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Comparison of single-port and reduced-port totally laparoscopic distal gastrectomy for patients with early gastric cancer

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Abstract
Background Laparoscopy-assisted distal gastrectomy (LADG) is a treatment method for patients with early gastric cancer; however, single- or reduced-port LADG for these patients has been rarely reported.
Objective To compare surgical outcomes of patients with gastric cancer undergoing single-port totally laparoscopic distal gastrectomy (TLDG) to those of patients undergoing reduced-port (three ports) TLDG.
Methods This retrospective study included 94 patients with early gastric cancer who underwent single-port or reduced-port TLDG at Samsung Medical Center between May 2014 and December 2014. Surgical outcomes were compared between operation methods.
Results There are more female patients (54.2 vs. 19.6 %, $p = 0.001$) and less obese patients (21.1 ± 2.1 vs. 24.6 ± 3.2 kg/m^2, $p = 0.001$) in the single-port TLDG group. There were no significant differences in blood loss during surgery, the number of dissected lymph nodes, and the pain score at postoperative first day between two groups. The *variance* in operation time for the reduced-port TLDG was significantly greater than that for single-port TLDG ($p = 0.01$). Complication rates in the single-port and reduced-TLDG groups were similar (20.8 vs. 21.7 %, $p = 1.000$). No postoperative deaths occurred in either group.
Conclusions Single-port TLDG might be considered as a treatment option for a limited subset, such as females or less obese patients with early gastric cancer.

Keywords Single port · Laparoscopy · Gastrectomy · Gastric cancer

Laparoscopy-assisted distal gastrectomy (LADG) has been used for the treatment of patients with early gastric cancer since 1994 [1]. Several studies have reported that LADG is safe and oncologically feasible [2–5], and patients who undergo this procedure have a better quality of life than those who undergo open distal gastrectomy [6]. As experience with laparoscopic surgery accumulates, LADG has become widely used as a treatment option for patients with early-stage gastric cancer.

Reduction in the number of ports might result in a decrease in both pain and cost, although associated technical difficulties must be overcome. Recently, reduced-port laparoscopic gastrectomy has been reported by several institutions [7–9]. In a previous study, we showed similar surgical outcomes for a reduced-port totally laparoscopic distal gastrectomy (duet TLDG) procedure using three ports compared with conventional LADG [10].

Single-incision laparoscopic surgery is performed with only one skin incision, commonly located in the umbilicus. Given the low invasiveness and better cosmetic outcomes, it has been expected to be the next step in reduced-port laparoscopy. This approach should achieve similar surgical outcomes compared with the conventional method; however, there have been no studies comparing single-incision laparoscopy to reduced-port laparoscopy.

The purpose of this study was to compare surgical outcomes of patients undergoing single-port TLDG with those of patients undergoing reduced-port TLDG.

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Patients and methods

Study design and participants

The study recruited 94 patients with early-stage gastric cancer who were treated by single-port or duet TLDG between May 2014 and December 2014 at Samsung Medical Center. Patients were included in the study if they had a newly diagnosed, histologically confirmed gastric adenocarcinoma that was mucosal or submucosal and had no metastatic lymph nodes on preoperative work-up. Patients with another cancer or tumor located in the upper one-third of the stomach that required total gastrectomy were excluded. All information was obtained with the appropriate institutional review board waivers, and the data were collected without revealing any personal information (IRB File No. 2014-08-013-003).

Patient characteristics and clinical data

All characteristics of patients were obtained from a retrospective review of the prospectively maintained database. Demographic characteristics collected included age, sex, and body mass index (BMI). Clinicopathologic characteristics included tumor location, size, differentiation, ulceration, depth of invasion, and the presence of lymph node metastases. In patients with multiple synchronous gastric cancers, the lesion with the deepest infiltration of the gastric wall was regarded as the main lesion and any other lesions were considered accessory lesions. The clinicopathologic characteristics of the main lesion were used for the analyses.

