Impact of technically qualified surgeons on laparoscopic colorectal resection outcomes: results of a propensity score-matching analysis

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Background: The Endoscopic Surgical Skill Qualification System (ESSQS) was introduced in Japan to improve the quality of laparoscopic surgery. This cohort study investigated the short- and long-term postoperative outcomes of colorectal cancer laparoscopic procedures performed by or with qualified surgeons compared with outcomes for unqualified surgeons.

Methods: All laparoscopic colorectal resections performed from 2010 to 2013 in 11 Japanese hospitals were reviewed retrospectively. The procedures were categorized as performed by surgeons with or without the ESSQS qualification and patients’ clinical, pathological and surgical features were used to match subgroups using propensity scoring. Outcome measures included postoperative and long-term results.

Results: Overall, 1428 procedures were analysed; 586 procedures were performed with ESSQS-qualified surgeons and 842 were done by ESSQS-unqualified surgeons. Upon matching, two cohorts of 426 patients were selected for comparison of short-term results. A prevalence of rectal resection (50.3% versus 40.5% per cent; P < 0.001) and shorter duration of surgery (230 versus 238 min; P = 0.045) was reported for the ESSQS group. Intraoperative and postoperative complication and reoperation rates were significantly lower in the ESSQS group than in the non-ESSQS group (1.2 versus 3.6 per cent, P = 0.014; 4.6 versus 7.5 per cent, P = 0.025; 1.9 versus 3.9 per cent, P = 0.023, respectively). These findings were confirmed after propensity score matching. Cox regression analysis found that non-attendance of ESSQS-qualified surgeons (hazard ratio 12.30, 95 per cent c.i. 1.28 to 119.10; P = 0.038) was independently associated with local recurrence in patients with stage II disease.

Conclusion: Laparoscopic colorectal procedures performed with ESSQS-qualified surgeons showed improved postoperative results. Further studies are needed to investigate the impact of the qualification on long-term oncological outcomes.

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Introduction

In 2004, the Japan Society for Endoscopic Surgery (JSES) introduced the Endoscopic Surgical Skill Qualification System (ESSQS)1–3 to maintain and improve the quality of laparoscopic surgery. Candidacy for the ESSQS requires academic achievements (3 conference presentations and 2 papers on laparoscopic surgery), laparoscopic experience (including 20 advanced procedures such as colorectal resection and gastrectomy, or 50 basic procedures such as...
Laparoscopic colorectal resection by ESSQS-qualified surgeons

Fig. 1 Patient flow diagram

ESSQS, Endoscopic Surgical Skill Qualification System.

cholecystectomy and inguinal hernia repair), attendance at JSES official training seminars, and 2 years of general surgical experience after the board certification by the Japan Surgical Society. The examination is based on anonymized unedited random video review and scoring by two or three expert laparoscopic surgeons designated by the JSES. ESSQS-certified surgeons in the colorectal surgery section are qualified to perform sigmoidectomies for colonic cancer and high anterior resections for rectosigmoid cancer.

Only 20–30 per cent of ESSQS examinees are considered adequate for qualification each year, and currently less than 10 per cent of Japanese general surgeons are ESSQS-certified. Still, it remains unclear whether technically qualified surgeons could safely perform procedures after ESSQS certification. It has been reported that mentoring and tutoring by an ESSQS-qualified surgeon are efficient methods for teaching laparoscopic colorectal surgical skills, and that supervision by an ESSQS-certified surgeon affects the safety of laparoscopic colectomy performed by a junior surgeon. However, no large study has investigated whether this qualification can actually improve the safety of the laparoscopic resections.

This study aimed to evaluate the impact of the ESSQS certification on the safety and oncological outcomes of laparoscopic colorectal resections.

Methods

All laparoscopic colorectal resections performed from January 2010 to December 2013 in Hokkaido University Hospital and ten affiliated hospitals were reviewed retrospectively. Inclusion criteria for the study were stage 0, I, II or III confirmed adenocarcinoma of the colon or rectum. Patients who had other synchronous or metachronous cancers (excluding in situ cancer) within 5 years and had undergone chemotherapy or radiotherapy before surgery were excluded.

The ethics committees of Hokkaido University Hospital and all participating hospitals approved this study. Informed consent was obtained from all patients, in accordance with the guidelines of the Japanese Ministry of Health, Labour and Welfare.

