Surgical Endoscopy (2019) 33:3864–3873
https://doi.org/10.1007/s00464-019-06920-w

DYNAMIC MANUSCRIPT

The efficacy of dental floss and a hemoclip as a traction method for the endoscopic full-thickness resection of submucosal tumors in the gastric fundus

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Received: 8 March 2019 / Accepted: 12 June 2019 / Published online: 2 August 2019

Abstract

Background Endoscopic full-thickness resection (EFTR) provides a significant advancement to the treatment of gastrointestinal submucosal tumors (SMTs). However, technological challenges, particularly in the gastric fundus, hinder its wider application. Here, we investigated the efficacy of a simple traction method that used dental floss and a hemoclip (DFC) to facilitate EFTR.

Methods Between July 2014 and December 2016, we retrospectively reviewed data from all patients with SMTs in the gastric fundus originating from the muscularis propria layer that were treated by EFTR at Zhongshan Hospital of Fudan University. Baseline characteristics and clinical outcomes, including procedure time and complications rate, were compared between groups of patients receiving DFC–EFTR and conventional EFTR.

Results A total of 192 patients were included in our analysis (64 in the DFC–EFTR group and 128 in the conventional EFTR group). Baseline characteristics for the two groups were similar. The mean time for DFC–EFTR and conventional EFTR was 44.2 ± 24.4 and 54.2 ± 33.2 min, respectively ($P = 0.034$). Although no serious adverse events presented in any of our cases, post-EFTR electrocoagulation syndrome (PEECS), as a minor complication, was less frequent in the DFC–EFTR group (3.1% vs. 12.5%, $P = 0.036$). Univariate and multivariate analysis identified that DFC, when used in EFTR, played a significant role in reducing procedure time and the rate of PEECS. The mean procedure time was significantly shorter in the DFC–EFTR group for lesions over 1.0 cm ($P = 0.005$), when the lesions were located in the greater curvature of the gastric fundus ($P = 0.025$) or when the lesions presented with intraluminal growth ($P = 0.032$). Moreover, when EFTR was carried out by experts, the mean procedure time was 20.4% shorter in the DFC–EFTR group ($P = 0.038$).

Conclusions This study indicated that DFC–EFTR for SMTs in the gastric fundus resulted in a shorter procedure time and reduced the risk of PEECS, a minor complication.

Keywords Endoscopic full-thickness resection · Submucosal tumors · Traction methods · Procedure time · Complications

Endoscopic full-thickness resection (EFTR) is a highly promising endoscopic procedure that allows full-thickness excision of a small piece of the complete gastrointestinal wall by using only a flexible endoscope. The characteristics of EFTR make it a very suitable form of treatment for submucosal tumors (SMTs) [1]. Although endoscopic submucosal dissection (ESD) has also been recently applied for the resection of SMTs [2, 3], this method is less than satisfactory for treating lesions with any form of extraluminal growth component. Several studies have provided evidence

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s00464-019-06920-w) contains supplementary material, which is available to authorized users.

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for the efficacy and safety of EFTR for resecting deep SMTs in the gastrointestinal wall [4–6]. However, it is important to highlight that EFTR is still a complex procedure without additional laparoscopic assistance, particularly in difficult-to-access locations, such as the fundus of the stomach, and when carried out in a retroflexed fashion.

Since 2014, our center has been using dental floss to create traction when treating gastrointestinal mucosal tumors by endoscopy; we have found this procedure is highly effective and represents a key optimization to our procedure [7]. We further hypothesized that the combined use of dental floss and a hemoclip (DFC) could provide countertraction to readily and clearly visualize the submucosa, thus reducing the frequency of adverse events. In fact, at the same time, this method of assistance has been used during EFTR for gastric SMTs by our group. Previously, we described our initial experience of using dental floss traction, and showed that this method can simplify the surgical procedure and reduce operation time [8]; however, this earlier work only involved a small number of cases and was published as a technical report. In our present study, we investigated the efficacy of DFC for EFTR, particularly in the gastric fundus in a large consecutive study involving a wide array of data and comprehensive analyses. Our research showed that this simple technique can significantly reduce procedure time and reduced the risk of minor complications.

Methods

Patients

Between July 2014 and December 2016, we collected and reviewed data from patients with SMTs originating from the muscularis propria (MP) layer in the gastric fundus, which were treated by EFTR at Zhongshan Hospital of Fudan University (Shanghai, China). Endoscopic ultrasonography (EUS) and/or computed tomography (CT) were used to characterize the lesions prior to EFTR, including size and other features.

