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Surgical assessment system reflexes and facilitates the developing the surgical skills of trainees for the Laparoscopic Distal Gastrectomy

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Background: To assess laparoscopic distal gastrectomy (LDG) for gastric cancer (GC), the Japanese Operative Rating Scale (JORS) for LDG has been developed. This study evaluated the learning curve of the initial experience of LDG for GC using JORS-LDG.

Methods: Thirty-one cases of LDG were performed by a trainee. The trainee and an instructor scored the surgical performance using JORS-LDG immediately after LDG. The 31 cases were evenly divided into early phase (EP), middle phase (MP), and late phase (LP).

Results: The trainee successfully completed all cases of LDG without any complications. There were also no severe postoperative complications with Clavien–Dindo classification grade III or higher. The average JORS-LDG points were stable after 24 cases of experience in the CUSUM analysis. The median JORS-LDG points in EP were significantly lower than those in LP (EP: MP: LP = 43.5: 44.3: 45.5, P = 0.02). In operative data, procedure time, bleeding, and the drain fluid amylase level were correlated with the JORS-LDG points.

Conclusion: The JORS-LDG scoring system is a practical tool to evaluate surgical performance in the initial LDG experience.

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Key words: Laparoscopic Distal Gastrectomy, Surgical performance, Gastric cancer

Introduction

Laparoscopic distal gastrectomy (LDG) for early and advanced gastric cancer results in a lower complication rate and a faster short-term recovery than open surgery (1, 2). LDG is a common operation for surgical trainees (3, 4).

Continuous surgical developments are accomplished by asking good questions, proving constructive feedback and devising a plan of action (5). In clinical practice, comprehensive surgical coaching, which involves debriefing, feedback, and behavior modeling, provides surgical skill acquisition (6). The surgical assessment system allows objective, reliable, and valid measures of surgical skills and helps instructors coach trainees (7). Clinical assessments of laparoscopic procedures have been developed in several fields (8-10). However, a surgical assessment system for LDG has not been established.

We developed a novel surgical assessment system using the Japanese Operative Rating Scale for Laparoscopic Distal

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Gastrectomy (JORS-LDG) (11). JORS-LDG was previously developed from expert opinions by the Delphi method. However, the sequential assessment of the surgical skills for LDG using JORS-LDG remains unclear. This study investigated the relationship between the JORS-LDG score and the process of surgical skill development, although only one trainee and instructor participated in this pilot study.

Materials and Methods

Patient population

The maximum sample size was determined to be 50 cases based on previous studies (12-14). Early termination was considered when a trainee received qualified surgeon status according to the endoscopic surgical skill qualification system (ESSQS), Japan Society for Endoscopic Surgery (JSES) (15). This study was terminated in 2018 because the trainee received their qualified surgeon status according to the ESSQS. Thus, from 2016 to 2018, 35 patients who underwent LDG for gastric cancer at the Department of Surgery in Nagasaki University Hospital were enrolled in this study. From these 35 patients, 4 patients were excluded because their operations were performed by other operators. The remaining 31 patients were treated by the trainee. Other data from the remaining 31 patients were collected and analyzed. The 31 cases were evenly divided into early phase (EP), middle phase (MP), and late phase (LP). The rules for classification and staging corresponded to the 8th edition of the International Union Against Cancer (UICC)/American Joint Committee on Cancer (AJCC) Tumor Node Metastasis (TNM) staging system (16).

Trainee and instructor

The trainee was a board-certified surgeon in the Japan Surgical Society (JSS). The trainee's laparoscopic surgical skills and knowledge were verified, regardless of operator experience with various operations, such as open gastrectomy and laparoscopic cholecystectomy, or experience as a first assistant or scopist for LDG for 6 months without using JORS-LDG. The trainee had experience with LDG in less than 10 cases without using JORS-LDG. The instructor was an expert in LDG and was a qualified surgeon according to ESSQS and JSES (15).

Surgical procedure

The position of first assistant was fulfilled by the instructor. LDG with curative lymph node dissection was performed according to the standardized procedure in all patients. The lymph nodes were dissected from the regional lymph nodes, which were recommended in the Japanese gastric cancer treatment guidelines (17). Briefly, the first 12-mm trocar was inserted into the umbilicus. Another two 12-mm ports were inserted at the right and left mid-clavicular lines, and two 5-mm ports were inserted at the right and left mid-axillary lines below the costal margin. Ultrasonic coagulating and vessel sealing systems were used for lymphadenectomy around the infrapyloric, perigastric, and suprapancreatic areas (18, 19). A midline skin incision of approximately 40 mm was made in the upper abdomen after the distal two-thirds of the stomach were resected. In all cases, delta-shaped Billroth-1 (B-1) anastomosis was laparoscopically performed (20). A closed suction drain was placed around the suprapancreatic area before the minilaparotomy and trocar sites were closed.

Assessments using JORS-LDG

JORS-LDG was previously reported (Table 1) (11). Briefly, JORS-LDG consists of 13 sections and 27 elements in B-1 reconstruction. The checklist consists of the following tasks: procedure setup, intra-abdominal check, lymph node dissection, stomach resection, reconstruction, and final check. Each task is scored by 2 or 3 grades in the elements. The maximum JORS-LDG's points are 46. The trainee and the instructor performed several assessments using JORS-LDG immediately after the operations. The average of the trainee's and instructor's total points of JORS-LDG (TITP-JORS-LDG) was used to evaluate the relationships with other surgical parameters.