Data related to the operation and postoperative course included operating time, blood loss during surgery, postoperative pain, use of additional analgesic drugs postoperatively, and duration of postoperative hospital stay. Postoperative pain was measured using a visual analogue scale on the first, third, and fifth postoperative day. In our hospital, all patients undergoing gastrectomy receive intravenous patient-controlled analgesia with fentanyl postoperatively, and additional analgesic drugs are administered depending on the requirements of the individual patient.

The number of lymph nodes dissected and both resection margins were collected as the oncologic data.

Operative procedures

All patients underwent radical distal gastrectomy with a tumor-free margin of 2 cm and appropriate lymph node dissection. The extent of lymph node dissection was $D1 + \beta$ or greater, which was determined using the recommendations of the Japanese Research Society for Gastric Carcinoma [11, 12]. All patients had a partial omentectomy.

The patient was placed in the lithotomy position with reverse Trendelenburg for single-port TLDG [13]. Three trocars—one 12-mm trocar and two 10-mm trocars—were inserted into a 3- to 3.5-cm transverse skin incision at the center of the umbilicus (Fig. 1A). A transverse skin incision gives a wider space for manipulation of instruments during operation than a vertical skin incision (Fig. 1B). Duet TLDG was performed as described earlier [10]. The patient was placed in the supine position with reverse Trendelenburg, and three 10-mm ports were used, located in the umbilical area and both flanks (Fig. 2A, B). The right flank and umbilical ports were used as acting and assistant ports for the operator, and the left flank port was primarily used for the camera.

We performed intracorporeal gastroduodenostomy (Billroth I anastomosis) using two linear staplers. The arms of the first stapler were inserted into each hole at the duodenum and the stomach. Continuity was achieved by

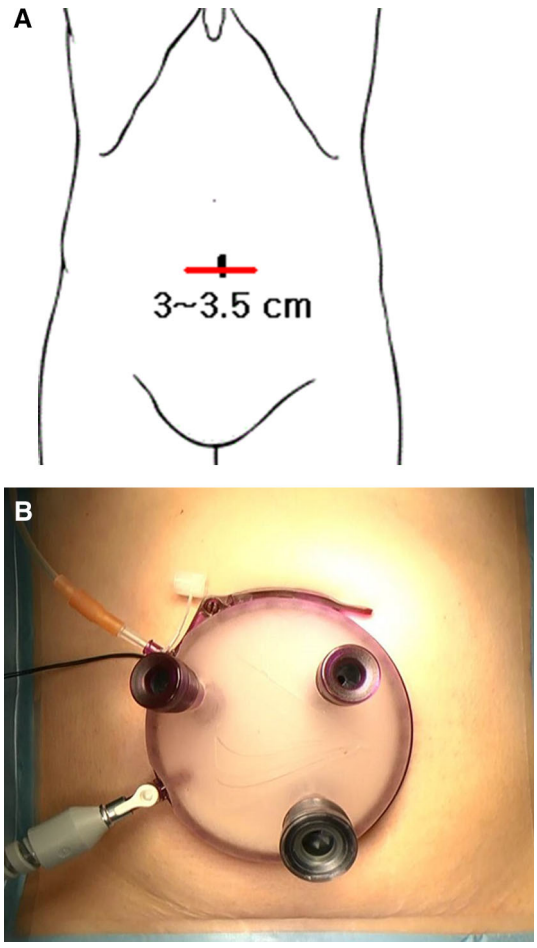

Fig. 1 **A** Single-port TLDG used just one incision on umbilicus. **B** Three trocars with one GelPort were used for single-port TLDG. *TLDG* totally laparoscopic distal gastrectomy