The inclusion criteria for the use of EFTR for SMTs in the gastric fundus were as follows: (1) the tumor originated predominantly in the MP layer; (2) SMTs were detected using EUS and CT and did not show metastasis; (3) the size of the tumors exceeded 2 cm; (4) lesions had high risk features under EUS, such as irregular borders, cystic spaces, ulceration, echogenic foci and heterogeneity; (5) lesions could not be diagnosed conclusively by EUS and/or EUS-FNA and required further histopathological review; (6) patients complained of upper gastrointestinal symptoms, and (7) patients were willing to have the tumor resected, after been fully informed of the risks and benefits of different treatment strategies. The exclusion criteria for EFTR were as follows: (1) disagreement regarding resection; (2) malignant tumor with metastasis, and (3) coagulation disorders. Considering that total operation time or post-operation outcomes could be affected, we also excluded patients undergoing immediate additional surgery after previous endoscopic resection, cases involving the application of novel suture devices to close the gastric wall, cases involving the use of a snare during resection, and patients with multiple lesions. Patients treated by EFTR without any additional traction assistance were classified into a conventional EFTR group, while patients undergoing DFC traction-assisted EFTR were classified into a DFC–EFTR group (Fig. 1).

Informed patient consent was obtained from all patients prior to the procedures. The study and procedures were conducted in accordance with the ethical standards of the Helsinki Declaration of 1975. This study was approved by the Institutional Review Board of Zhongshan Hospital (reference number: 2009-135).

EFTR procedure and traction method

All patients were treated under intravenous anesthesia with airway intubation while a range of cardiorespiratory function parameters were monitored, including heart rate, blood pressure, and oxygen saturation. The EFTR procedure was performed with a single-channel endoscope or by dual-channel endoscopy (GIF-Q260 J or GIF-2T240, Olympus, Tokyo, Japan). An insulated-tip knife (KD-611L; Olympus), a hook knife (KD-620LR; Olympus), and/or I-type Hybrid-Knife (ERBE, Tuebingen, Germany) was used to incise the mucosal or submucosal layers and to peel the tumor. The ERBE HybridKnife system was used as a high frequency generator. Other equipment included injection needles (NM-4L-1), hot biopsy forceps (FD-410LR) (all from Olympus),

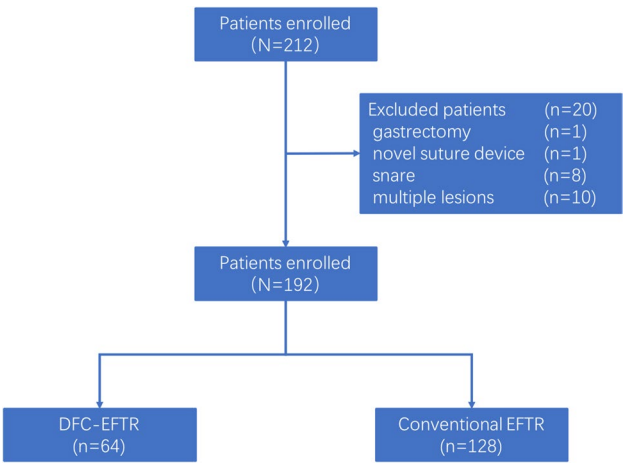

Fig. 1 Flowchart of patients and lesions. *EFTR* endoscopic full-thickness resection, *DFC* dental floss and a hemoclip

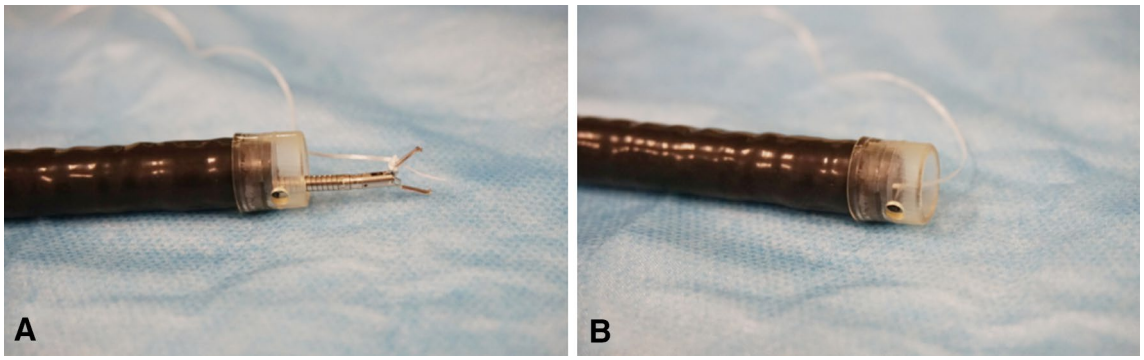

Fig. 2 Preparation of the DFC during the EFTR procedure. **A** Dental floss was tied directly to one arm of the hemoclip. **B** The hemoclip with dental floss was placed in the accessory channel before reinserting the endoscope into the stomach. *EFTR* endoscopic full-thickness resection, *DFC* dental floss and a hemoclip

and hemoclips (ROCC-D-26-195-C) (from Micro-tech, Nanjing, China).