For each patient, data extracted from records included: clinical features, demographics, presentation, surgical data, postoperative outcome and follow-up.
### Table 1 Characteristics of the 11 institutions

| Institution | % of operations attended by ESSQS-qualified surgeons | No. of beds | No. of surgeons | Annual no. of colorectal operations | % of colorectal operations done laparoscopically | No. of registered patients |
|-------------|--------------------------------------------------|------------|----------------|-----------------------------------|----------------------------------------------|---------------------------|
| A           | 97                                               | 944        | 5              | 47                                | 75                                           | 92                        |
| B           | 71.3                                             | 519        | 14             | 172                               | 44.6                                         | 254                       |
| C           | 88                                               | 382        | 5              | 74                                | 78                                           | 155                       |
| D           | 0                                                | 747        | 8              | 98                                | 42                                           | 160                       |
| E           | 3                                                | 539        | 10             | 145                               | 40.5                                         | 133                       |
| F           | 13.6                                             | 410        | 5              | 91                                | 50                                           | 132                       |
| G           | 47:0                                             | 358        | 4              | 64                                | 51                                           | 115                       |
| H           | 100                                              | 498        | 4              | 65                                | 51                                           | 102                       |
| I           | 0                                                | 300        | 6              | 65                                | 43                                           | 99                        |
| J           | 0                                                | 430        | 5              | 81                                | 38                                           | 97                        |
| K           | 1                                                | 450        | 8              | 110                               | 24.4                                         | 89                        |
| Mean        | 38:3                                             | 507.0      | 6.7            | 92:0                              | 48:9                                         | 129:8                     |

ESSQS, Endoscopic Surgical Skill Qualification System.

### Table 2 Patient characteristics

|                                | ESSQS group ($n = 586$) | Non-ESSQS group ($n = 842$) | $P$† |
|--------------------------------|------------------------|----------------------------|------|
| **Age (years)**                | 67:6 (66:7–68:5)       | 68:5 (67:8–69:3)           | 0.143|
| **Sex ratio (M:F)**            | 337:249                | 474:368                    | 0.649|
| **BMI (kg/m²)**                | 23:1 (22:9–23:5)       | 23:0 (22:7–23:3)           | 0.427‡|
| **ASA fitness grade III–IV**   | 79 (13:5)              | 69 (8:2)                   | 0.013|
| **Previous laparotomy**        | 144 (24:6)             | 209 (24:8)                 | 0.915|
| **Obstruction**                | 20 (3:4)               | 15 (1:8)                   | 0.049|
| **Tumour location**            |                        |                            | 0.046|
| Colon                          | 390 (66:6)             | 602 (71:5)                 |      |
| Rectum                         | 196 (33:4)             | 240 (28:5)                 |      |
| **cT category**                |                        |                            | 0.136|
| cT0                            | 27 (4:6)               | 36 (4:3)                   |      |
| cT1                            | 152 (25:9)             | 197 (23:4)                 |      |
| cT2                            | 108 (18:4)             | 159 (18:9)                 |      |
| cT3                            | 272 (46:4)             | 383 (45:5)                 |      |
| cT4                            | 27 (4:6)               | 67 (8:0)                   |      |
| **cN category**                |                        |                            | 0.002|
| cN0                            | 481 (82:1)             | 633 (75:2)                 |      |
| cN1                            | 77 (13:1)              | 172 (20:4)                 |      |
| cN2                            | 25 (4:3)               | 36 (4:3)                   |      |
| cN3                            | 3 (0:5)                | 1 (0:1)                    |      |
| **Clinical stage**             |                        |                            | 0.021|
| 0                              | 27 (4:6)               | 36 (4:3)                   |      |
| I                              | 249 (42:5)             | 323 (38:4)                 |      |
| II                             | 205 (35:0)             | 274 (32:5)                 |      |
| III                            | 105 (17:7)             | 209 (24:8)                 |      |
| **Procedure**†                 |                        |                            | <0.001|
| Right colectomy                | 154 (26:3)             | 284 (33:7)                 |      |
| Transverse colectomy           | 33 (5:6)               | 35 (4:2)                   |      |
| Left colectomy                 | 21 (3:6)               | 31 (3:7)                   |      |
| Sigmoidectomy                  | 78 (13:3)              | 149 (17:7)                 |      |
Procedures were categorized according to whether they were performed by surgeons with or without the ESSQS qualification, and patients’ clinical, pathological and surgical features were used to match subgroups using propensity scoring.

**Outcome measures**

Groups were compared for differences in short- and long-term outcomes. Short-term results included: duration of surgery, blood loss, conversion rate, intraoperative complication rate (defined as injury to major vessels, intestinal tract or surrounding organs, or another intraoperative accidental event), postoperative complication rate, reoperation rate, length of postoperative hospital stay, number of harvested lymph nodes, and R0 resection rate. Postoperative complications were assessed according to the Clavien–Dindo classification⁶. Follow-up was conducted in day clinics. The 5-year overall recurrence-free and local recurrence-free rates (defined as the time from surgery to recurrence or local recurrence) were compared in patients with pathological stage II and III cancers. In addition, the association between overall and local recurrence and intervention by ESSQS-qualified or unqualified surgeon was examined in patients with stage II and III cancer.