Postoperative managements

Liquid intake was started on the first postoperative day (POD). The oral intake of solid foods was started on POD3. The drain fluid amylase level was measured on POD1. An amylase level of more than 1,000 IU/L in the drainage fluid was defined as pancreatic injury because more than approximately 1,000 IU/l of amylase concentration on POD1 was an independent risk factor for pancreatic abscess (21-23). Complications were classified according to the Clavien-Dindo (C-D) classification (24, 25). Postoperative complications were defined as grade II or higher in the C-D Classification.

Ethical Issues

This study was approved by the institutional review board of Nagasaki University Hospital (1512118).

Statistical analysis

The data are expressed as the medians and interquartile ranges (IQRs). Wilcoxon's tests and Steel's test were used for comparisons of values in the EP, MP, and LP groups. The

Table 1. JORS-LDG score sheet (11)

Subtask	Score
#1 Set up	
1. Set theting patient to appropriate position	0 1
2. Checking and setting up the surgical instruments	0 1
3. Checking the operation of the instruments	0 1
#2 Port insertion	
4. Safely insert the first camera port	0 1 2
5. Set the pneumoperitonium to appropriate level	0 1
6. Insert operation ports under direct vision	0 1 2
#3 Check distant metastasis	
7. Checking for the distant metastasis including peritoneal dissemination and liver metastasis	0 1
#4 Liver retraction	
8. Ensure good visualization by gentle retraction of liver	0 1 2
#5 LN dissection Grater curvature (No. 4d-4Sb)	
9. Resection of omentum by ensuring at least 3 cm margin from gastroepiploic vessels	0 1 2
10. Visual confirmation to avoid injury to transverse colon	0 1
11. Resection of LGEA	0 1 2
#6 LN dissection Subpylorici (No. 6)	
12. Takedown of Transverse colon by dissection of fusion tissue	0 1 2
13. Confirmation of the confluence pattern of gastrocolic trunk	0 1 2
14. Identification of ASPDV and determination of the lower margin of the dissection of #6 LN	0 1 2
15. Resection of RGEV	0 1 2
16. Confirmation of branching of ASPDA, RGEA, IPA from GDA	0 1 2
17. Resection of RGEA and IPA	0 1 2
#7 Duodenum resection	
18. Determine the resection line of the duodenum after confirming the location of the pyloric ring and resect the duodenum	0 1 2
#8 LN dissection Suprapyloricus (No. 5)	
19. Resection of RGA after confirming its root	0 1 2
#9 LN dissection Upper margin of pancreas (No. 8a,9)	
20. Ensure good visualization of upper margin of pancreas by gentle retraction of pancreas	0 1 2
21. Dissection of #8a LN by dissection of outer layer of the nerve plexus of CHA	0 1 2
22. Resection of LGA and LGV after dissection around the vessels	0 1 2
#10 LN dissection Lesser curvature (No. 1, 3)	
23. Dissection of #1 – 3 LN by dissection of the lesser curvature	0 1 2
#11 Stomach resection	
24. Division of the stomach after confirming adequate margin from the lesion	0 1
Select to evaluate A. Roux–en–Y or B. Billroth-I reconstruction	
A. Roux-en-Y reconstruction (R-Y)	
25. Construction of tension free Roux limb	0 1
26. Gastro-jejunal anastomosis considering the location and diameter of the anastomosis	0 1 2
27. Jejuno-jejunal anastomosis taking in consideration the tension and reflux of intestinal fluid to the gastro-jeujenal anastomosis	0 1 2
28. Closure of the Mesentric defect between the mesentry of the limbs and jejunum	0 1 2
29. Closure of the Petersons defect	0 1 2
B. Billroth-I reconstruction (B-I)	
30. Confirmation that there is no excessive tension between the remnant stomach and duodenum	0 1
31. Gastro-duodenal anastomosis considering the diameter of the anastomosis	0 1 2
#12 Check final appearance	
32. Confirmation that there is no bleeding in the whole operation field	0 1
33. Confirmation of the final appearance	0 1
	/ 52 points (R-Y)
	/ 46 points (B-I)

[Evaluation Criteria]

Scoring by 2 grades	Scoring by 3 grades
0 not performed 1 Performed	0 Unable to perform due to lack of knowledge and skill 1 Need moderate guidance due to insufficient knowledge and skill 2 Able to perform independently without guidance

relationships of categorical clinical factors between the groups were analyzed using chi-square tests or Fisher's exact tests. Fisher's exact test was applied if the theoretical frequency was less than five. Probability values (P) less than 0.05 were considered to be statistically significant. To investigate the correlations between the number of experiences or the TITP-JORS-LDG and the procedure time, intraoperative bleeding, or drain fluid amylase level, Spearman's rank correlation coefficient was adopted. The following rule was used to characterize the strength of the association: a coefficient under 0.20 was classified as very weak; between 0.20 and 0.40 weak; between 0.40 and 0.60 moderate; between 0.60 and 0.80 strong; and between 0.80 and 1.00 very strong. All statistical analyses were performed using the SAS-JMP program for Windows (SAS Institute Inc. Cory, NC). The CUSUM method is a type of sequential analysis test that was initially used in industrial settings for quality control purposes (26). The target value was set at 45.5 ± 0.5.