First, we placed marker dots around the lesion. Then, we injected several mL of solution (100 mL saline, 5 mL 0.8% indigo carmine, and 1 mL epinephrine with the concentration of 1 mg/mL) around the lesion using a 23-gauge disposable needle; this helped us to lift the mucosa off. Then, the mucosa was partly incised along the marker dots using the hook knife or I-type HybridKnife from the anal side. The next step was to construct a traction device, similar to the devices used for ESD, with DFC (Fig. 2). The endoscope was removed and the dental floss was tied to any arm of the metallic clip. We trimmed the shorter end of the floss to prevent it from obscuring the field of view. When the endoscope was reinserted, the hemoclip was attached onto the incised mucosa (Fig. 3A). The submucosa could then be clearly exposed as a result of the traction created by the dental floss and the full-thickness resection could proceed along the tumor base without causing accidental injury to the adjacent organs or significant bleeding.

As the tumor was peeled under direct visualization, we carried out active perforation using a hook knife or an I-type HybridKnife. First, we perforated one point around the lesion, and then used an I-type HybridKnife to make a circumferential incision to the depth of the serosal layer surrounding the lesion (Fig. 3B, C). As we made a full-thickness incision around the tumor, we continually used the hemoclip to grasp the tumor and move it into the gastric cavity to prevent the tumor from falling into the peritoneal cavity until it was fully resected. After complete resection, the SMT was easily retrieved through the mouth (Fig. 3D). We then closed the gastric wall defect using multiple metallic clips or a mixture of metallic clips and interrupted sutures with an endoloop, as reported previously [9] (Supplementary Video. 1). In the conventional EFTR group, the gravity of the tumor was used for traction during surgery; this method worked well when a lesion

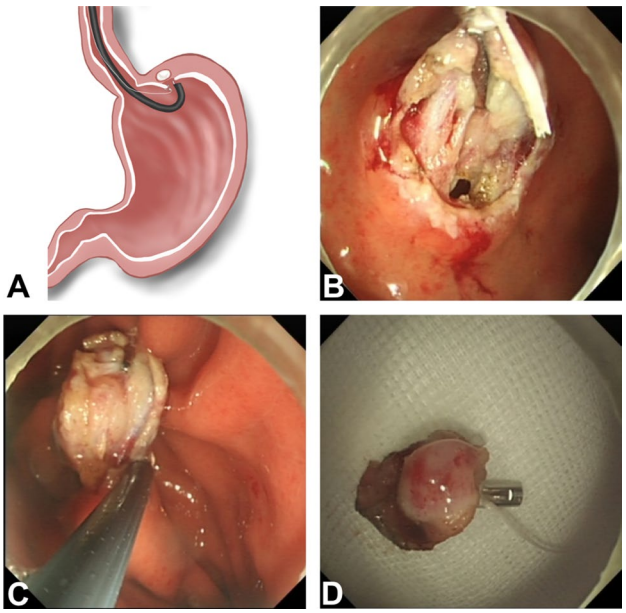

Fig. 3 Schema and endoscopic view of EFTR with DFC. **A** In the lesions located in the fundus near the cardia, the anal side of the resected mucosa was elevated by pulling the dental floss out through the mouth. **B** Active perforation was carried out during continuous peeling of the tumor under good conditions of visualization and tension. **C** A circumferential incision was made to the depth of the serosal layer surrounding the tumor using the dental floss as traction. **D** The submucosal tumor was always grasped by the hemoclip and dental floss until resected. *EFTR* endoscopic full-thickness resection, *DFC* dental floss and a hemoclip

was in the gastric fundus, and was particularly effective when part of the tumor had been cut away from the stomach wall (Supplementary Video 2).

In the presence of pneumoperitoneum, a 20-gauge needle was inserted into the right upper quadrant of the abdomen to percutaneously decompress the abdominal cavity during the procedure. A nasogastric (NG) tube was routinely inserted into all patients after endoscopic resection.

Definitions

EFTR procedure time was defined as the time taken from the start of the submucosal injection to the end of tumor removal and closure of the gastric wall defect. We adopted the classification criteria for SMTs of the esophagogastric junction [2]: a tumor in the proximity of the cardia and fundus, located within an area 1 cm proximal to, and 2 cm distal to, the cardia. The remaining fields of the fundus were defined as the greater curvature. The surgical operator was considered a trainee or an expert if their experience amounted to ≤ 25 or > 25 EFTR procedures per year, respectively, and were all certified EFTR endoscopists.