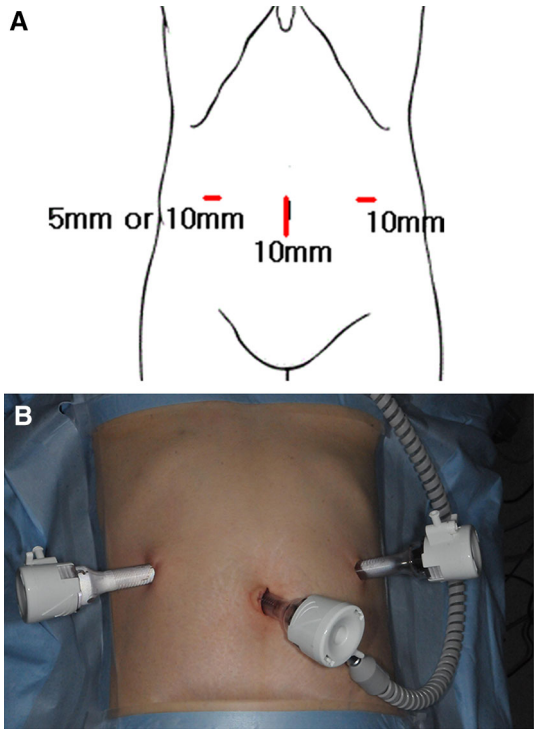

Fig. 2 **A** Duet TLDG used three incisions located at umbilicus, left lower quadrant, and right lower quadrant. **B** Three 10-mm trocars inserted into intraperitoneal space for duet TLDG. *TLDG* totally laparoscopic distal gastrectomy

firing the stapler, and then, the entry hole was closed using a second stapler.

A flexible laparoscope was used for single-port TLDG, and the other instruments were the same as those used for conventional LADG. There were several tips of single-port TLDG for lymphadenectomy. Bending the laparoscope gives a better operation field and reduces clashing of instruments. When supraduodenal vessels and tissues were dissected from the anterior side of the stomach to identify the right gastric artery, the camera was located in right side of the patient and bending to the left side for the better view. The camera from the right and upper side makes better operation fields during the right-side omentectomy.

The camera and instruments in single-port TLDG were similar than in duet TLDG. The camera was usually introduced at center trocar except the time for intracorporeal gastroduodenostomy. The camera was located through right-side trocars in the two groups for appropriate angle of linear stapler for anastomosis.

A 1–0 nylon suture was used to retract the liver as a usual manner. The nylon suture was passed percutaneously to make a ring. And the one side of the ring was fixed at the skin by a knot, and the opposite side was placed at the gastrohepatic ligament by hemolock (Fig. 3).

Number six lymph nodes including right gastroepiploic vessels were dissected from the anterior side of the

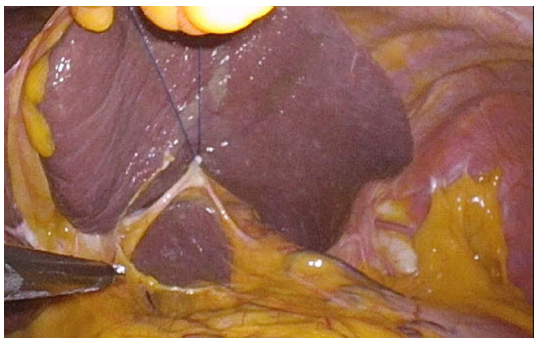

Fig. 3 Liver was retracted by a 1–0 nylon suture

stomach not to pull up the stomach as is the usual manner in conventional LADG (Fig. 4A).

Dissection of suprapancreatic lymph nodes should be done from the left to right side for dissection of right side of left gastric artery (Fig. 4B). This approach made lymph node dissection easier. Even if we used a flexible laparoscope, the upper border of common hepatic artery was hardly to be seen so that adequate traction of lymph nodes to the anterior and caudal side was essential (Fig. 4C). After dividing the left gastric artery with number seven lymph nodes, traction of soft tissue in the suprapancreatic region was easier.

