

# Direct percutaneous endoscopic jejunostomy tube placement in patients post Roux-en-Y gastric bypass, a single tertiary care center experience



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## ABSTRACT

**Background and study aims** Obesity prevalence continues to rise in the United States with Roux-en-Y gastric bypass (RYGB) surgery being one of the most common bariatric procedures. With this trend, more patients with altered upper gastrointestinal (UGI) anatomy have required endoscopic intervention including direct percutaneous endoscopic jejunostomy (DPEJ) placement. We aimed to assess the safety and success rates of DPEJ in RYGB patients.

**Patients and methods** All patients at a tertiary care referral center who underwent DPEJ during an 8-year period were queried from a prospectively maintained registry of all enteroscopy procedures. Duplicate cases and altered upper UGI anatomy subtypes other than RYGB were excluded. The final cohort consisted of two groups: RYGB vs native anatomy (NA). Demographic, procedural, readmission, follow-up, and complication data were recorded. Comparative analysis was performed.

**Results** Seventy-two patients were included where 28 had RYGB and 44 had NA. Both groups had similar baseline and pre-procedure data. Procedure success rate was 89% in RYGB patients and 98% in NA patients ( $P=0.13$ ). There were no intraprocedural complications. Early and late post-procedural complication rates were similar between the groups (both 4% vs 7%). Average follow-up times in the RYGB and NA groups were  $12.97 \pm 9.35$  and  $13.44 \pm 9.21$  months, respectively. Although readmission rates at 1 and 6 months were higher in the NA versus the RYGB group (21% vs 7% and 25% vs 15%), these differences were not significant.

**Conclusions** DPEJ can be successful and safely placed in RYGB patients with no significant difference in procedure success, complication, or readmission rates when compared to control.

## Introduction

The prevalence of obesity within the United States has been on the rise, with a prevalence of 42.4% between 2017 and 2018 [1]. Such a trend has led to increased referrals for bariatric sur-

geries leading to more patients with altered upper gastrointestinal (UGI) anatomy [2]. Among bariatric surgery options, Roux-en-Y gastric bypass (RYGB) is offered to those with a body mass index (BMI)  $\geq 40$  or BMI  $\geq 35$  with obesity-related comorbidities. This procedure consists of creation of a gastric pouch, biliopan-

creatic limb, jejunojejunostomy, and gastrojejunostomy [3]. Endoscopic depiction of RYGB is shown in ► **Fig. 1**. As this procedure becomes more prevalent with the worsening obesity epidemic in the US, endoscopists are encountering a higher percentage of patients with various altered UGI anatomy subtypes including RYGB who require endoscopic intervention [4].

Endoscopic-guided enteral access is often applied in patients who cannot maintain long-term enteral nutritional requirements through oral intake alone [5, 6]. The European Society of Gastrointestinal Endoscopy (ESGE) recommends considering enteral tube insertion under the following circumstances: conditions that prohibit oral intake, clinical states where oral intake is insufficient to meet caloric needs, and chronic small bowel obstruction that requires decompression. Percutaneous access should be considered if enteral nutrition needs are beyond 4 weeks [7]. Percutaneous endoscopic gastrostomy (PEG), percutaneous endoscopic transgastric jejunostomy (PEG-J), and direct percutaneous endoscopic jejunostomy (DPEJ) are modalities that have been applied to multiple patients. These procedures can prevent surgical intervention in sometimes critically ill patients [8] and have now been applied to those with surgically altered anatomy including RYGB [4].

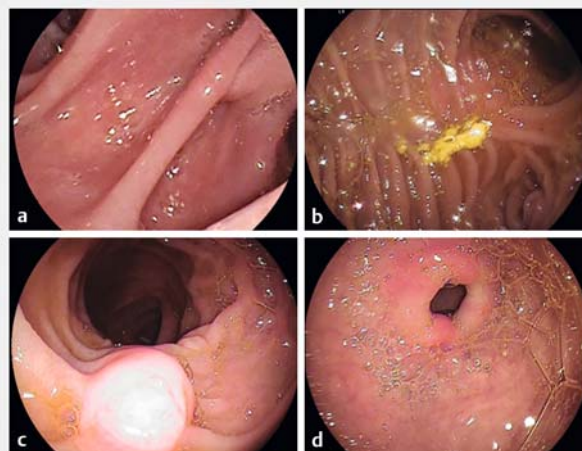
Indications for more distal placement of the feeding tube through DPEJ specifically over PEG or PEG-J include high risk for aspiration, following foregut surgeries, severe gastric outlet obstruction, nonfunctioning gastrojejunostomy, proximal complications of RYGB surgery including leaks and dehiscence, or gastric dysmotility [6, 9]. DPEJ can also be placed in patients who failed PEG placement and has been shown to be a more stable jejunal access than PEG-J [10, 11]. By circumventing gastric passage, DPEJ may help prevent gastric feeding-related adverse events (AEs) altogether [4,9,12]. The success rates of DPEJ vary between 68% to 100% on first attempt [4, 8, 10, 13–15]. AEs within 30 days of procedure have remained relatively low, ranging between 9% and 13% [4,9,12]. Complication rates beyond 30 days have been reported to be as high as 17% to 23% [4,9].