En bloc resection was defined as the excision of a tumor in one piece without fragmentation. Complete resection was defined as en bloc resection of a lesion with a tumor removed in a single piece with the capsule intact [10]. For histological evaluation, we considered the World Health Organization (WHO) classification for tumors of the digestive system [11]. When the organization of a tumor was difficult to determine, we performed additional immunohistochemistry [12].

Postoperative bleeding was defined as hematochezia or melena that required an endoscopic hemostatic procedure anywhere between 0 and 14 days after completion of EFTR. Hydrothorax was defined as the accumulation of excess fluid in the pleural cavity and confirmed by chest X-ray. Pneumoperitoneum was defined as pneumatosis in the peritoneal cavity which could be visualized by either on X-ray or CT scan. Minor cases of pneumoperitoneum and minor hydrothorax had minimal clinical impact or symptoms, and did not require therapeutic intervention; other cases required intervention. Post-EFTR electrocoagulation syndrome (PEECS), as a minor complication, similar to post-ESD electrocoagulation syndrome, was defined as symptoms of fever (> 37.7 °C) and abdominal pain with localized tenderness that was observed after confirmation by radiological examination that there was no definite evidence of perforation within a few hours to 7 days after EFTR treatment [13].

Data collection and analysis

Clinicopathological, endoscopic, and follow-up data were collected and analyzed, including age, sex, tumor characteristics, histopathology, operation information, en bloc and complete resection rates, adverse events, local recurrence, and metastasis. Data were initially obtained from a surgical recording system and medical records. For patients who had moved away from our hospital, we attempted to obtain outcome details by telephone conversation with either the patient or their family members.

The Chi-square test was used to compare categorical variables, and the Mann–Whitney *U* test was used to compare continuous variables for univariate analysis. Statistical analysis of independent risk factors for long operative time and PEECS were assessed using a combination of univariate and multivariate analyses. Commercial software (IBM SPSS Statistics 18; Chicago, IL, USA) was used for all statistical analyses, and $P < 0.05$ indicated statistical significance.

Results

Baseline characteristics

In total, we recruited 192 patients with gastric SMTs located in the fundus and treated by EFTR: 64 patients were treated by EFTR with DFC and 128 patients were treated by conventional EFTR. The baseline characteristics of patients and lesions are shown in Table 1. The mean age of the entire patient population was 58.9 ± 9.8 years (median: 60; range: 27–85 years) and the female:male ratio was 1.8:1 (124:68). The mean tumor size was 1.3 ± 1.0 cm (median: 1.0; range: 0.2–7.0 mm). Of all the SMTs encountered, 137 (71.4%) were located in the fundus near to the greater curvature and 55 (28.6%) were located near to the cardia. Forty two (21.9%) tumors showed extraluminal growth; the remaining 150 (78.1%) tumors did not. There were 141 (73.4%) gastrointestinal stromal tumors (GISTs), 46 (24.0%) leiomyomas, 2 (1.0%) calcifying fibrous tumors, 2 (1.0%) granular cell tumors, and 1 schwannoma (0.5%). In 90 cases, only metallic clips were used to close the gastric wall defect; the combined use of metallic clips with an endoloop was applied in 102 (53.1%) patients. In total, 156 (60.7%) patients underwent EFTR by expert surgeons, the remaining 36 (18.7%) cases were carried out by trainees. Patient characteristics and clinical data relating to tumors and procedures were similar when compared between the DFC–EFTR group and the conventional EFTR group.

Treatment outcomes of DFC–EFTR and conventional EFTR

The main treatment outcomes from the two groups of patients are described in Table 2. There was no slippage or dislodgement of the clip or dental floss during any of the cases in the DFC–EFTR group. All gastric fundus SMTs were resected, with a 100% en bloc resection rate. In addition, there were no significant differences between DFC–EFTR and conventional EFTR in terms of complete resection rate ($P = 0.666$).

The mean time required for the DFC–EFTR procedure and the conventional EFTR procedure was 44.2 ± 24.4 min and 54.2 ± 33.2 min, respectively. The procedure time for DFC–EFTR was significantly shorter than that for conventional EFTR ($P = 0.034$). The median time required for the EFTR procedure was 45 min (range: 10–210 min).