Upper border of the pancreas was dissected along the splenic artery for number eleven lymph nodes as usual manner. Because the energy device was introduced through the umbilical port, the pancreas was pressed naturally by the energy device and the region around the proximal splenic artery could be easily dissected (Fig. 4D). In addition, the bending a flexible scope above the pancreas made better operating view of upper border of the pancreas. Gerota's fascia and Toldt's fusion fascia were usually identified; however, they should not be verified because single-port TLDG targeted minimally $D1 + \beta$ lymphadenectomy. This view was similar to operation field of open gastrectomy (Fig. 4E). The right and posterior sides of the vessels were hardly to be seen even if bending the laparoscope, so curved instruments might be helpful to divide the vessels.

Outcome data

The primary endpoint of the study was the median number of lymph nodes dissected. The operating time was defined as the time from skin incision to closure. Morbidities were defined as complications that required an extended hospital stay or readmission. Postoperative complications included those that occurred in the initial 30 days after surgery. The severity of postoperative complications was assessed according to the Clavien–Dindo classification [14].

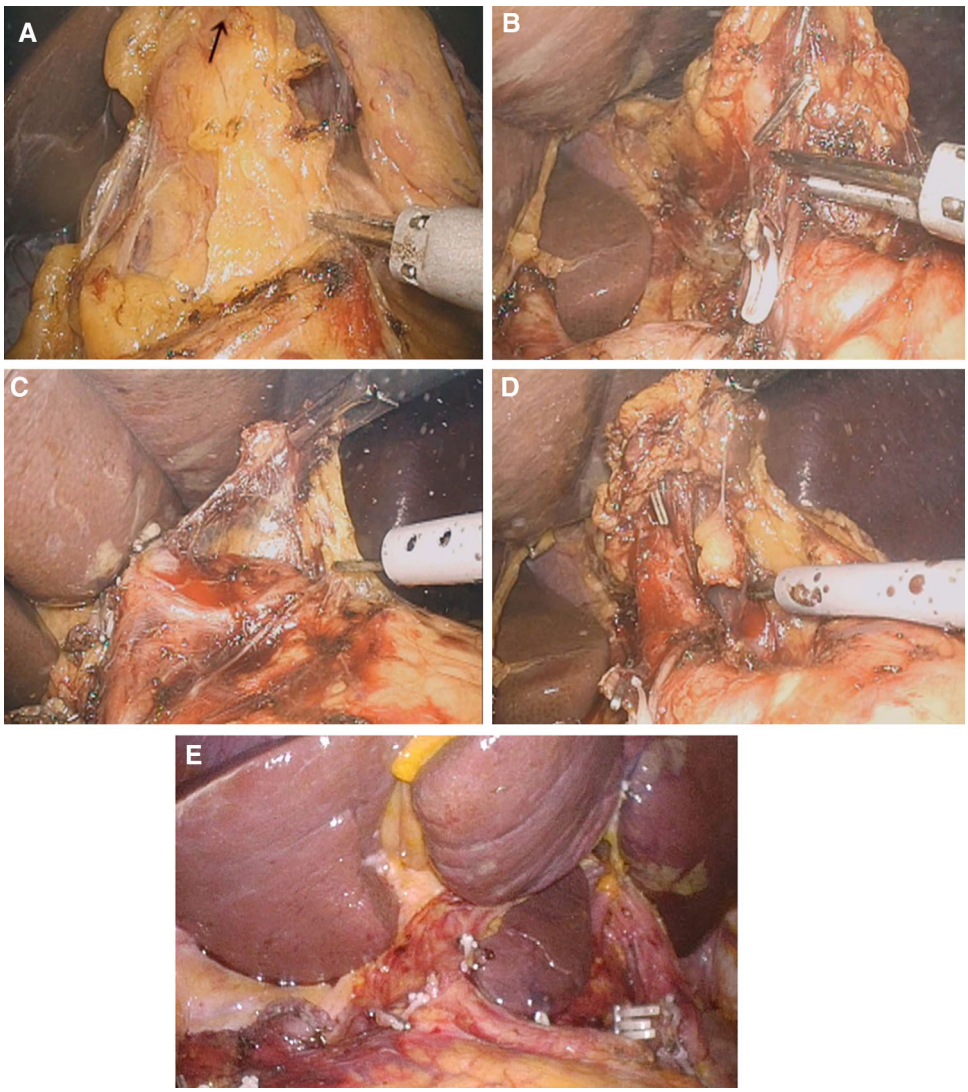

Fig. 4 **A** Number six lymph nodes including right gastroepiploic vessels were removed. The *arrow* indicates the direction of traction. **B** Suprapancreatic lymph nodes were dissected, and the coronary vein was divided. **C** The picking and pulling tissues near common hepatic artery by right hand enabled the dissection of number eight lymph nodes to be easily dissected without additional assistant. **D** The upper border of the pancreas was dissected along the splenic artery. The pancreas was pressed naturally by the energy device and gravity. **E** Common hepatic artery, celiac axis, and proximal splenic artery were showed after lymph node dissection

Statistical methods and analyses

Continuous variables were compared using the Student *t* test, and categorical variables were compared using the χ^2 test or Fisher exact test, as appropriate. An *F* test was used for comparison of variances between two groups. Statistical analysis was performed using SPSS version 21.0 (IBM Corp., Armonk, NY, USA).

Results

Patient and tumor characteristics