**Statistical analysis**

Continuous data are reported as mean values with 95 per cent confidence intervals. All statistical tests were performed using an α level of 0·05 (two-sided). χ² and Student’s t tests were used for categorical and non-normal continuous data respectively.

The following clinical, surgical and pathological features were selected as factors for propensity score matching: age, sex, BMI, ASA fitness grade, previous laparotomy, obstruction, cT status, cN status, clinical stage, procedure, anastomosis, lymph node dissection (D1, D2 or D3) and diverting stoma. Propensity scores were generated using multivariable logistic regression models with attendance of ESSQS-qualified surgeons as the outcome.

Survival curves for the studied groups were estimated using the Kaplan–Meier method and compared with the log rank test. Cox regression with co-variable adjustment was performed separately for patients with stage II and III cancer.
those with stage III disease, with selected prognostic values (attendance of ESSQS-qualified surgeon, rectal cancer, age, sex, primary tumour size and depth, lymph node metastasis, extent of lymph node dissection, BMI, ASA grade, occurrence of postoperative complication, R status, tumour differentiation, adjuvant chemotherapy, and lymph and venous vessel invasion of the primary lesion). Simple linear regression was performed to assess the relationship between institutional heterogeneity (number of beds, annual volume of colorectal cancer surgery, number of surgeons, and the proportion of operations performed or attended by ESSQS-qualified surgeons in each institution) and the rate of postoperative complications.

All statistical analyses were performed using JMP® Pro version 14.0 (SAS Institute, Cary, North Carolina, USA).

## Results

A total of 1428 laparoscopic colorectal procedures that met the inclusion criteria were performed in 2010–2013, including 586 procedures performed with or by ESSQS-qualified surgeons and 842 procedures performed by non-ESSQS-qualified surgeons. Seven ESSQS-qualified surgeons attended 177, 154, 143, 102, seven, two and one operation respectively. Each ESSQS-qualified surgeon contributed as an operator (312 operations), assistant (260) or endoscopist (14) (Fig. 1).

Institutional characteristics are summarized in Table 1. The mean number of beds was 507±0 and a mean of 519±5 and 92-0 annual cases of general surgery and colorectal surgery were identified, respectively. The mean number of attending surgeons was 6±7 and the rate of laparoscopic surgery for colorectal cancers was 48-9 per cent. There was no correlation between the proportion of operations attended by ESSQS-qualified surgeons and institutional volume (number of beds: R² = 0.08, P = 0.397; general surgery volume: R² = 0.10, P = 0.334; colorectal surgery volume: R² = 0.06, P = 0.515).

Patient characteristics are summarized in Table 2. A total of 337 men and 249 women with a mean age of 67-6 years were treated in the ESSQS group, and 474

| Table 3 Operative outcomes |
|----------------------------|
| **ESSQS group** (n = 586) | **Non-ESSQS group** (n = 842) | **P** |
| **Duration of surgery (min)** | 230 (224–237) | 238 (234–244) | 0·045§ |
| **Blood loss (ml)** | 51·7 (38·9–64·4) | 59·7 (49·0–70·4) | 0·342§ |
| **Conversion** | 16 (2·7) | 32 (3·8) | 0·270 |
| **Intraoperative complication** | 7 (1·2) | 30 (3·6) | 0·014 |
| **Bleeding** | 1 (0·2) | 13 (1·5) | 0·021 |
| **Injury to intestinal tract** | 2 (0·3) | 4 (0·5) | 0·999 |
| **Injury to surrounding organs** | 3 (0·5) | 8 (1·0) | 0·533 |
| **Other** | 1 (0·2) | 5 (0·6) | 0·424 |
| **Postoperative complication** | 27 (4·6) | 63 (7·9) | 0·025 |
| **Bleeding** | 3 (0·5) | 3 (0·4) | 0·975 |
| **Superficial SSI** | 0 (0) | 3 (0·4) | 0·390 |
| **Deep SSI** | 2 (0·3) | 4 (0·5) | 0·999 |
| **Anastomotic leak** | 7 (1·2) | 31 (3·7) | 0·007 |
| **Ileus** | 4 (0·7) | 12 (1·4) | 0·291 |
| **Cardiac, pulmonary or cerebral** | 3 (0·5) | 0 (0) | 0·136 |
| **Other** | 8 (1·4) | 10 (1·2) | 0·956 |
| **Reoperation** | 11 (1·9) | 33 (3·9) | 0·023 |
| **Bleeding** | 1 (0·2) | 2 (0·2) | 0·990 |
| **Deep SSI** | 0 (0) | 1 (0·1) | 0·999 |
| **Anastomotic leak** | 4 (0·7) | 19 (2·3) | 0·035 |
| **Ileus** | 3 (0·5) | 4 (0·5) | 0·999 |
| **Other** | 3 (0·5) | 7 (0·8) | 0·697 |
| **Postoperative hospital stay (days)** | 14·5 (13·6–15·4) | 16·3 (15·6–17·1) | 0·002§ |
| **No. of harvested lymph nodes** | 18·0 (17·2–19·0) | 18·3 (17·6–19·1) | 0·681§ |
| **Pathological R0 resection** | 570 (97·3) | 832 (98·8) | 0·099 |