Table 1 Baseline characteristics of the 192 patients with SMTs in gastric fundus treated by EFTR

	Total ($n=192$)	EFTR with DFC ($n=64$)	Conventional EFTR ($n=128$)	P value
Patients				
Age (years)				0.992
Mean ± SD	58.9 ± 9.8	58.9 ± 10.6	58.9 ± 9.4	
Median (range)	60 (27–85)	58 (27–76)	60 (29–85)	
Sex				0.393
Male	68 (35.4%)	20 (31.3%)	48 (37.5%)	
Female	124 (64.4%)	44 (68.7%)	80 (62.5%)	
Lesion characteristics				
Size (cm)				0.424
Mean ± SD	1.3 ± 1.0	1.4 ± 1.3	1.3 ± 0.9	
Median (range)	1.0 (0.2–7.0*)	1.0 (0.2–7.0)	1.0 (0.2–4.5)	
Position				0.114
Greater curvature	137 (71.4%)	41 (64.1%)	96 (75.0%)	
Near cardia	55 (28.6%)	23 (35.9%)	32 (25.0%)	
Extraluminal growth				0.267
Yes	42 (21.9%)	11 (17.2%)	31 (24.2%)	
No	150 (78.1%)	53 (82.8%)	97 (75.8%)	
Histopathology				0.488
GIST	141 (73.4%)	45 (70.3%)	96 (75.0%)	
Others	51 (26.6%)	19 (29.7%)	32 (25.0%)	
Leiomyoma	46 (24.0%)	16 (25.0%)	30 (23.4%)	
Clarifying fibrous tumor	2 (1.0%)	2 (3.1%)	0 (0%)	
Granular cell tumor	2 (1.0%)	1 (1.6%)	1 (0.8%)	
Schwannoma	1 (0.5%)	0 (0%)	1 (0.8%)	
Procedure-related characteristics				
Suturing methods				0.978
Metallic clips	90 (46.9%)	28 (43.8%)	62 (48.4%)	
Metallic clips with endoloop	102 (53.1%)	36 (56.2%)	66 (51.6%)	
Operator level				0.433
Experts	156 (81.3%)	54 (84.4%)	102 (80.0%)	
Trainees	36 (18.7%)	10 (15.6%)	26 (20.0%)	

*A longitudinal submucosal tumor

Univariate and multivariate analysis showed that when combined with EFTR, DFC represented a significant factor which could reduce procedure time; analysis further showed that tumors with a larger size, and the use of metallic clips with endoloop sutures, represented significant risk factors for long procedure times (Table 3).

None of our patients experienced any serious adverse events, such as delayed bleeding or perforation. However, minor pneumoperitoneum occurred in 7 (3.6%) patients, and thoracic effusion presented in 6 (3.1%) patients. One patient with major thoracic effusion required thoracic drainage, while the five patients with minor effusion did not. Eighteen (9.4%) patients developed PEECS and were administered with intravenous antibiotics and fluids; oral food consumption was discontinued until symptoms improved. When the two groups were compared in terms of complications, PEECS was significantly less frequent in the DFC–EFTR group than in the conventional EFTR group (2 patients, 3.1% vs. 16 patients, 12.5%; $P=0.036$). Based on logistic regression analysis for risk factors associated with PEECS, the combined use of DFC and EFTR was identified as a protective factor. Large tumors and extraluminal growth tumors were identified as significant risk factors for PEECS after EFTR (Table 4). The median post-operation hospitalization time was 3 days (range: 1–7). There were no treatment-related deaths.

Subgroup analyses based on patient, tumor, and operator characteristics

According to subgroup analysis, EFTR procedure time was significantly associated with tumor size, tumor position,

Table 2 A comparison of treatment outcomes between EFTR with DFC and conventional EFTR groups

Outcomes	Total ($n=192$)	EFTR with DFC ($n=64$)	Conventional EFTR ($n=128$)	*P* value
En bloc resection	192 (100%)	64 (100%)	128 (100%)	1.000
Complete resection	187 (97.4%)	63 (98.4%)	124 (96.9%)	0.666
Procedure time (min)	50.8 ± 30.7	44.2 ± 24.4	54.2 ± 33.2	0.034
Complications				
Pneumoperitoneum	7 (3.6%)	2 (3.1%)	5 (3.9%)	1.000
Hydrothorax	6 (3.1%)	2 (3.1%)	4 (3.1%)	1.000
Minor hydrothorax	5 (2.6%)	1 (1.6%)	4 (3.1%)	0.666
Major hydrothorax	1 (0.5%)	1 (1.6%)	0 (0%)	0.340
PEECS	18 (9.4%)	2 (3.1%)	16 (12.5%)	0.036
Delayed bleeding	0 (0%)	0 (0%)	0 (0%)	1.000
Delayed perforation	0 (0%)	0 (0%)	0 (0%)	1.000
Follow-up				
Recurrence	0 (0%)	0 (0%)	0 (0%)	1.000
Metastasis	0 (0%)	0 (0%)	0 (0%)	1.000

PEECS post-EFTR electrocoagulation syndrome

Table 3 The association of the clinicopathological characteristics of SMTs in gastric fundus treated by EFTR over the median procedure time (45 min)