Ninety-four patients were included in this study. Clinical and pathological characteristics of the patients and tumors are given in Table 1. The single-port TLDG group consisted of 22 men and 26 women with a median age of 53.5 years (range 33–80 years), and the duet TLDG group consisted of 37 men and nine women with a median age of 58.5 years (range 33–76 years). There were more female patients (54.2 vs. 19.6 %, $p = 0.001$) and patients were less obese (21.1 ± 2.1 vs. 24.6 ± 3.2 kg/m^2, $p = 0.001$) in the single-port TLDG group. Patient age was not statistically different between the two groups.

Effect of operation method on short-term outcomes

There was no significant difference in blood loss during surgery or operating time (135.3 ± 18.8 vs. 132.8 ± 27.0 min, $p = 0.634$) between the groups. The pain score at postoperative first, third, and fifth day was similar between single-port TLDG and duet TLDG groups ($p = 0.666$, 0.250, and 0.130, respectively). The use of additional analgesic drugs postoperatively and duration of postoperative hospital stay were not statistically different

Table 1 Patient demographics and clinical characteristics

Characteristic	Single-port TLDG ($n = 48$)	Reduced-port TLDG ($n = 46$)	p
Age (years)	53.5 (33–80)	58.5 (33–76)	0.174
Sex			0.001
Male	22 (45.8 %)	37 (80.4 %)	
Female	26 (54.2 %)	9 (19.6 %)	
BMI (kg/m^2)	21.1 ± 2.1	24.6 ± 3.2	0.001
	21.1 [15.7–26.1]	24.4 [14.7–31.2]	0.000
Tumor size (cm)	2.7 ± 1.7	2.9 ± 1.7	0.474
Tumor location			0.541
Middle	25 (52.9 %)	27 (58.7 %)	
Lower	23 (47.1 %)	19 (41.3 %)	
Tumor histologic type			0.659
Differentiated	14 (42.2 %)	16 (34.8 %)	
Undifferentiated	34 (57.8 %)	30 (65.2 %)	
Ulceration			0.334
Absent	9 (28.4 %)	13 (28.3 %)	
Present	39 (71.6 %)	33 (71.7 %)	
Tumor depth of invasion			0.942
Mucosa	36 (57.8)	32 (70.0)	
Submucosa	9 (42.2)	11 (30.0)	
Muscularis propria	2	2	
Subserosa	1	1	
Lymph node metastases			0.356
Absent	47 (91.2 %)	43 (88.0 %)	
Present	1 (8.8 %)	3 (12.0 %)	

TLDG totally laparoscopic distal gastrectomy, *BMI* body mass index

between the two groups (Table 2). Three patients (two patients with single-port TLDG and one patient with duet TLDG) had admitted for more 2 weeks from the surgery due to delayed gastric emptying and postoperative ileus. One patient with duet TLDG who had the reoperation for small bowel obstruction had discharged after 24 days from the first operation. No patient required conversion to open surgery in either group.