Placement of DPEJ has been studied in patients following esophagectomy [15] and other altered UGI anatomy subtypes. Although RYGB patients have been included in previous single-center experiences [4], data remain limited on RYGB anatomy specifically with regard to DPEJ. We aimed to study the role of DPEJ in RYGB patients with comparison to a control group with native anatomy (NA).

## Patients and methods

### Patient population

We performed a retrospective review of a prospectively maintained database of all endoscopic procedures performed between November 1, 2014 and March 1, 2022 at a tertiary care center. The study was approved by the Institutional Review Board. The study population was identified through a prospectively collected registry and data extracted from the Provation Endoscopy software, into which all recorded endoscopic procedures are logged and saved within the electronic medical record. Over the 8-year period included in our study, we filtered

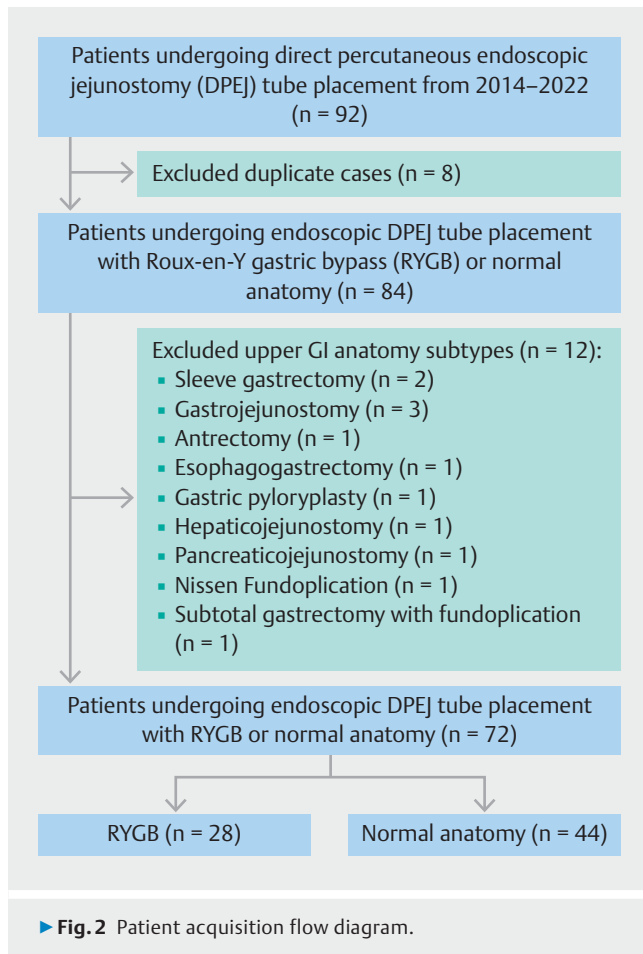


► **Fig. 1** Endoscopic view of Roux-en-Y upper gastrointestinal anatomy. **a** Gastrojejunostomy for gastric bypass site. **b** Jejunal anastomosis of Roux-en-Y. **c** Duodenal limb with ampulla in view. **d** Duodenal limb with pylorus in retro view.

our search within this database to include only patients that had undergone DPEJ placement to arrive at our study population. Inclusion criteria for our study included a patient's first attempted DPEJ tube insertion. Duplicate cases were excluded from our study. In addition, given our focus of assessing DPEJ insertion in RYGB patients, those with any other form of altered UGI anatomy were excluded. The final patient population was stratified into one of two groups based on UGI anatomy: those with RYGB vs those with NA (control). A patient selection flow diagram is shown in ► **Fig. 2**.