Results

Patient characteristics

The clinical characteristics of the 31 patients are summarized in Table 2. The average procedure time was 266 (IQR 247–311) min. The median estimated blood loss was 50 g (IQR 20–108). Postoperative complications with C-D classification grade II developed in 8 patients (25.8%). There were no patients who developed severe complications with C-D classification grade III or higher.

Table 2. Patient characteristics

Factor	
Age	62 (53, 72)
Sex (Male/Female)	20/11
BMI	23.9 (20.6, 25.2)
pStage (1a/1b/2/3)	19/4/6/2
Lymphodectomy (D1+/D2)	22/11
Lymph node number	35 (25, 41)
Procedure time (min)	266 (247, 311)
Intraoperative bleeding (g)	50 (20, 108)
Drain amylase (IU/L)	596 (266, 1044)
Pancreatic injury	8 (25.8%)
Postoperative complications	8 (25.8%)
Pancreatic fistula	2 (6.4%)
Abdominal abscess	2 (6.4%)
Enteritis	2 (6.4%)
Gastric delayed empty	2 (6.4%)
Wound infection	1(3.2%)
Postoperative hospital stay (days)	10 (9, 12)
JORS-LDG score	44.5 (43.5, 45.5)
Matching rate of JORS-LDG	96.4 (92.9, 96.4)

JORS-LDG; Japanese Operative Rating Scale for Laparoscopic Distal Gastrectomy

Summary of the total and deduction points of JORS-LDG

For the total JORS-LDG score, the median was 44.5 (IQR 43.5–45.5). The median rate of matched evaluations between the trainee and instructor was 96.4% (IQR 92.9–96.4). In the deduction points for each station of JORS-LDG, the infrapyloric lymphadenectomy section had higher deduction points than the other sections (Figure 1).

Correlations between TITP-JORS-LDG and amount of experience

There were moderate correlations observed between the trainee's and instructor's JORS-LDG scores and the amount of experience (Spearman's $\rho = 0.46$, $P < 0.01$, and Spearman's $\rho = 0.45$, $P = 0.01$, respectively) (Supplemental Figure 1). There was a moderate correlation observed between the average TITP-JORS-LDG and the amount of experience (Spearman's $\rho = 0.48$, $P < 0.01$) (Figure 2A). The CUSUM graphs also demonstrated a continuous improvement in the average TITP-JORS-LDG and the amount of experience (Figure 2B). In the CUSUM analysis, the average TITP-JORS-LDG was stable throughout 24 cases. Next, we evaluated the relationship with TITP-JORS-LDG and the amount of experience or the 3 categorized terms. The median TITP-JORS-LDG in EP was significantly lower than that in LP (EP: MP: LP = 43.5 (42.4, 44.6): 44.3 (43.9, 45.6): 45.5 (44.5, 46), P = 0.02) (Figure 3A). There was also no significant difference in the matching rates of JORS-LDG in the 3 categorized terms (94.6 (89.3, 97.3): 96.4 (89.3, 97.3): 96.4 (96.4, 100), P = n.s.) (Figure 3B).

Comparison of other factors between EP, MP, and LP

Table 3 shows a comparison of the characteristics of the patients in the EP, MP, and LP. The 3 groups were matched in sex, age, BMI, and TNM classification. The median procedure time in LP was significantly shorter than that in EP (EP: MP: LP = 311 (267, 373): 277 (254, 323): 245 (223, 265) (min), P = 0.01). The rate of pancreatic injury in LP was significantly lower than that in EP (EP: MP: LP = 60, 20, 0(%), $P < 0.01$).

Correlations between TITP-JORS-LDG and surgical performance

Figure 4 shows the relationship with surgical performance and the number of experiences or the average TITP-JORS-