Effect of operation method on surgical qualities

There was no significant difference in the median number of dissected lymph nodes in the single-port TLDG and duet TLDG groups (35.5 [range 16–67] vs. 37.5 [range 15–81; $p = 0.300$). No patient in either group had fewer than 15 lymph nodes retrieved. The size of the proximal and distal margins was not significantly different between groups.

Effect of operation method on postoperative complications

The postoperative complications are given in Table 3. Complication rates in the single-port and duet TLDG groups were not significantly different (20.8 vs. 21.7 %, $p = 1.000$). The most common complication in the single-port TLDG group was ileus (three patients), followed by delayed gastric emptying, anastomosis stricture, and wound-associated complications. A similar pattern was noted in the duet TLDG group, in which ileus was the most common complication (five patients), followed by delayed gastric emptying, anastomosis stricture, and bleeding. No postoperative deaths occurred in either group. Five patients in the single-port TLDG had readmission and recovery with conservative management due to anastomosis stenosis (two patients), wound seroma (two patients), and ileus (one patient). One patient in each group had reoperation because of intestinal obstruction. No postoperative deaths occurred in either group.

Subanalysis for operation time

The operating time in the single-port TLDG group was similar to that in the reduced-port TLDG group (135.3 ± 18.8 vs. 132.8 ± 27.0 min, $p = 0.634$). Interestingly, there were significant differences in sex and BMI between the two groups, which might affect the operation time. When adjusted for sex and BMI, there was a significant difference in operation time between the groups

Table 2 Comparison of surgical outcomes of single-port totally laparoscopic distal gastrectomy and reduced-port totally laparoscopic distal gastrectomy

Outcomes	Single-port TLDG (n = 48)	Reduced-port TLDG (n = 46)	*p*
Operating time (min)	135.3 ± 18.8	132.8 ± 27.0	0.634
	[96–173][a]	[96–209]	
Blood loss during surgery (mL)	101.1 ± 78.5	80.6 ± 49.3	0.145
	[25–400]	[30–300]	
Postoperative VAS pain scores			
POD #1	4.1 ± 1.0	4.0 ± 0.8	0.666
POD #3	3.4 ± 1.0	3.3 ± 0.7	0.300
POD #5	2.8 ± 0.8	2.8 ± 0.7	0.876
Use of additional analgesic drugs postoperatively (number of doses)	4.7	4.8	0.850
Postoperative hospital stay (days)	7 (7–24)	7 (7–15)	0.684
Number of lymph nodes dissected			
Median	35.5	37.5	0.300
Range	16–67	15–81	
Resection margin			
Distal margin (cm, mean ± SD)	5.8 ± 2.6	6.0 ± 3.3	0.686
	[1.1–11]	[0.3–14]	
Proximal margin (cm, mean ± SD)	4.7 ± 3.2	4.0 ± 3.0	0.281
	[0.5–12.3]	[0.1–11.2]	

TLDG totally laparoscopic distal gastrectomy, *VAS* visual analogue scale, *POD* postoperative day, *SD* standard deviation

[a] The value in the "[]" means the range

Table 3 Early postoperative complications

Complication	Single-port TLDG (*n* = 48)	Reduced-port TLDG (*n* = 46)	*p*
Overall complications	10 (20.8 %)	10 (21.7 %)	1.000
Specific complications			
Ileus	3	5	
Delayed gastric emptying	2	2	
Intestinal obstruction	1	1	
Anastomosis stricture	2	1	
Anastomosis bleeding	0	1	
Wound-associated complications	2	0	
Clavien–Dindo classification			0.364
I	4	6	
II	5	2	
III	1	2	

TLDG totally laparoscopic distal gastrectomy

($p = 0.01$). The *variance* in operation time for the reduced-port TLDG was significantly greater than that for the single-port TLDG ($p = 0.01$, Fig. 5).