### Procedure description

Procedure approach can vary based on a patient's BMI as well as the patient's UGI anatomy. Small bowel enteroscopy with or without balloon procedure assistance (single balloon [SBE]/double balloon enteroscopy [DBE]) is applied to achieve DPEJ placement. The procedural details of our DPEJ placement are consistent with that previously described at our institution along with implementation of the Ponsky "pull" technique [16, 17]. Briefly, the abdominal wall undergoes routine antiseptic cleaning and local anesthesia in preparation for tube placement in sterile manner. Transillumination and finger indentation are used to identify optimal window of puncture. An initial search needle is used as an anchoring device under direct endoscopic view to guide trocar needle insertion through the abdominal wall into the jejunum. A snare is passed through the endoscope and opened into the jejunal lumen. A guidewire is then passed through the trocar and into the open snare. Next, the endoscope and the ensnared guidewire are removed, pulling the wire through the mouth. A 20F or 24F jejunostomy tube is lubricated and passed over the guidewire through the mouth and into the jejunum. The trocar needle is removed and the jejunostomy tube is pulled out from the jejunum through the skin. The guidewire is removed, and the feeding tube is cut to an ap-



appropriate length. The endoscope is then reinserted to confirm the final position. Although reinsertion for position confirmation is not routine practice, we performed such technique to guide the inner bolster of the DPEJ in its luminal position and to easily follow the tube with the endoscope through the over tube to verify its final position.

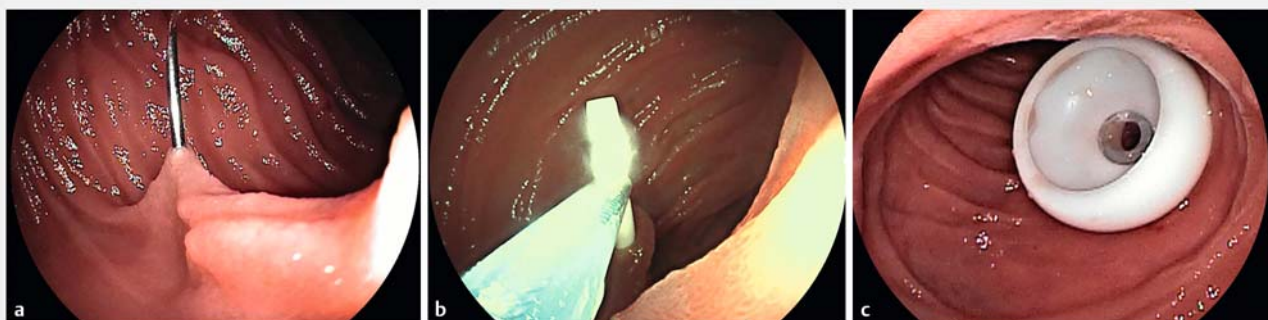
In patients with NA, the enteroscope was used to access the mid-jejunum beyond the ligament of Treitz. In those with RYGB,

access sites for DPEJ placement included the Roux limb or the common channel limb of their altered UGI anatomy. Fluoroscopy guidance can be utilized to help identify the UGI anatomy structure in RYGB patients. In RYGB patients, the best point of insertion was selected based on ideal skin transillumination and one to one finger palpation; therefore, the site was not preselected, but rather guided by the technique with the intent to provide ideal enteral nutrition anywhere in the limbs of the small bowel anastomosis. Based on our experience, most of the tube insertion sites were located over the left mid to lower quadrant of the abdomen. Following insufflation of the desired area of small bowel, transillumination with external compression are used to guide a percutaneous window for PEJ placement (► **Fig. 3**).

### Data collection

Data were extracted on each patient through medical chart review in a password-protected, deidentified Excel document. Baseline demographic information including BMI, comorbidities, and anticoagulation or antiplatelet use were obtained. Procedural data consisted of type of endoscopic procedure, total procedure time, type of sedation, and American Society of Anesthesiologists (ASA) classification. Other variables included procedural setting and indication for procedure taken from clinical documentation and procedure notes. The primary outcome of the study was procedure success rate, which was defined as successful placement of DPEJ tube. Secondary outcomes were clinical success and AEs, which included intraprocedural complication, early postprocedural complications, and late postprocedural complications. Early postprocedural complications were within 48 hours of procedure. Late postprocedural complications were up to 90 days post DPEJ placement. Procedure complications that were collected included inability to tolerate the procedure secondary to hemodynamic instabilities (hypoxemia, hypotension, etc.), excessive bleeding, or bowel perforation. Early and late postprocedural complications included aspiration as well as PEJ bleeding, leakage, infection, dislodgement, and dysfunction.