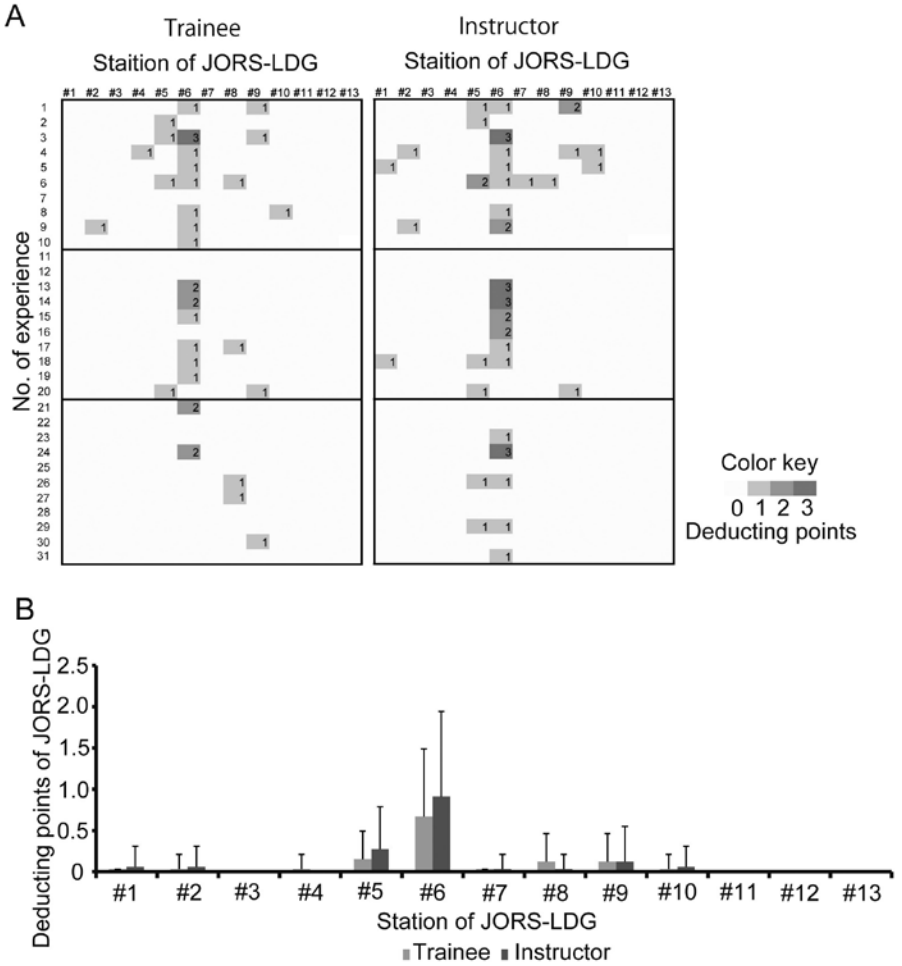
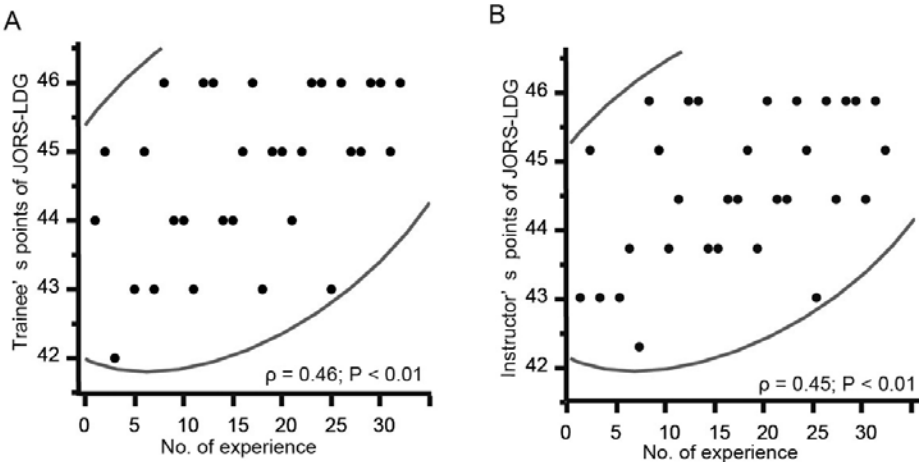


Figure 1. Points deduction in the JORS-LDG station
A: Heat map for the trainee and the instructor regarding points deduction in the JORS-LDG station.
B: The average points deduction in the JORS-LDG station.



Supplemental Figure 1. Correlations between the trainee's experience and the trainee's and instructor's JORS-LDG points
There were significant correlations between the trainee's and instructor's JORS-LDG points and the amount of experience ($r = 0.46$, $P < 0.01$, and $r = 0.45$, $P = 0.01$, respectively). Red lines show the 95% confidence ellipse. JORS-LDG; Japanese Operative Rating Scale for Laparoscopic Distal Gastrectomy.

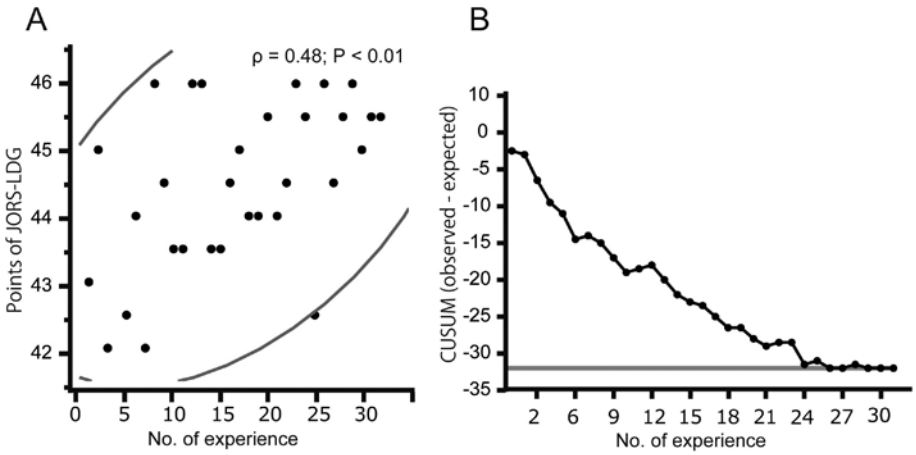


Figure 2. JORS-LDG points and the rate of matching JORS-LDG in the trainee's experience
A: Relationship between the average JORS-LDG points and the trainee's experience.
A moderate correlation was observed between the average JORS-LDG score and the amount of experience (Spearman's $\rho = 0.48$, $P < 0.01$).
B: The CUSUM graphs also demonstrated a continuous improvement in the average JORS-LDG points and the amount of experience.
Red lines show the 95% confidence ellipse. Green line shows the stable line. JORS-LDG; Japanese Operative Rating Scale for Laparoscopic Distal Gastrectomy