Discussion

Laparoscopic gastrectomy is technically more difficult than open gastrectomy because of the limited view and the restricted working space [1]. Nonetheless, with accumulating experience and the development of improved instruments LADG has become widely performed for early-stage gastric cancer. Patients treated by LADG have shown similar surgical outcomes and a superior quality of life compared with those treated by open gastrectomy [6]. Single-incision laparoscopic surgery would be even less invasive, but more technically complex.

There are several reports on the application of single-incision laparoscopic surgery in various surgeries such as colectomy, cholecystectomy, and gynecologic surgery [15–

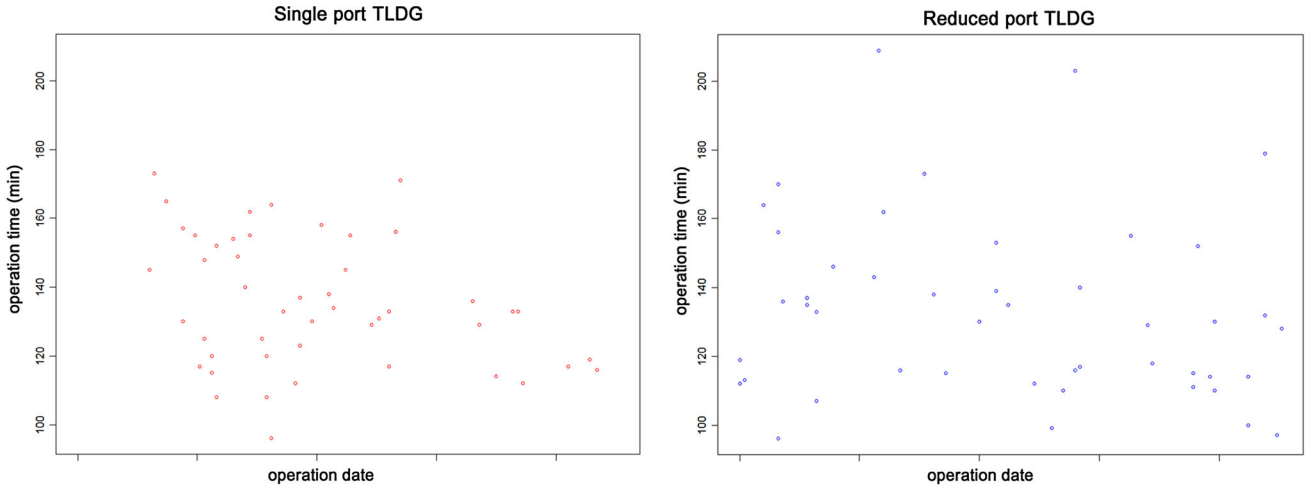

Fig. 5 Scatter plot showing the variance for single-port TLDG and reduced-port TLDG. *x*-axis represents the operation date; *y*-axis represents the operation time. The *variance* in operation time for the reduced-port TLDG is significantly greater than that for the single-port TLDG ($p = 0.01$). *TLDG* totally laparoscopic distal gastrectomy

17]. Although single-incision laparoscopic surgery has shown a reduction in surgical trauma and better cosmetic results, there are few reports of single-incision laparoscopic gastric cancer surgery because of the need for a wider operation field for systemic lymph node dissection than for other organs [7].