Albumin levels were measured on day of DPEJ placement as well as 30, 60, and 90 days post DPEJ placement. Overall and



► **Fig. 3** Steps for direct percutaneous endoscopic jejunostomy tube. **a** Needle puncture in the jejunal limb. **b** Trocar through the jejunal limb for PEJ insertion **c** Inner bumper of the PEJ in adequate position to the jejunal lumen.

DPEJ readmission rates at 1 and 6 months were calculated. Follow-up data up to 2 years post DPEJ placement was recorded on each patient as well as whether the DPEJ tubes were removed or replaced. Time to removal or replacement in months was recorded. Overall and 2-year mortality were measured.

### Statistical analysis

Patient data were depicted through descriptive statistical analysis as a mean ± standard deviation (SD) for continuous variables or as a frequency percentage for categorical variables. For comparison between groups, Student's 2 Sample T-Test and Chi-Squared test were used for continuous and categorical variables respectively. All statistical analysis was performed with Stata Statistical Software (StataCorp LLC, College Station, Texas, United States).

## Results

### Baseline patient information

Following our initial search, 92 patients were identified who underwent DPEJ placement. Eight were duplicate cases and 12 patients had other forms of altered UGI anatomy, all of which were excluded (► Fig. 2). A total of 72 patients met inclusion criteria for our study of which 28 were RYGB patients and 44 were NA patients.

Within the RYGB group, the average age of this group was 55.89 ± 14.39 years with an average BMI of 25.17 ± 7.69. Most of these patients were Caucasian (86%) and female (75%). Comorbidities included diabetes mellitus (14%), hypertension (57%), hyperlipidemia (11%), chronic obstructive pulmonary disease (COPD) (3%), coronary artery disease (CAD) (3%), chronic kidney disease (CKD) (7%), and congestive heart failure (CHF) (14%). There were six patients (21%) on anticoagulation and three patients (11%) on antiplatelets. The average length of time between RYGB surgery and DPEJ placement was 11.55 ± 6.52 years. Average albumin level on day of DPEJ placement was 2.97 ± 0.59 g/dL. DPEJ was placed after at least 1 year following RYGB apart from two patients who had their DPEJs placed at 3 and 6 months post-RYGB.

The group with NA anatomy had an average age of 52.57 ± 16.38 years and an average BMI of 22.64 ± 6.13. Most of these patients were also White (88%) and female (68%). The comorbidities in this cohort consisted of diabetes mellitus (25%), hypertension (52%), hyperlipidemia (23%), COPD (7%), CAD (11%), CHF (2%), CKD (2%), end-stage renal disease (ESRD) (2%), and cirrhosis (2%). Prior to the procedure, 14% of these patients were on anticoagulants and 25% were on antiplatelets. Average albumin level on day of procedure was 3.07 ± 0.58 g/dL.

All anticoagulation was held prior to the procedure in both groups as per American Society of Gastrointestinal Endoscopy guidelines. A comparison of these baseline variables between our two groups (RYGB vs control) showed no significant difference in demographics, medication use, or comorbidities (all  $P > 0.05$ ) (► Table 1).

► **Table 1** Baseline patient demographic and comorbidity data compared between those with Roux-en-Y and those with normal anatomy (NA).

Variable, n (%)	RYGB (n=28)	NA (n=44)	P value
Age, mean ± SD	55.89 ± 14.39	52.57 ± 16.38	0.382
BMI, mean ± SD	25.17 ± 7.69	22.64 ± 6.13	0.127
Male	7 (25%)	14 (32%)	0.535
Race			0.715
▪ White	24 (86%)	39 (88%)	–
▪ African American	4 (14%)	5 (13%)	–
Albumin, mean ± SD	2.97 ± 0.59	3.07 ± 0.58	0.481
Diabetes	4 (14%)	11 (25%)	0.275
Hypertension	16 (57%)	23 (52%)	0.686
Hyperlipidemia	3 (11%)	10 (23%)	0.196
COPD	3 (11%)	3 (7%)	0.560
CAD	3 (11%)	5 (11%)	0.932
ESRD	0 (0%)	1 (2%)	0.369
CKD	2 (7%)	1 (2%)	0.313
Cirrhosis	0 (0%)	1 (2%)	0.422
CHF	4 (14%)	1 (2%)	0.051
Anticoagulation	6 (21%)	6 (14%)	0.387
Antiplatelet	3 (11%)	11 (25%)	0.135

BMI, body mass index; COPD, chronic obstructive pulmonary disease; CAD, coronary artery disease; ESRD, end-stage renal disease; CKD, chronic kidney disease; CHF, congestive heart failure.