Factors	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Age (years)		0.082		0.063
< 60	1 (reference)		1 (reference)	
≥ 60	1.661 (0.938–2.940)		1.911 (0.966–3.781)	
Sex		0.669		0.614
Male	1 (reference)		1 (reference)	
Female	0.879 (0.486–1.588)		1.201 (0.590–2.447)	
Size (cm)		< 0.001		< 0.001
< 1.0	1 (reference)		1 (reference)	
≥ 1.0	4.773 (2.557–8.909)		3.856 (1.875–7.931)	
Position		0.398		0.164
Greater curvature	1 (reference)		1 (reference)	
Near cardia	1.310 (0.700–2.452)		1.728 (0.800–3.730)	
Extraluminal growth		0.001		0.158
No	1 (reference)		1 (reference)	
Yes	3.548 (1.686–7.468)		1.867 (0.785–4.436)	
Histopathology		0.403		0.559
Others	1 (reference)		1 (reference)	
GIST	0.760 (0.400–1.444)		0.788 (0.355–1.750)	
DFC		0.042		0.007
No	1 (reference)		1 (reference)	
Yes	0.529 (0.287–0.978)		0.351 (0.165–0.747)	
Metallic clips with endoloop		< 0.001		0.001
No	1 (reference)		1 (reference)	
Yes	3.276 (1.788–5.999)		3.414 (1.663–7.007)	
Operator level		0.082		0.139
Trainees	1 (reference)		1 (reference)	
Experts	0.518 (0.247–1.086)		0.521 (0.220–1.236)	
Operator level		0.692		0.269
Trainees	1 (reference)		1 (reference)	
Experts	0.789 (0.243–2.555)		0.444 (0.105–1.875)	

Table 4 Risk factors for PEECS of EFTR for SMTs in gastric fundus

Factors	Univariate analysis		Multivariate analysis	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Age (years)		0.283		0.122
< 60	1 (reference)		1 (reference)	
≥ 60	0.580 (0.215–1.567)		0.373 (0.107–1.301)	
Sex		0.067		0.549
Male	1 (reference)		1 (reference)	
Female	0.400 (0.150–1.068)		0.698 (0.215–2.266)	
Size (cm)		0.010		0.020
≤ 1.0	1 (reference)		1 (reference)	
> 1.0	14.806 (1.928–113.719)		8.178 (1.397–47.860)	
Position		0.932		0.773
Greater curvature	1 (reference)		1 (reference)	
Near cardia	0.954 (0.323–2.816)		0.817 (0.206–3.236)	
Extraluminal growth		< 0.001		0.001
No	1 (reference)		1 (reference)	
Yes	9.600 (3.339–27.598)		9.688 (2.427–38.676)	
Histopathology		0.078		0.060
Others	1 (reference)		1 (reference)	
GIST	0.410 (0.152–1.106)		0.271 (0.069–1.058)	
DFC		0.052		0.044
No	1 (reference)		1 (reference)	
Yes	0.226 (0.050–1.014)		0.146 (0.022–0.948)	
Metallic clips with endoloop		0.216		0.807
No	1 (reference)		1 (reference)	
Yes	1.970 (0.673–5.766)		1.201 (0.277–5.212)	
Procedure time (min)		0.037		0.558
≤ 45	1 (reference)		1 (reference)	
> 45	3.127 (1.068–9.149)		0.630 (0.134–2.958)	
Operator level		0.692		0.269
Trainees	1 (reference)		1 (reference)	
Experts	0.789 (0.243–2.555)		0.444 (0.105–1.875)	

growth pattern, and operator experience (Table 5). When the size of lesions exceeded 1.0 cm, the mean procedure time was 35.8% shorter in the DFC–EFTR group than in the conventional EFTR group (55.5 vs. 86.5 min, $P = 0.005$). For SMTs located in the greater curvature of the gastric fundus, the mean procedure time was 23.1% shorter in the DFC–EFTR group than in the conventional EFTR group (41.2 vs. 53.6 min, $P = 0.025$). In cases involving tumors which did not present with extraluminal growth, the mean procedure time was 18.8% shorter in the DFC–EFTR group than in the conventional EFTR group (40.1 vs. 49.4 min, $P = 0.032$). Moreover, when EFTR was carried out by experts, the mean procedure time was 20.4% shorter in the DFC–EFTR group than in the conventional EFTR group (42.6 vs. 53.5 min, $P = 0.038$). No significant differences were noted with regard to the age and sex of patients and tumor histopathology.

Follow-up results

Of the 192 patients with gastric SMTs treated by EFTR, six cases were lost to follow-up, and the other 186 cases had a follow-up period exceeding 20 months. The overall median follow-up period was 35 months (range: 20–50 months), and all patients remained free from local recurrence or distant metastasis during the study period.