Values in parentheses are percentages unless indicated otherwise; *values are mean (95 per cent c.i.). †Grade III or above according to the Clavien–Dindo classification. ESSQS, Endoscopic Surgical Skill Qualification System. ¥χ² test, except §Student’s t test.
Table 4 Short-term outcomes by procedure

| Procedure                        | ESSQS group (n = 586) | Non-ESSQS group (n = 842) | P†     |
|----------------------------------|-----------------------|---------------------------|--------|
| **Duration of surgery (min)**    |                       |                           |        |
| Right colectomy                  | 204 (195–214)         | 210 (203–217)             | 0.353‡ |
| Transverse colectomy             | 220 (194–246)         | 210 (184–235)             | 0.575‡ |
| Left colectomy                   | 227 (192–263)         | 238 (209–266)             | 0.650‡ |
| Sigmoidectomy                    | 206 (191–222)         | 215 (204–227)             | 0.344‡ |
| High anterior resection          | 222 (213–232)         | 244 (235–253)             | 0.001‡ |
| Low anterior resection           | 280 (266–296)         | 309 (297–322)             | 0.004‡ |
| **Blood loss (ml)**              |                       |                           |        |
| Right colectomy                  | 69.4 (34.2–104.6)     | 65.5 (39.5–91.5)          | 0.857‡ |
| Transverse colectomy             | 47.7 (19.5–75.7)      | 34.5 (7.2–61.9)           | 0.507‡ |
| Left colectomy                   | 28.2 (−37.6–93.9)     | 81.4 (33.2–141.5)         | 0.169‡ |
| Sigmoidectomy                    | 52.8 (25.8–80.0)      | 44.1 (24.3–63.8)          | 0.653‡ |
| High anterior resection          | 25.8 (11.4–40.2)      | 40.5 (26.9–54.1)          | 0.145‡ |
| Low anterior resection           | 43.0 (20.7–65.4)      | 73.7 (55.1–92.3)          | 0.039‡ |
| **Intraoperative complication**  |                       |                           |        |
| Right colectomy                  | 4 of 154 (2.6)        | 5 of 284 (1.7)            | 0.562  |
| Transverse colectomy             | 0 (0)                 | 0 (0)                     | –      |
| Left colectomy                   | 0 (0)                 | 2 of 31 (6)               | 0.235  |
| Sigmoidectomy                    | 0 (0)                 | 7 of 149 (4.7)            | 0.014  |
| High anterior resection          | 2 of 157 (1.3)        | 7 of 182 (3.8)            | 0.124  |
| Low anterior resection           | 0 (0)                 | 9 of 147 (6.1)            | 0.002  |
| **Conversion**                   |                       |                           |        |
| Right colectomy                  | 5 of 154 (3.2)        | 9 of 284 (3.2)            | 0.964  |
| Transverse colectomy             | 2 of 33 (6)           | 0 (0)                     | 0.139  |
| Left colectomy                   | 1 of 21 (5)           | 2 of 31 (6)               | 0.798  |
| Sigmoidectomy                    | 1 of 78 (1)           | 3 of 149 (2.0)            | 0.691  |
| High anterior resection          | 3 of 157 (1.9)        | 7 of 182 (3.6)            | 0.276  |
| Low anterior resection           | 2 of 101 (2.0)        | 10 of 147 (6.8)           | 0.066  |
| **Postoperative complication**   |                       |                           |        |
| Right colectomy                  | 9 of 154 (5.8)        | 18 of 284 (6.3)           | 0.837  |
| Transverse colectomy             | 1 of 33 (3)           | 2 of 35 (6)               | 0.590  |
| Left colectomy                   | 3 of 21 (14)          | 3 of 31 (10)              | 0.610  |
| Sigmoidectomy                    | 2 of 78 (3)           | 9 of 149 (6.0)            | 0.247  |
| High anterior resection          | 5 of 157 (3.1)        | 10 of 182 (5.5)           | 0.286  |
| Low anterior resection           | 6 of 101 (5.9)        | 16 of 147 (10.9)          | 0.169  |
| **Reoperation**                  |                       |                           |        |
| Right colectomy                  | 1 of 154 (0.6)        | 10 of 284 (3.5)           | 0.042  |
| Transverse colectomy             | 0 (0)                 | 1 of 35 (3)               | 0.246  |
| Left colectomy                   | 3 of 21 (14)          | 3 of 31 (10)              | 0.610  |
| Sigmoidectomy                    | 0 (0)                 | 4 of 149 (2.7)            | 0.065  |
| High anterior resection          | 2 of 157 (1.3)        | 4 of 182 (2.2)            | 0.505  |
| Low anterior resection           | 4 of 101 (4.0)        | 10 of 147 (6.8)           | 0.324  |