### Procedure indication

Indications for procedure in the RYGB mainly consisted of failure to thrive (FTT) secondary to either inability to tolerate oral intake (50%), dysphagia from esophageal dysmotility (7%), and chronic pancreatitis (1%). Other indications included neurologic disease (14%), medication infusion (7%), anastomotic stenosis or ulcer (4%), and other (4%). In those with NA anatomy, procedure indications included FTT from chronic pancreatitis (30%), inability to tolerate oral intake (27%), and dysphagia from esophageal dysmotility (7%). Additional indications consisted of gastroparesis (23%), medication infusion (9%), neurologic disease (2%), and other (2%).

### Procedure data

Most procedures were performed in the inpatient setting (86%) with the specific types of procedures being push enteroscopy with a pediatric colonoscope (EVIS EXERA III (PCF-H190L/I) Olympus America) (12%), SBE ((EVIS EXERA II (SIF-Q180), Olympus America)) (7%), and DBE (EN-580 T, FUJIFILM Holdings America Corporation) (81%). ASA classes included category II (3%), III (83%), and IV (14%) with types of sedation being general (15%) and monitored anesthesia care (MAC) (85%). Fluoro-

**► Table 2** Comparison of endoscopic procedure indications and descriptive variables between those with Roux-en-Y and those with native anatomy (NA).

Variable, n (%)	RYGB (n=28)	NA (n=44)	P value
Inpatient	22 (79%)	40 (91%)	0.140
Indication			
▪ FTT from chronic pancreatitis	1 (4%)	13 (30%)	–
▪ FTT from dysphagia	2 (7%)	3 (7%)	–
▪ FTT from inability to tolerate oral feeds	14 (50%)	12 (27%)	–
Gastroparesis	0 (0%)	10 (23%)	–
Neurologic disease	4 (14%)	1 (2%)	–
Anastomotic ulcer/stenosis	4 (14%)	0 (0%)	–
Medication Infusion	2 (7%)	4 (9%)	–
Other	1 (4%)	1 (2%)	–
Type of procedure			
▪ Push enteroscopy	3 (11%)	6 (14%)	–
▪ Single balloon enteroscopy	4 (14%)	1 (2%)	–
▪ Double balloon enteroscopy	21 (75%)	37 (84%)	–
ASA class			
▪ II	0 (0%)	2 (4.5%)	–
▪ III	21 (75%)	39 (87.5%)	–
▪ IV	7 (25%)	3 (7%)	–
General anesthesia	25 (89%)	36 (82%)	0.391
Total procedure time (mins), mean ± SD	44.57 ± 27.44	42.11 ± 20.03	0.662
Procedure success	25 (89%)	43 (98%)	0.127
Size of tube			
▪ 20F	24 (96%)	39 (91%)	–
▪ 24F	1 (4%)	4 (9%)	–
BMI 90 days post DPEJ, mean ± SD	23.74 ± 5.66	23.41 ± 5.52	0.831

ASA, American Society of Anesthesiologists; BMI, body mass index; DPEJ, direct percutaneous endoscopic jejunostomy; FTT, failure to thrive; SD, standard deviation.

scopy was used in 53 (75%) patients: 19 (68%) in the RYGB patients and 34 (77%) in the NA patients. In RYGB patients, the DPEJ tube was placed in the common channel in 13 (52%) patients and the Roux limb in 12 (48%) patients. Average BMI at 90 days post DPEJ placement was 23.74 ± 5.66 in the RYGB group and 23.41 ± 5.52 in the NA anatomy group. This represents a 0.2% increase in average BMI in the RYGB group and a 0.3% decrease in average BMI in the NA group. Prophylactic antibiotics were used in all patients as standard of care.

Most of the tubes used for the DPEJ were 20F Wilson-Cook PEG tubes (n=56). Other tubes included 24F Wilson-Cook PEG tubes (n=3), 20F Boston Scientific gastrostomy tubes (n=7), and 24F Boston Scientific gastrostomy tubes (n=2). In the RYGB group, a 20F sized tube was used in 96% of patients whereas a 24F was used in 4% of these patients. Average total procedure time in these patients was 44.57 ± 27.44 minutes. In

the NA group, most patients had a 20F DPEJ placed (91%) whereas a few patients had a 24F DPEJ placed (9%). The average procedure time in NA patients was 42.11 ± 20.03 minutes (► **Table 2**).