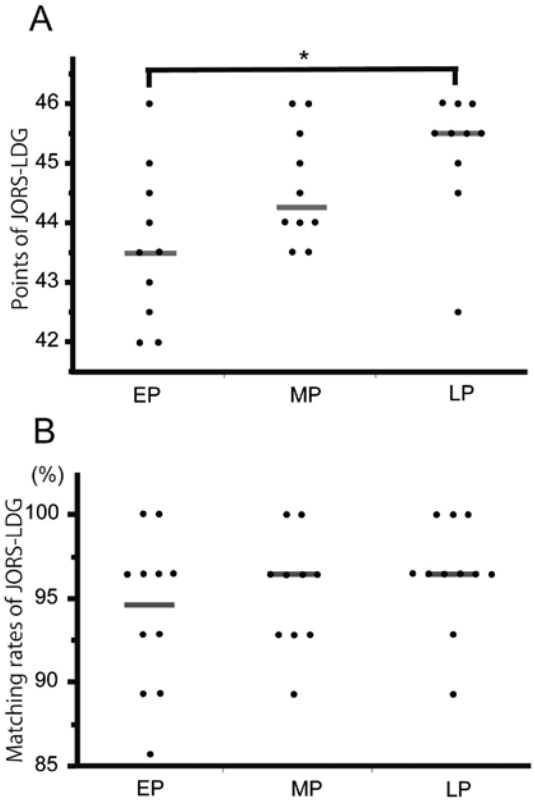


Figure 3. Comparison of data of JORS-LDG between EP, MP, and LP
A: The median JORS-LDG points in EP were significantly higher than those in LP (EP: MP: LP = 43.5:44.3:45.5, P = 0.02).
B: In the rate of matching JORS-LDG, there was no significant difference between the three groups (94.6 (89.3, 97.3):96.4 (89.3, 97.3):96.4 (96.4, 1), P = n.s.). Bars show the median. JORS-LDG; Japanese Operative Rating Scale for Laparoscopic Distal Gastrectomy, EP; early phase, MP; middle phase, LP; late phase

LDG score. A strong correlation was observed between procedure time and the average TITP-JORS-LDG score (Spearman's $\rho = -0.63$, $P < 0.01$). A strong correlation was observed between intraoperative bleeding and the average TITP-JORS-LDG score (Spearman's $\rho = -0.74$, $P < 0.01$). A moderate correlation was observed between the drain fluid amylase level and the average TITP-JORS-LDG (Spearman's $\rho = -0.48$, $P < 0.01$). A moderate correlation was observed between the procedure time or intraoperative bleeding and the average deduction points in the infrapyloric lymphadenectomy section (Spearman's $\rho = -0.42$, $P < 0.01$, Spearman's $\rho = -0.42$, $P < 0.01$, respectively) (Supplemental Figure 2).

Discussion

In this study, we evaluated the relationship between the assessment of JORS-LDG and the process of surgical skill development for suitable assessments in the initial training of LDG. The relationships between the learning curve and TITP-JORS-LDG are shown. In addition, the TITP-JORS-LDG also shows moderate validity and reliability assessments regarding several surgical performances in the initial LDG experience. Thus, JORS-LDG would be a feasible tool to evaluate the surgical performance in the initial training of LDG.

The learning process depends on the surgeons themselves as well as the patient volume of the institution. In general, at least 50 to 60 cases are necessary to ensure an optimal

Table 3. Comparison of clinical factors between early, middle, and late phases.

Factor	Early phase	Middle phase	Late phase	P Value
Age	63 (56.5, 73.0)	67.5 (50.8, 80.0)	59.0 (49, 63)	n.s.
Sex (Male/Female)	(8/2)	(6/4)	(6/5)	n.s.
BMI	23.9 (20.4, 25.4)	23.6 (20.4, 26.1)	23.7 (21.8, 24.9)	n.s.
pStage (Stage II or more)	3 (30.0%)	4 (40.0%)	1 (9.1%)	n.s.
Lymphodectomy (D1+)	7 (70%)	7 (70%)	8 (72.7%)	n.s.
Lymph node number	29.5 (18.8, 40.5)	29.5 (22.3, 46.0)	38.0 (33.0, 44.0)	n.s.
Drain amylase (IU/L)	1053 (278, 2859)	601 (344, 897)	416 (209, 690)	n.s.
Pancreatic injury	6 (60%)	2 (20%)	0 (0%)	< 0.01
Procedure time (min)	311 (267, 373)	277 (254, 323)	245 (223, 265)	< 0.01
Intraoperative bleeding (g)	104 (33, 144)	54 (19, 103)	30 (10, 70)	n.s.
Postoperative complications	4 (40%)	2 (20%)	2 (18.2%)	n.s.
Surgical site infections	3 (30%)	2 (20%)	0 (0%)	n.s.
Postoperative hospital stay (days)	10 (8, 12.3)	9 (8.8, 12.5)	11 (9, 13)	n.s.