Values in parentheses are percentages unless indicated otherwise; *values are mean (95 per cent c.i.). ESSQS, Endoscopic Surgical Skill Qualification System. 12-test, except ‡Student’s t test.

men and 368 women with a mean age of 68.5 years had surgery performed by non-ESSQS-qualified surgeons. No differences in BMI or history of previous surgery were observed between the two groups. The frequency of preoperative co-morbidity with ASA grade III or above was higher in the ESSQS group than in the non-ESSQS group (13.5 versus 8.2 per cent respectively; P=0.013). In addition, 3.4 and 1.8 per cent of patients in the ESSQS and non-ESSQS groups respectively had a preoperative obstruction due to the tumour that required decompression...
The ESSQS group had more patients who underwent rectal resection (295 (50·3 per cent) versus 341 (40·5 per cent); \(P < 0·001\)) and D3 lymph node dissection (67·1 versus 60·9 per cent; \(P = 0·007\)) than the non-ESSQS group. The types of colonic anastomosis and the frequency of double-stapling technique using linear and circular staplers in the entire cohort were different between the two groups. Moreover, combined resection of surrounding organs was performed significantly more in the ESSQS group (2·0 versus 0·6 per cent; \(P = 0·025\)). Surrounding organs involved in combined resections included the small bowel (5), uterus and its adnexa (3), ureter (1) and bladder (3) in the ESSQS group and small bowel (2), uterus and its adnexa (2) and bladder (1) in the non-ESSQS group.

### Table 5 Patient characteristics and short-term surgical outcomes in the propensity score-matched cohort

|                      | ESSQS group \(n = 428\) | Non-ESSQS group \(n = 428\) | \(P^{†}\) |
|----------------------|--------------------------|-----------------------------|----------|
| Age (years)*         | 67·4 (66·4–68·5)         | 67·4 (66·4–58·5)            | 0·989;†  |
| Sex ratio (M: F)     | 247:179                  | 250:176                     | 0·835    |
| BMI (kg/m²)*         | 23·2 (22·9–23·6)         | 23·0 (22·7–23·4)            | 0·447;†  |
| Tumour location      |                          |                             |          |
| Colon                | 270 (63·4)               | 256 (60·0)                  |          |
| Rectum               | 156 (36·6)               | 170 (40·0)                  |          |
| Clinical stage       |                          |                             | 0·868    |
| 0                    | 21 (4·9)                 | 21 (4·9)                    |          |
| I                    | 185 (43·4)               | 173 (40·6)                  |          |
| II                   | 131 (30·8)               | 138 (32·4)                  |          |
| III                  | 89 (20·9)                | 94 (22·1)                   |          |
| Procedure            |                          |                             | 0·945    |
| Right colectomy      | 110 (25·8)               | 111 (26·1)                  |          |
| Transverse colectomy | 18 (4·2)                 | 14 (3·3)                    |          |
| Left colectomy       | 14 (3·3)                 | 9 (2·1)                     |          |
| Sigmoidecotomy       | 42 (9·9)                 | 40 (9·4)                    |          |
| High anterior resection | 142 (33·3)          | 149 (35·0)                  |          |
| Low anterior resection | 88 (20·7)            | 91 (21·4)                   |          |
| APR                  | 11 (2·6)                 | 10 (2·3)                    |          |
| Other                | 1 (0·2)                  | 2 (0·5)                     |          |
| Anastomosis          |                          |                             | 0·537    |
| n = 415              | n = 415                  |                             |          |
| FEEA                 | 125 (30·1)               | 125 (30·1)                  |          |
| Triangular anastomosis | 55 (13·3)             | 47 (11·3)                   |          |
| DST                  | 230 (55·4)               | 241 (58·1)                  |          |
| Other                | 5 (1·2)                  | 2 (0·5)                     |          |
| Lymph node dissection|                          |                             | 0·956    |
| D1                   | 12 (2·8)                 | 12 (2·8)                    |          |
| D2                   | 133 (31·2)               | 129 (30·3)                  |          |
| D3                   | 281 (66·0)               | 285 (66·9)                  |          |
| Diverting stoma      | 17 (4·0)                 | 20 (4·7)                    | 0·614    |
| Outcomes             |                          |                             |          |
| Duration of surgery (min)* | 226 (219–234)   | 249 (241–256)               | 0·001;†  |
| Blood loss (ml)*     | 48·7 (35·6–61·8)         | 57·9 (44·7–71·0)            | 0·329;†  |
| Conversion           | 9 (2·1)                  | 16 (3·8)                    | 0·153    |
| Intraoperative complication | 7 (1·6)              | 18 (4·2)                    | 0·025    |
| Postoperative complication | 20 (4·7)          | 42 (9·9)                    | 0·003    |
| Reoperation          | 7 (1·6)                  | 21 (4·9)                    | 0·007    |
| No. of harvested lymph nodes* | 17·5 (16·4–18·6) | 18·9 (17·8–20·0)            | 0·078;†  |
| Pathological R0 resection | 416 (97·7)          | 420 (98·6)                  | 0·449    |