### Procedure complications

There was no difference in the procedure success rate between the RYGB group vs control group; 89% vs 98% respectively, (P=0.13). Reasons for procedure failure included unsuitable percutaneous window and inflammation with erythema of the jejunum making the environment unsuitable for DPEJ placement. Among the entire population, there were no documented complications during the endoscopic procedure. Early postprocedural complication rates were similar between the two groups (4% vs 7%) with DPEJ bleeding being reported in the RYGB group, and DPEJ leakage and aspiration pneumonia in the NA

**► Table 3** Complications and readmission rates following DPEJ placement compared between those with Roux-en-Y and those with native anatomy (NA).

Variable, n (%)	RYGB (n=28)	NA (n=44)	P value
Intraprocedural complications	0 (0%)	0 (0%)	–
Early postprocedural complications	1 (4%)	3 (7%)	0.557
Bleeding	1 (4%)	0 (0%)	–
Leakage	0 (0%)	2 (5%)	–
Hypoxia/aspiration	0 (0%)	1 (2.5%)	–
Late postprocedural complications	1 (4%)	3 (7%)	0.558
Dislodged PEJ	1 (4%)	2 (4.5%)	–
Leakage	0 (0%)	1 (2.5%)	–
1-month overall readmission	2 (7%)	9 (21%)	0.126
1-month PEJ readmission	0 (0%)	2 (5%)	0.253
6-month overall readmission	4 (15%)	11 (25%)	0.343
6-month PEJ readmission	2 (7%)	1 (4%)	0.313

DPEJ, direct percutaneous endoscopic jejunostomy; RYGB, Roux-en-Y gastric bypass; PEJ, percutaneous endoscopic jejunostomy.

group. Those with DPEJ leakage or bleeding all had 20F tubes. The patient who suffered from aspiration pneumonia had undergone MAC sedation without endotracheal intubation.

Late postprocedural complications were also comparably similar between groups (4% vs 7%) with dislodged DPEJ and leakage being the reported findings. Among the three dislodged DPEJ tubes, two (67%) were 20F in size while one (33%) was 24F in size. The one reported late postprocedural leakage was seen in a 20F tube. There were no reported complications regarding tolerance of tube feeds or tube feed dysfunction following placement across the entire cohort.

### Readmission rates

One- and 6-month overall readmission rates were higher in the control group when compared to the RYGB group (21% vs 7% and 25% vs 15% respectively); however, these differences were not statistically significant. DPEJ related readmission rates were lower at 1 month (0% vs 5%) but higher at 6 months (7% vs 4%) in the RYGB group when compared to the control group; however, these differences were not deemed statistically significant (► Table 3).

### Follow-up albumin levels

Within the entire cohort, 44% of RYGB patients and 56% of the NA patients had albumin follow-up data up to 90 days post DPEJ placement. In the RYGB, average albumin levels at 30 days, 60 days, and 90 days post DPEJ placement were  $3.59 \pm 0.81$  g/dL,  $3.80 \pm 0.69$  g/dL, and  $4.06 \pm 0.61$  g/dL respectively. Average albumin levels in the NA group were  $3.63 \pm 0.80$  g/dL at 30 days,  $3.78 \pm 0.68$  g/dL at 60 days, and  $4.05 \pm 0.64$  g/dL at 90 days. A graph of this data is shown in ► Fig. 4. The percentage rise in average albumin level on day of procedure to 90 days was 37% in the RYGB group and 31% in the NA group.

### Tube removal or reinsertion

There were 24 patients total in our cohort who had documented DPEJ removal. These tubes were either removed with endoscopic procedure (n = 16, 67%), with a surgical team at bedside (n = 7, 29%), or with interventional radiology (n = 1, 4%). A total of 7 RYGB patients had their DPEJ removed with an average time to removal being  $10.25 \pm 5.28$  months. There were 17 NA patients who underwent DPEJ removal with average time to removal being  $10.88 \pm 5.92$  months.