JORS-LDG; Japanese Operative Rating Scale for Laparoscopic Distal Gastrectomy

operative performance of LDG (12, 27, 28). Recently, several approaches to shorten the training periods of LDG were reported from high-volume LDG centers (4, 13, 14, 29). In this study, the trainee also participated in video conferences of LDG and was educated by many laparoscopic gastrectomy experts in addition to the JORS-LDG evaluation. Off-the-job training for LDG might shorten the learning period. TITP-JORS-LDG was stable throughout only 24 cases in the CUSUM analysis.

The validation of trainee surgical skills is an effective tool for surgical coaching (8). Operative performance rating systems provide surgical trainees with milestone performance measures (7). In this study, the average TITP-JORS-LDG had a stronger correlation with surgical outcomes than the experienced cases. As a result, JORS-LDG may be an appropriate tool for trainees to validate the development of LDG.

Lymphadenectomy of LDG is a significant challenge for trainees because of complicated lymph node stations, complicated anatomical variations of vessels, the various shapes of the pancreatic head, and tracing the suitable layer, which consists of loose connective tissue space and enables dedicated lymphatic tissue to be resected (28, 30, 31). In particular, the use of delicate techniques and the recognition of suitable layers are essential to avoid injury to the pancreas and its associated vessels in infrapyloric lymphadenectomy because releasing complicated embryologic fixation of the greater omentum and transverse mesocolon overlay on the lymphatic tissue and dissecting the lymphatic tissue that incorporates the pancreas is required to protect the pancreas and preserve its vessels (30, 32). In this study, the heat map of JORS-LDG demonstrated that there was room for improvements in the infrapyloric lymphadenectomy stations. Moreover, the procedure time and intraoperative bleeding were also improved. These results show that JORS-LDG provides trainees with unsatisfactory parts as well as successful parts in LDG. As a result, JORS-LDG can support concise and effective coaching to improve surgical performance and avoid postoperative complications.

Reliable self-assessment is a skill for professional development (6). In this study, the high matching rates of JORS-LDG between the trainee and the instructor during all terms suggested a clear objective for the JORS-LDG items (Figure 3B). The high rate of JORS-LDG matching also demonstrated that the trainee had already established judgment skills for their own surgical performance with the same value of the instructor. The trainee had various experiences with open distal gastrectomy or various laparoscopic procedures and obtained board-certified surgeon status in the JSS.

Video-based per surgical assessment and coaching is a promising approach (5). A validation study using blind video assessment of laparoscopic gastric cancer surgery, sleeve gastrectomy, and colorectal surgery showed that good surgical skills decreased postoperative complications (33-35). In this study, the trainee's surgical skills in LDG were qualified by the viewing of unedited videos by two review boards according to ESSQS and JSES; these experts were selected from a pool of active laparoscopic experts who had passed the same video-based peer reviews more than 5 years previously (15, 36). The assessment of both surgical skill and perioperative conduct, particularly in relation to dangerous procedures that could lead to complications, are based on detailed criteria for the basic laparoscopic surgical skills and autonomy of the operator, which are regularly revised by the JSES committee