Discussion

EFTR, as a technical addition to ESD, is associated with clear advantages when an SMT is buried deep in the MP layer or grows in an extraluminal manner [14]. Our center previously reported the successful use of EFTR in 26 gastric SMTs without laparoscopic assistance, when no

Table 5 Procedure time of EFTR for SMTs in gastric fundus, stratified according to characteristics of patient, tumor, and operator

Subgrouping criterion	EFTR with DFC	Conventional EFTR	*P* value
Age (years)			
< 60	39.7 ± 19.8	48.6 ± 29.4	0.123
≥ 60	49.0 ± 28.0	59.3 ± 35.8	0.159
Sex			
Male	43.1 ± 28.9	58.2 ± 38.5	0.118
Female	44.8 ± 22.3	51.9 ± 29.9	0.168
Size (cm)			
≤ 1.0	36.0 ± 16.4	43.3 ± 21.5	0.075
> 1.0	55.5 ± 28.9	86.5 ± 47.7	0.005
Position			
Greater curvature	41.2 ± 22.1	53.6 ± 31.8	0.025
Near cardia	49.7 ± 27.6	56.5 ± 39.4	0.479
Extraluminal growth			
Yes	64.0 ± 31.0	69.3 ± 44.6	0.721
No	40.1 ± 20.8	49.4 ± 27.3	0.032
Histopathology			
GIST	44.6 ± 24.6	53.5 ± 34.3	0.122
Others	43.3 ± 24.3	56.5 ± 30.3	0.112
Operator level			
Experts	42.6 ± 24.0	53.5 ± 35.1	0.038
Trainees	54.3 ± 25.2	56.9 ± 25.0	0.780

gastric bleeding, peritonitis signs, or abdominal abscesses occurred after EFTR [6]. Perforation is not a cause for concern for endoscopic resection, which is a technically safe and less invasive approach for SMTs compared with laparoscopic surgery. However, EFTR becomes technically difficult in specific anatomic locations where retroflexion is required, particularly in the fundus, in which the tumor is approached with the knife held vertically in relation to the fundus, thus increasing the procedure time [15, 16]. In addition, the diaphragm, the spleen, and the multitude of blood vessels surrounding the gastric fundus increase the risk of complications. Consequently, such cases require high levels of technology and a highly experienced endoscopist.

The use of a hemoclip and long suture material as a simple traction method was first reported by Jeon et al and Li et al [17, 18]. Sho et al., using propensity score matching analysis, were the first to report the efficacy of a simple traction method using DFC compared with conventional ESD, and showed that ESD–DFC facilitated rapid ESD with good visualization and traction while ensuring high curability and safety [19]. Subsequently, a multicenter, randomized controlled trial reported that DFC–ESD did not result in a shorter procedure time in the overall patient population, but could reduce the risk of perforation [20].

A previous study reported that the use of simple traction method in EFTR reduced both procedure and perforation time [21]; however, this previous study only involved 13 patients in the traction group. To the best of our knowledge, there has been no previous study reporting the efficacy of DFC in EFTR in a large population of patients. In the present study, involving 64 patients, DFC–EFTR was found to be significantly associated with a shorter procedure time than a conventional EFTR group in the gastric fundus; this finding was confirmed by both univariate and multivariate analysis. Although serious complications did not present in either of the two groups, PEECS was significantly less frequent in the DFC–EFTR group than in the conventional EFTR group. Logistic regression analysis also indicated that when used in EFTR, DFC acted as a protective factor for complications, such as PEECS. Consequently, this study revealed that the incorporation of DFC made EFTR easier and safer.

Based on previous research, DFC shared some of the advantages of ESD but also possesses additional advantages. First, DFC provided good visualization and adequate tissue tension because of the traction it created; this made it easier to distinguish and access the edges of lesions. With the help of traction, the incision of the gastric wall was performed from the mucous to the serosal layer; it was then possible to complete circumferential removal of the mucosal and tissues covering the lesion site. By using DFC, the endoscopist benefited enormously by being provided with an uninterrupted view of every layer surrounding the lesion, while both preventive treatments for the vasculature, and therapeutic hemostasis for active bleeding, were handled in a timely and effective manner during EFTR. Furthermore, our research on the combined use of DFC in EFTR demonstrated a striking reduction in operation time during EFTR procedures applied to SMTs located in the gastric fundus. Previous studies have investigated factors that might impact upon procedure outcomes for EFTR for gastric SMTs and reported that the location of a tumor in the greater curvature was significantly associated with the length of the procedure, and that the greater curvature of the upper or middle stomach is also the area in which DFC–ESD provides a remarkable reduction in procedure time [20, 22]. Thus, the gastric fundus, as part of the greater curvature in the upper stomach, should also be an appropriate location for DFC–EFTR in the treatment of SMTs.