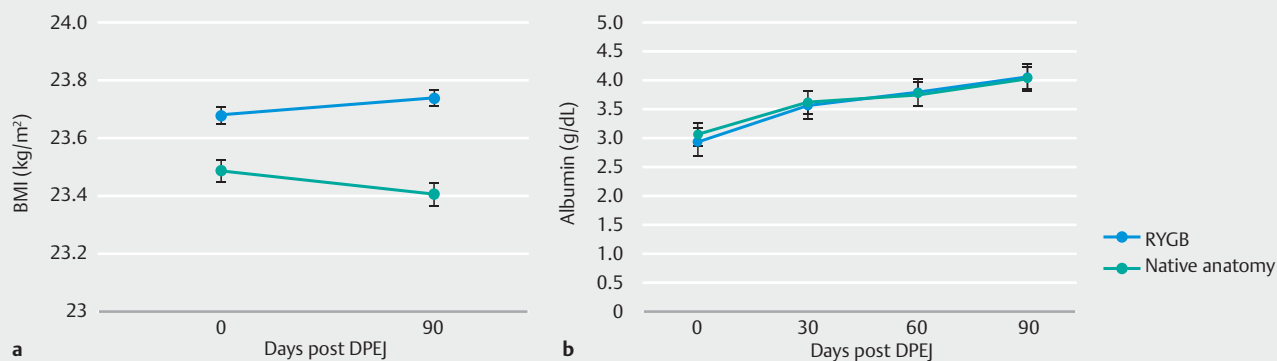
A total of 14 patients had their DPEJ replaced following initial endoscopic insertion: 7 endoscopically and seven with interventional radiology. Seven RYGB patients underwent tube replacement with average time to replacement being  $10.81 \pm 5.75$  months. There were also 7 NA patients who had their DPEJ replaced with average time to replacement being  $10.22 \pm 5.43$  months.

### Follow-up and mortality data

Average follow-up in our RYGB patients up to 2 years post DPEJ placement was  $12.97 \pm 9.35$  months, whereas average follow-up was  $13.44 \pm 9.21$  months in our NA patients. The overall mortality rate in our cohort was 14%. This included four RYGB patients and six NA patients. Two-year mortality rate was 11%, with four RYGB and four NA each suffering 2-year mortality. None of the deaths within the entire cohort were related to the procedure.

### Discussion

This is the largest study evaluating placement of DPEJ in patients with surgically altered anatomy after RYGB. Our study of consecutive cases of DPEJ placement in patients with RYGB



► **Fig. 4** Follow-up average BMI and albumin levels following DPEJ placement in those with RYGB and native anatomy. **a** Stability of average BMI from day of procedure to 90 days post DPEJ placement. **b** Average albumin levels on day of procedure and 30, 60, and 90 days post DPEJ placement.

highlights the feasibility and safety of such a procedure in these patients. Procedure success rates were at 89% with no significant differences between those with NA. Intraprocedural complication rate was at zero with overall low early and late post-procedural complications rates at 4% each. One-month overall and DPEJ related readmission rates were also low at 7% and zero, respectively and lower than the control group. Furthermore, 6-month overall and DPEJ related readmission rates were similar between the two groups.

RYGB has become a regularly implemented bariatric surgical option for those with severe obesity; however, it can be associated with various types of postoperative complications. In the immediate postoperative period, leaks, stenosis, venous thromboembolism, and bleeding can arise [18]. Later complications include anastomotic stricture, marginal ulceration, fistulas, cholelithiasis, and small bowel obstruction [18–20]. Our RYGB group did not consist of any patients in the immediate postoperative period. Three patients suffered anastomotic strictures, and one patient had marginal ulceration. These areas of stricture were able to be traversed following balloon dilation. However, most of our patients had significant problems with FTT.

Malabsorption leading to FTT and nutritional deficiencies in folate, B12, thiamine, iron, vitamin D, calcium, zinc, copper, selenium, and vitamin C can also be a significant issue [19, 21]. A large portion of our RYGB patients (61%) suffered from FTT. Interestingly, 50% of these patients had no definitive anatomic or surgical pathology that could explain their inability to tolerate orals. Persistent nausea and vomiting can be a significant complication post-RYGB, and many of these patients warrant endoscopic investigation to rule out potential reversible causes of their inability to tolerate orals [20, 21]. In this light, post-bariatric patients are prone to functional gastrointestinal symptoms and substantial weight loss. Dietary enteral nutritional complications can pose a serious challenge [22]. Given the growing population of patients undergoing RYGB surgery, such severe anatomic, functional, and nutritional complications should be carefully considered prior to offering surgery.