We have previously reported the technique of reduced-port laparoscopic gastrectomy and surgical outcomes compared with conventional LADG [10]. Reduced-port TLDG showed similar surgical outcomes and patient safety, but required fewer incisions, trocars, and assistants and no special techniques or instruments.

As our experiences of reduced-port TLDG accumulated, we developed the technique of single-port laparoscopic distal gastrectomy. Unlike reduced-port TLDG, the patient was placed in lithotomy position to extend the motion range of the operator stand between the patient's legs. In this way, gravity was considered a hidden assistant. We selected a flexible laparoscope and performed a transverse umbilical incision instead of a vertical umbilical incision to resolve the problems of a poor operation field and limited intraabdominal space. Despite these two changes, we used the same instruments as for the conventional method without any additional ports.

A flexible scope can improve the operation field through bending [18]. The flexible scope has the benefit of allowing dissection of the eighth, eleventh, and twelfth lymph nodes above the common hepatic artery and the splenic artery. This view is similar to the operation field of open gastrectomy. In addition, the umbilical transverse incision gives us a wider space in which to manipulate instruments, and prevents clashing of instruments. It even gives faint scar at several months after the surgery

Fig. 6 Transverse incision in single-port TLDG was fade after 1 month from the surgery. *TLDG* totally laparoscopic distal gastrectomy

because the direction of scarring matches that of the skin folds (Fig. 6).

We compared surgical outcomes of patients with early gastric cancer who underwent single-port and reduced-port (duet) TLDG. There were no significantly differences in the surgical outcomes, including the number of retrieved lymph nodes and resection margins. The single-port TLDG group had no patient with fewer than 15 dissected lymph nodes, which is the minimum required for lymph node dissection in gastric cancer. The two groups also had similar complication rates. Single-port TLDG is therefore safe for early-stage gastric cancer in terms of surgical outcomes.

From previous reports, the evidence base for single- or reduced-port laparoscopic surgery is inadequate to determine the reduction in postoperative pain compared with conventional laparoscopic surgery [19]. There was no significant difference in postoperative pain between single-port TLDG and reduced-port TLDG in our study. Also, a previous study reported that pain after duet TLDG was

similar to that after conventional LADG, despite the use of fewer ports [10]. Incisional pain might be dependent on various factors, including the number of ports, length of the incision, and individual characteristics. A large-scale clinical trial using standard measurement tools is required to clarify whether pain is less after a single-incision or reduced-port laparoscopic gastrectomy than after conventional LADG.

Regarding operation time, the *variance* for reduced-port TLDG was higher than that for single-port TLDG, and there was a significant difference between the groups in sex- and age-adjusted data, even though there was no significant difference in the raw data. This study had a selection bias of patients; it was not a randomized trial, and there were more females and non-obese patients in the single-port TLDG group. Although we have more than 1000 experiences of laparoscopic gastrectomy, we had no experience of single-incision laparoscopic gastrectomy before this study. Single-port TLDG is technically more difficult and more time demanding in unpredictable events such as sudden bleeding during operation. We expect that single-port TLDG would exhibit a learning curve similar to the first applications of laparoscopy itself. In fact, the time for learning curve might be rather longer, and this study by single surgeon could not be overgeneralized to large population or center. Therefore, further studies are certainly necessary to clarify this. Despite these technical difficulties, there were no significant differences in surgical outcomes between single-port TLDG and reduced-port TLDG.

In conclusion, we found that single-port TLDG is feasible for patients with early gastric cancer; however, for now it might be considered as a treatment option for a limited subset, such as females or less obese patients. Further advancements in techniques and instruments are required to expand the indications for single-port TLDG.

Compliance with ethical standards

Disclosures Drs. Su Mi Kim, Man Ho Ha, Jeong Eun Seo, Ji Eun Kim, Min Gew Choi, Tae Sung Sohn, Jae Moon Bae, Sung Kim, and Jun Ho Lee have no conflicts of interest or financial ties to disclose.

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