Values in parentheses are percentages unless indicated otherwise; *values are mean (95 per cent c.i.). ESSQS, Endoscopic Surgical Skill Qualification System; APR, abdominoperineal resection; FEEA, functional end-to-end anastomosis; DST, double-stapling technique. †\(\chi^2\) test, except ‡Student’s \(t\) test.
Table 6 Pathological features

| pT category | ESSQS group (n = 586) | Non-ESSQS group (n = 842) | P† |
|-------------|----------------------|---------------------------|----|
| pT0         | 32 (5-5)             | 49 (5-8)                  | 0.695 |
| pT1a        | 7 (1-2)              | 9 (1-1)                   |    |
| pT1b        | 140 (23-9)           | 180 (21-4)                |    |
| pT2         | 95 (16-2)            | 163 (19-4)                |    |
| pT3         | 269 (45-9)           | 382 (45-4)                |    |
| pT4a        | 35 (6-0)             | 48 (5-7)                  |    |
| pT4b        | 8 (1-4)              | 11 (1-3)                  |    |
| pN category |                      |                           |    |
| pN0         | 427 (72-9)           | 598 (71-0)                | 0.491 |
| pN1         | 122 (20-8)           | 199 (23-6)                |    |
| pN2         | 31 (5-3)             | 40 (4-8)                  |    |
| pN3         | 6 (1-0)              | 5 (0-6)                   |    |
| Pathological stage |               |                           |    |
| 0           | 39 (6-7)             | 49 (5-8)                  | 0.784 |
| I           | 213 (36-3)           | 300 (35-6)                |    |
| II          | 179 (30-5)           | 252 (29-9)                |    |
| III         | 155 (26-5)           | 241 (28-6)                |    |
| Tumour size (mm)* |                 |                           |    |
| 34.5 (32-8–36-2) | 34.4 (33-0–35-9)     | 0.939‡                    |
| No. of metastatic nodes* |       |                           |    |
| 0.79 (0-61–0-98) | 0.73 (0-58–0-89)     | 0.617†                    |
| Lymph vessel invasion |              |                           |    |
| 299 (51-0)  | 342 (40-6)           | < 0.001                   |
| Venous vessel invasion |            |                           |    |
| 300 (51-2)  | 350 (41-6)           | < 0.001                   |
| Differentiated adenocarcinoma |        |                           |    |
| 553 (94-4)  | 805 (95-6)           | 0.287                     |
| With undifferentiated features |          |                           |    |
| 116 (20-0)  | 121 (14-4)           | 0.007                     |
| Adjuvant chemotherapy |            |                           |    |
| Stage II    | 56 of 179 (31-3)     | 36 of 252 (14-3)          | < 0.001 |
| Stage III   | 108 of 155 (69-7)    | 173 of 241 (71-8)         | 0.852 |

Values in parentheses are percentages unless indicated otherwise; *values are mean (95 per cent c.i.). ESSQS, Endoscopic Surgical Skill Qualification System. †χ² test, except ‡Student’s t test.

Short-term outcomes

Duration of surgery (230 versus 238 min; P = 0.045) and postoperative hospital stay (14-5 versus 16-3 days; P = 0.002) were significantly shorter in the ESSQS group. Intraoperative and postoperative complication rates (grade III or above) were 1-2 and 4-6 per cent respectively in the ESSQS group, and 3-6 and 7-5 per cent in the non-ESSQS group (Table 3). Significant differences in intraoperative accidental bleeding from major vessels and postoperative anastomotic leakage were observed between the groups. The reoperation rate was also significantly lower in the ESSQS group than in the non-ESSQS group (1-9 versus 3-9 per cent; P = 0.023), particularly reoperation due to anastomotic leak (0-7 versus 2-3 per cent; P = 0.035). No differences in conversion rate, blood loss, number of harvested lymph nodes or pathological R0 rate were found (Table 3).