Data remain limited on the role of DPEJ in RYGB patients, and our study adds to the growing literature on this topic. Previous studies have assessed the role of DPEJ in various UGI altered anatomy subtypes. Buneo et al. reported a case series of DPEJ in esophagectomy patients with overall low incidence PEJ related complications [15]. Recent meta-analysis has investigated DPEJ and PEG-J across several patient populations with limited numbers of RYGB included within these studies [23]. Al-Bawardy et al. included 17 RYGB patients in their 94-patient single center study, Strong et al. included 19 RYGB patients in their 59 cases, and Wong Kee Song et al. included two RYGB in their cohort of 33 patients [4, 12, 24]. These studies, however, did not perform stratified analysis of RYGB patients with regards to procedure success and other outcome variables. Simones et al. described 24 patients undergoing DPEJ in their cohort with a procedure success rate of 92%, overall comparable to our results [25]. While most of our patients underwent DBE for DPEJ placement, SBE and push enteroscopy were also implemented. The advantage of DBE when compared to other endoscopic modalities is highlighted in increased insertion depth and better performance when reaching the jejunal anastomosis.

Our study is unique as we used a comparative model of DPEJ in RYGB patients to a control population with NA. With the growing number of patients receiving bariatric surgeries within the US, our study demonstrates that DPEJ can be successfully performed in RYGB. Endoscopic driven enteral feeding tube placement more often has shorter procedure times, less cost, less exposure to anesthesia, and quicker recovery time when compared to surgery [23]. The low procedural failure rate (11%) was secondary to appropriate parameters to avoid endoscopic placement given inability to find ideal transillumination or an inflamed jejunum unsuitable for DPEJ placement. Additionally, overall postprocedural complication rate remains low and comparable to control. Moreover, no association was observed between size of DPEJ tube and postprocedural complications.

Our overall procedure success and complication rate is comparable to those among other studies [23]. Regarding RYGB pa-

tients, our study sheds light on the safety and efficacy of DPEJ placement based on specific procedure components in both the inpatient and outpatient setting. SBE and DBE are routinely employed however small bowel push enteroscopy was effectively implemented in those with lower BMIs. DPEJ was successfully placed in either the common channel or Roux limb, with no association between DPEJ location with postprocedural complications. This procedure was also tolerated well with a 24F tube compared to the more frequently implemented 20F tube. Although most patients underwent general anesthesia, 11% tolerated the procedure well with MAC.

The effectiveness of DPEJ in RYGB patients is highlighted in their ability to maintain their BMI at 90 days post DPEJ placement. The rise in average albumin levels up to 90 days post DPEJ placement indicate that DPEJ can be effective to help these patients achieve nutritional requirements. Although albumin has been applied as a biomarker to predict surgical outcomes and to aid in nutritional assessment, albumin levels have been shown to be nonspecific with a half-life as short as 20 days [26–28]. The impact of underlying inflammation alongside liver dysfunction and potential proteinuria in the form of nephrotic syndrome can limit the application of albumin for nutritional assessment [26, 28].

The safety of such procedure in RYGB patients is also highlighted in our follow-up data beyond 90 days. Our findings indicate that DPEJ can be safely and effectively removed when no longer indicated or replaced if tube feed needs persist after several months. Overall and 2-year mortality rates were low with none of these deaths being related to the DPEJ procedure itself.

Our study has potential limitations. First, the retrospective design is a limitation in and of itself. Our small sample size also impacts the overall power of this study; however, our study represents the largest consecutive group of RYGB DPEJ patients to date. Given the study was performed at a tertiary care referral center, referral bias may have impacted our results. Nonetheless, in general practice it is customary to refer patients with complex post-surgical anatomy to tertiary centers. Fourth, the procedures being performed by multiple providers may limit the study conclusions. However, the homogenous success in placing DPEJ by various providers suggests that other advanced endoscopists shall be able to reproduce our findings. Data were unavailable on patient BMI prior to RYGB surgery. The longer procedure times were based on skills, technique, and anesthesia support at our single-center experience, keeping in mind there was additional assistance primarily with tube insertion. Furthermore, even though we include mortality data in our results, we realize we cannot make mortality conclusions given our underpowered design. Despite these limitations, our study is unique in being the first to date to assess DPEJ in RYGB patients with comparison to a control group.

## Conclusions

With the obesity epidemic on the rise in the US, more patients are being offered RYGB. Our study also highlighted the potential severe complications that can arise post-RYGB that can lead

to FTT. Importantly, we demonstrated that DPEJ placement in this patient population is a safe and effective and can be successfully performed with similar incidence of complications and readmission rates post procedure as control patients with NA. Further work with multiple centers is needed to confirm our findings.

## Competing interests

The authors declare that they have no conflict of interest.

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