Complications after EFTR might represent challenges for medical workers and cause numerous problems for patients. In this study, none of our patients exhibited delayed bleeding or perforation, although the DFC–EFTR group showed a 3.1% incidence of PEECS which is not only lower than that which occurred in the conventional EFTR group, but was also lower than that reported for gastric ESD [23]. Although PEECS usually appears in cases of colorectal ESD, gastric PEECS following ESD and EFTR should not be ignored

as otherwise unnecessary exploratory operations might be carried out [24]. We speculate that the lower incidence of PEECS in the DFC–EFTR group was related to a shorter operating time, as a longer time may either directly or indirectly increase risk for both the stomach and colorectum [23, 25]. In addition, exposure of the internal lumen is inevitable during the full-thickness resection step, and using DFC to shorten operation times may therefore lead to less bacterial contamination, and avoid PEECS in some patients.

Unlike ESD, it is important to prevent lesions falling into the perineal cavity during EFTR [26]. In effect, DFC creates an "extra hand" for the endoscopist with which to catch the inside edge of the lesion, thus replacing the need for laparoscopic assistance and minimizing the area of resected serosa. Furthermore, this technique should be considered as non-exposed endoscopic surgery without the risk of tumor dissemination into the peritoneum in patients with SMTs, irrespective of ulceration. For SMTs with a smooth surface, lesions will always be wrapped by gastric mucosa, serosa, and other tissues during the process of DFC–EFTR. Even if SMTs present with ulceration, the countertraction provided by DFC will ensure that the ulcerative surface faces the gastric cavity rather than the abdominal cavity at all times.

Having established that the main advantage of DFC was a shorter procedure time, we next carried out additional subgroup analyses to investigate the effect of characteristics related to the patient, tumor, and operator. We found that experts required a significantly shorter procedure time for DFC–EFTR than for conventional EFTR. This result was explained by the contribution of supervisors who were experienced in the use of DFC traction; younger, less experienced operators required more practice. In addition, various tumor-related factors also affected the efficacy of traction, and thus the length of the procedure, including tumor size, position, and whether there was any extraluminal growth. The data and experience accumulating from our group's experience indicated that SMTs located near the cardia and showing extraluminal growth were associated with increased technical difficulty and therefore reduced the time-saving benefit of DFC. Our data also showed that DFC was a significant role in reducing procedure time when tumors are large.

The literature shows that a variety of different traction methods and novel devices have been applied to improve the safety and efficiency in ESD or EFTR for tumor resection, including a balloon arm-mechanical countertraction system, a magnetic countertraction device, suture loop needle T-tag (SLNT) tissue anchors, and others [27–29]. However, it is obvious that by carrying out DFC with just DFC, we created a range of advantages over other techniques, including low cost, simple production, convenience, and practicability. Of course, there are several potential limitations for this method which should not be ignored. First, the clip might fall off during the procedure (although this situation did not happen in our present study), and sometimes more than one clip is required to provide optimum countertraction. Second, the optimal anchoring site and pulley tension to provide the best traction are mainly determined and adjusted at the discretion of the operators; thus, experience plays a key role in this procedure. Therefore, more data and scientific research needs to be carried out before constructing a definitive guideline for this technique. This study also had some limitations. First, the study was retrospective in nature, and was carried out in a single institution. Thus, a prospective, randomized study is now warranted.

In conclusion, the DFC method was a very promising method with which to facilitate resection visualization, capture tumors, and reduce operation time during EFTR. This procedure can also reduce the risk of minor complications, particularly PEECS. This method therefore provides a significant overall improvement in the EFTR technique for SMTs in the gastric fundus by creating a simple method of traction.

Funding This project was supported by the Shanghai Engineering and Research Center of Diagnostic and Therapeutic Endoscopy (16DZ2280900), the National Natural Science Foundation of China (81672329), the Shanghai Municipal Health System Outstanding Academic Leaders Foundation Program (2017BR010), and the Jianfeng Project of Xuhui Provincial Commission of Health and Family Planning (SHXH201701). The funders had no role in study design, data collection and analysis, the decision to publish, or preparation of the manuscript.

Compliance with ethical standards

Disclosures Bing Li, Qiang Shi, Zhi-Peng Qi, Li-Qing Yao, Mei-Dong Xu, Zhen-Tao Lv, Ayimukedisi Yalikong, Shi-Lun Cai, Di Sun, Ping-Hong Zhou, and Yun-Shi Zhong have no conflicts of interest or financial ties to disclose.

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