For rectal resections, both high and low anterior resections were performed more quickly in the ESSQS group (high anterior resection: mean 222 versus 244 min, P = 0.001; low anterior resection: 280 versus 309 min, P = 0.004). Blood loss was also lower in the ESSQS group for low anterior resection (43-0 versus 73-7 ml; P = 0.039), as were the intraoperative complication (0 versus 6-1 per cent; P = 0.002) and conversion (2-0 versus 6-8 per cent; P = 0.066) rates. The intraoperative complication rate for sigmoidectomy performed by ESSQS-qualified surgeons was lower (0 versus 4-7 per cent; P = 0.014), as was the reoperation rate for right colectomy (0-6 versus 3-5 per cent; P = 0.042) (Table 4).

Short-term outcomes in the propensity score-matched cohort

Short-term outcomes were also compared following propensity score matching. Some 426 patients from each group were included in the matched cohort. After matching, each ESSQS-qualified surgeon in the ESSQS...
group contributed as an operator (214), assistant (202) or endoscopist (10). There was no difference between groups for any preoperative factor or procedure (age, sex, BMI, ASA grade, previous laparotomy, obstruction, tumour location, cT and cN status, clinical stage, type of procedure, combined resection, anastomosis, lymph node dissection, lateral lymph node dissection and diverting stoma). Duration of surgery (226 versus 249 min; \(P=0.001\)) and postoperative hospital stay (13-7 versus 17-5 days; \(P<0.001\)) were significantly shorter in the ESSQS group. Intraoperative and postoperative complication rates (grade III or above) were 1-6 and 4-7 per cent respectively in the ESSQS group and 4-2 and 9-9 per cent in the non-ESSQS group (Table 5). Significant differences in intraoperative accidental bleeding from major vessels (0-2 versus 1-8 per cent; \(P=0.021\)) and postoperative anastomotic leakage (1-4 versus 5-2 per cent; \(P=0.002\)) were observed between the groups. The reoperation rate was also lower in the ESSQS group than in the non-ESSQS group (1-6 versus 4-9 per cent; \(P=0.007\)), particularly that due to anastomotic leakage (0-7 versus 3-3 per cent; \(P=0.014\)). No differences in conversion rate, blood loss, number of harvested lymph nodes, and pathological R0 rate were found (Table 5).

**Pathological outcomes and survival**

Overall, no differences in tumour depth, node status, pathological stage or tumour size were observed between subgroups. However, the ESSQS group had a higher rate of
adenocarcinoma with undifferentiated features (20·0 versus 14·4 per cent; \(P = 0·007\)) (Table 6). The rate of lymph vessel invasion in the ESSQS and non-ESSQS group was 51·0 and 40·6 per cent respectively (\(P < 0·001\)), and the venous vessel invasion rate was 51·2 and 41·6 per cent (\(P < 0·001\)). The median length of follow-up was 60 months for both groups. Of 333 patients in the ESSQS group 31 (9·3 per cent) were lost to follow-up, and of 492 patients in the non-ESSQS group 39 (7·9 per cent) were lost to follow-up (\(P = 0·485\)). The 5-year overall recurrence-free survival rates for patients with stage II–III cancers were 76·1 (95 per cent c.i. 71·0 to 80·6) and 80·5 (76·5 to 83·9) per cent in the ESSQS and non-ESSQS group respectively (\(P = 0·221\)) (Fig. 2a).

In Cox regression analysis for stage II and stage III disease (excluding R2), R1 resection, obstruction, T4 status and venous vessel invasion were significantly associated with recurrence in stage II, whereas obstruction, node status, high ASA grade, lymph vessel invasion, T4 status and rectal cancer were significantly associated with recurrence in stage III. However, attendance of ESSQS-qualified surgeons was not an independent factor (stage II: hazard ratio (HR) 1·05, 95 per cent c.i. 0·58 to 1·89, \(P = 0·881\); stage III: HR 1·07, 0·69 to 1·67, \(P = 0·761\)) (Fig. 2b,c).

There were eight local recurrences in the ESSQS group and 22 in the non-ESSQS group. In the ESSQS group, local recurrence occurred in the peritoneum or retroperitoneum around the primary site (4 patients), lesion lymph node (3) and anastomotic site (1), and in the non-ESSQS

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**Fig. 3 Association between intervention by ESSQS-qualified surgeons and local recurrence-free survival in patients with stage II and III cancers**

- **a** Kaplan–Meier analysis of local recurrence-free survival (RFS) in patients with stage II and III colorectal cancer operated on by ESSQS-certified or non-ESSQS-qualified surgeons. \(P = 0·092\) (log rank test). **b, c** Cox regression analysis of local recurrence. Hazard ratios are shown with 95 per cent confidence intervals for each risk factor for patients with stage II (b) and stage III (c) disease. *\(P < 0·050\). ESSQS, Endoscopic Surgical Skill Qualification System; LND, lymph node dissection; Por, poorly differentiated; Muc, mucinous.
Fig. 4 Correlation between the proportion of procedures attended by ESSQS-qualified surgeons and the postoperative complication rate, and the proportion of colorectal procedures done laparoscopically

**a** Postoperative complication rate in each institution. $R^2 = 0.29$, $P = 0.041$ (linear regression). **b** Proportion of colorectal procedures done laparoscopically. $R^2 = 0.57$, $P = 0.007$ (linear regression). ESSQS, Endoscopic Surgical Skill Qualification System.