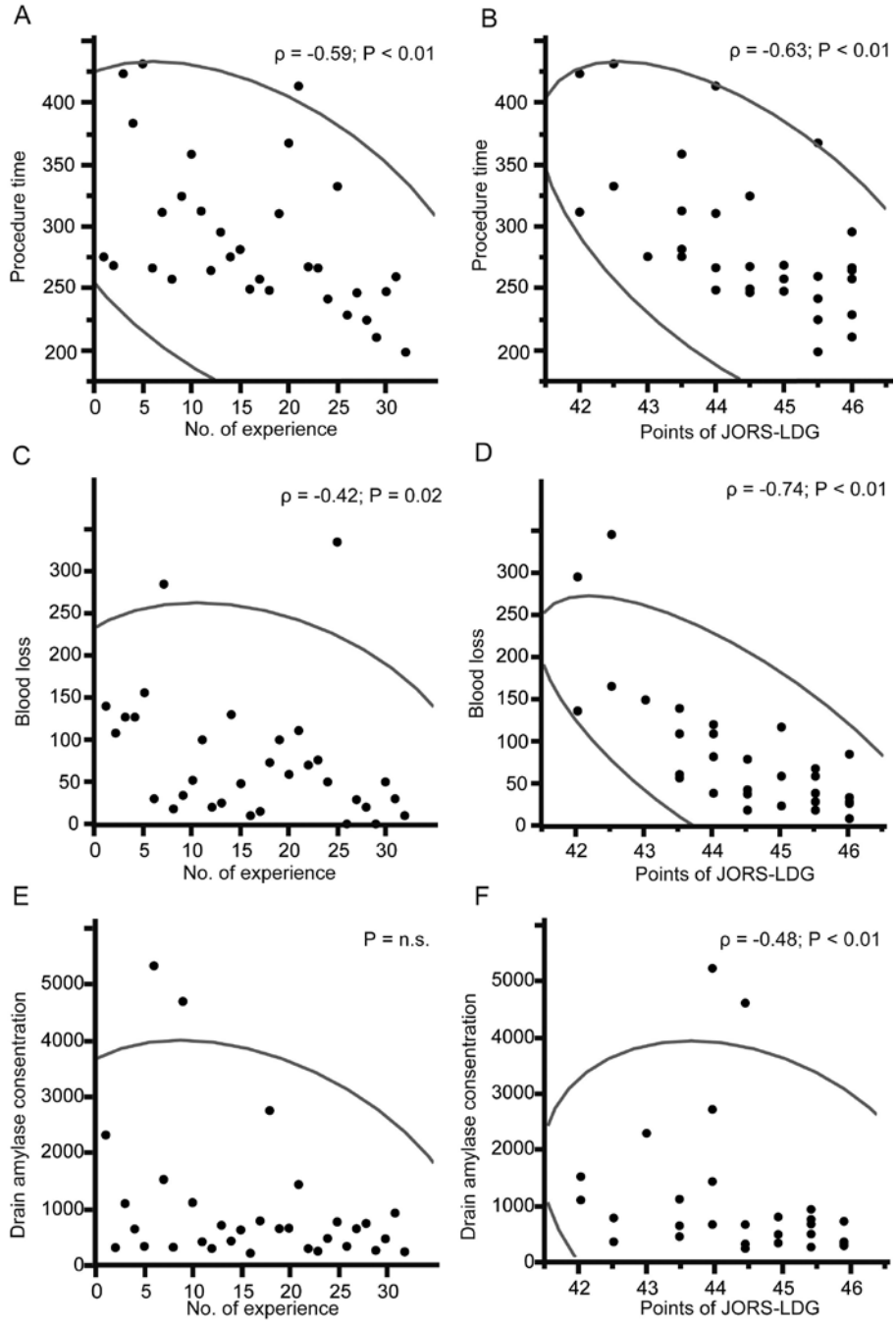
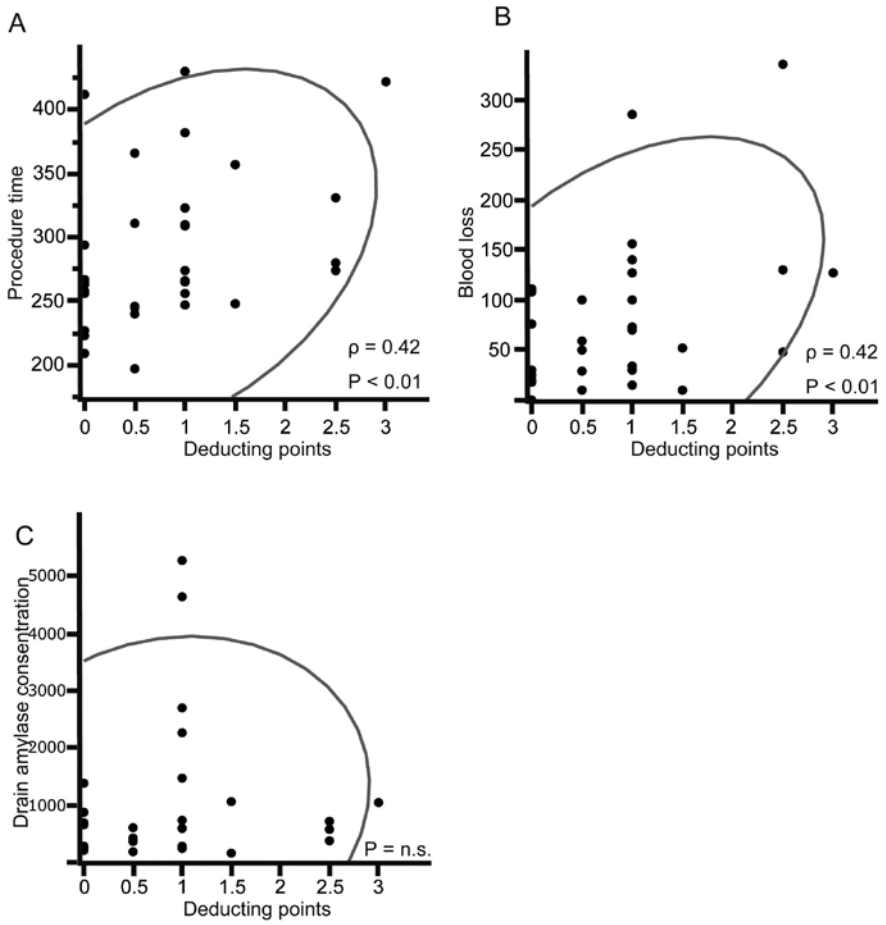


