value	RDG 2016–2018 (n = 21)	RDG 2019–2020 (n = 21)	p-value
Time to first oral feeding(day)						
Mean ± SEM	3.8 ± 0.3	3.5 ± 0.1	0.50836	3.9 ± 0.4	3.6 ± 0.2	0.98861
Median(IQR)	3.0 (3.0–4.0)	3.0 (3.0–4.0)		3.0 (3.0–4.0)	3.0 (3.0–4.0)	
Surgery-related complications						
Postoperative ileus	1 (3.1%)	0 (0.0%)	0.40506	1 (4.8%)	0 (0.0%)	0.30622
Postoperative bleeding	0 (0.0%)	1 (2.6%)		0 (0.0%)	1 (4.8%)	
Postoperative bleeding anastomotic ulcer	1 (3.1%)	0 (0.0%)		1 (4.8%)	0 (0.0%)	
Postoperative wound infection	0 (0.0%)	2 (5.1%)		0 (0.0%)	2 (9.5%)	
Postoperative intra-abdominal abscess	1 (3.1%)	2 (5.1%)		1 (4.8%)	0 (0.0%)	
Reoperations	none	none	–	none	none	–
Mortality	none	none	–	none	none	–
Postoperative length of stay(day)						
Mean ± SEM	12.5 ± 0.6	13.4 ± 1.2	0.8521	12.5 ± 0.8	12.4 ± 0.7	0.89546
Median(IQR)	12.0 (10.0–15.0)	12.0 (10.0–13.0)		11.0 (9.8–16.3)	12.0 (10.0–13.3)	

PSM=Propensity score matching; LDG = laparoscopic distal gastrectomy; RDG = robot-assisted distal gastrectomy.
*P < 0.05 indicates statistical significance (**P < 0.01, and ***P < 0.001).

safer dissection is possible (Fig. 6).

5. Conclusions

Due to the high level of laparoscopic surgery, it is difficult to determine the superiority of robotic surgery over laparoscopic surgery other than the number of lymph nodes dissection harvested. The other advantages are probably more significant for the surgeon than the patient. It is imagined that it reduces surgeon fatigue and keeps them focused for extended periods of operative time that can be shortened as a surgeon experiences more. As a result, this would lead to more accurate and safer surgeries, fewer complications, fewer hospital days, less risk of recurrence, and less burden on the patient and society.

Technology, including electronics, will evolve further, and robotic surgery will sharpen its precision and safety even more. Although cost-effectiveness may be an issue with robotic surgery compared to laparoscopic surgery, the improved accuracy and safety of the procedure may reduce complications and approximate costs through the use of fewer drugs and shorter hospital stays.

Authors' contributions

MK designed the study and drafted the manuscript. MF analyzed the data and edited the draft. SU, ME and NI participated in the critical revision of the manuscript. All authors read and approved the final manuscript.

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Ethical approval

Informed consent was obtained from the patient regarding the report of their clinical scenario data in an anonymous way.

Declaration of competing interest

The authors declare no conflicts of interest.

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