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Relationship between institutional heterogeneity and postoperative complications

The rate of postoperative complications was related to the proportion of procedures that ESSQS surgeons participated in ($R^2 = 0.39$, $P = 0.041$), but had no relationship with the number of beds, annual volume of colorectal cancer procedures or number of surgeons (data not shown). Furthermore, the proportion of colorectal operations that were performed laparoscopically increased along with the proportion of operations that ESSQS surgeons participated in ($R^2 = 0.57$, $P = 0.007$) (Fig. 4).

**Discussion**

In this study, the superiority of attendance over non-attendance of ESSQS-qualified surgeons in laparoscopic colorectal resection was apparent in terms of duration of surgery, intraoperative and postoperative complications (Clavien–Dindo grade III or above) rates, reoperation rate and length of postoperative hospital stay. More difficult cases were reported in the ESSQS group, such as rectal cancer, patients with obstruction and high ASA grade. The procedures performed by ESSQS-qualified surgeons were also considered to be more advanced, such as rectal resection and D3 lymph node dissection. Nevertheless, the ESSQS group had significantly shorter duration of surgery and postoperative hospital stay, lower intraoperative and postoperative complication rates, and a lower reoperation rate than the non-ESSQS group. Additionally, the differences in duration of surgery and postoperative complication rate were significant for advanced procedures such as anterior rectal resection. These results support the supposition that the ESSQS-qualified surgeons have improved laparoscopic surgical skills and provide better short-term outcomes.
These findings were further validated in the propensity score-matched cohort. Similarly, the mean duration of surgery (226 min), blood loss (48.7 ml), conversion rate (2.1 per cent), postoperative complication rate (Clavien–Dindo grade III or above, 4.7 per cent) and reoperation rate (1.6 per cent) in the ESSQS group were comparable to the respective values of 211 min, 30 ml, 5.4 per cent, 4.6 per cent (Common Terminology Criteria for Adverse Events version 3.0 grade 3 or above) and 1.7 per cent reported in the Japan Clinical Oncology Group (JCOG) 0404 study, a nationwide RCT investigating the safety of laparoscopic colectomy performed by expert surgeons.

Among patients with stage II and III disease, local recurrence was improved in the ESSQS group compared with that in the non-ESSQS group. In particular, non-attendance of ESSQS-qualified surgeons was one of the independent risk factors for local recurrence in patients with stage II disease. However, in patients with stage III disease, the local recurrence rate was similar in the two groups, although these long-term outcomes should be validated in larger studies. The recurrence-free survival rate of patients with stage II–III cancers in the ESSQS group was 76.1 (95 per cent c.i. 71.0 to 80.6) per cent, which is comparable to the rate of 79 (75.6 to 82.6) per cent in the JCOG 0404 study with similar patient distributions.

The present study is representative of real-world practice. In 2010, laparoscopic colorectal surgery was performed in more than ten colorectal procedures per year in the 13 institutions affiliated to the Hokkaido University, although only ten of these institutions agreed to participate in the study. Therefore, there was a slight bias in the selection of institutions. A number of studies10 have reported that hospital case volume or surgeon volume is associated with short- and long-term outcomes in some types of cancer, including colorectal cancer. However, in the present study, the postoperative complication rate was not associated with the number of beds, annual volume of colorectal cancer procedures or number of surgeons, but was related to the attendance of ESSQS-qualified surgeons.

This study has some other limitations. As it was not a prospective study or an RCT, there were several differences in patients’ backgrounds. Furthermore, it was a regional study limited to Hokkaido Prefecture rather than nationwide, and the numbers of attending ESSQS-qualified surgeons and advanced rectal cancers were small. Over 30 per cent of patients with low rectal cancer underwent low anterior resection using the laparoscopic approach in Japan. However, both the short-term safety of this procedure in the general setting and the long-term safety have not been well established. Clarifying the value of ESSQS-qualified surgeons in the performance of safe laparoscopic rectal resection is one of the issues that needs to be resolved. Finally, the circumstances surrounding laparoscopic colorectal resection are changing. The rate of laparoscopic surgery has increased year on year compared with that of open surgery, and young surgeons have more opportunity to learn and perform laparoscopic surgery safely. In the future, nationwide studies will help to clarify fully the relevance of the ESSQS in colorectal surgical laparoscopic practice.

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