Figure 4. Correlations between JORS-LDG and surgical performances
A: Relationship between the trainee's experience and procedure time.
There was a moderate correlation between the amount of experience and the procedure time (Spearman's $\rho = -0.59$, $P < 0.01$).
B: Relationship between the JORS-LDG points and the procedure time.
There was also a strong correlation between the JORS-LDG points and procedure time (Spearman's $\rho = -0.63$, $P < 0.01$).
C: Relationship between the amount of trainee experience and intraoperative bleeding.
There was a moderate correlation between the amount of experience and intraoperative bleeding (Spearman's $\rho = -0.42$, $P = 0.02$).
D: Relationship between JORS-LDG points and intraoperative bleeding.
There was a strong correlation observed between the JORS-LDG points and intraoperative bleeding (Spearman's $\rho = -0.74$, $P < 0.01$).
E: Relationship between the amount of trainee experience and the drain fluid amylase level.
There was no significant correlation between the amount of experience and the drain fluid amylase level.
F: Relationship between JORS-LDG points and the drain fluid amylase level.
There was a moderate correlation between the JORS-LDG points and the drain fluid amylase level (Spearman's $\rho = -0.48$, $P < 0.01$).
Red lines show the 95% confidence ellipse. JORS-LDG; Japanese Operative Rating Scale for Laparoscopic Distal Gastrectomy.



Supplemental Figure 2. Correlations between surgical performance and the average JORS-LDG points deduction in the infrapyloric lymphadenectomy section

A: Relationship between the procedure time and the average JORS-LDG points deduction in the infrapyloric lymphadenectomy section.

A moderate correlation was observed between the procedure time and the average JORS-LDG points deduction in the infrapyloric lymphadenectomy section (Spearman's $\rho = -0.42$, $P < 0.01$).

B: Relationship between intraoperative bleeding and the average JORS-LDG points deduction in the infrapyloric lymphadenectomy section.

A moderate correlation was observed between intraoperative bleeding and the average JORS-LDG points deduction in the infrapyloric lymphadenectomy section (Spearman's $\rho = -0.42$, $P < 0.01$).

C: Relationship between the drain fluid amylase level and the average JORS-LDG points deduction in the infrapyloric lymphadenectomy section.

There was no significant correlation between the drain fluid amylase level and the average JORS-LDG points deduction in the infrapyloric lymphadenectomy section.

Red lines show the 95% confidence ellipse. JORS-LDG; Japanese Operative Rating Scale for Laparoscopic Distal Gastrectomy.

(15, 36). In addition, adequate oncological clearance is also assessed in video-based peer reviews (15, 36). Supervision by a technically qualified surgeon can affect the proficiency and safety of laparoscopic procedures performed by trainees (37). Thus, the certification by outside experts' assessment supported that the trainee has achieved the surgical skill of adequate oncological clearance and laparoscopic techniques.

Postoperative morbidity is a matter of concern in the learning process. Pancreatitis, pancreatic fistula, and pancreatic abscess are specific complications after LDG. High amylase levels in drainage fluid can lead to the development of pancreatic fistulas and intraabdominal abscesses (38, 39). Thus, pancreatic injury was employed as the postoperative assessment of the potential injury of LDG in this study. Certainly, two cases with intraabdominal abscesses also developed from pancreatic injury (33.3%, 2/6). The correlation between the drain fluid amylase level and TITP-JORS-LDG demonstrated that the surgical performance of LDG might reflect potential pancreatic damage. Reviewing the video of the cases with pancreatic injury, fat saponification around

the pancreas, which was caused by pancreatitis and pancreatic fistula, was often detected. In the infrapyloric lymphadenectomy section, the average deduction points of JORS-LDG for the cases with pancreatic injury were also higher than those without pancreatic injury, although the difference was not statistically significant (1 (1,1.38) vs. 0.5 (0,1), P = 0.06). In the learning period, pancreatic injury and intraabdominal abscess often develop in the early phase. Thus, the JORS-LDG may suggest critical points to avoid pancreas-related complications for trainees in the initial LDG experience.

Our study has several limitations. First, this pilot study investigated the performance of a surgeon in a single institution. Thus, further prospective studies are needed to examine more trainees' performance at multiple institutions. Second, case difficulty was not validated in this study. In laparoscopic surgery for gastric cancer, locally advanced cancer or obesity can cause heavy bleeding, prolonged operation time, conversion to open surgery, and postoperative complications (2, 40). Thus, comprehensive predictive difficulty should be taken into consideration in a large cohort study. Third, long-term outcomes were not assessed in this study. To assess the oncological quality, determining the rate of local recurrence is required in the long term. Finally, surgical education using JORS-LDG should be evaluated in randomized trials in multiple institutions.

In conclusion, the JORS-LDG may be a measurement tool with great potential to assess the surgical performance of trainees in the initial LDG experience.

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Conflict of interest

Drs. Shinichiro Kobayashi, Yo Kurashima, Akira Yoneda, Ryo Matsumoto, Yoichi Koga, Masaaki Hidaka, Satoshi Hirano, and Susumu Eguchi have no conflicts of interest or financial ties to disclose. Kengo Kanetaka belongs to an endowed department sponsored by Terumo Corporation.

Clinical Trial Registration

URL: http://www.clinicaltrials.gov. Unique identifier: NCT03408795.

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