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ORIGINAL CONTRIBUTIONS

Comparing the Efficacy and Safety of Roux-en-Y Gastric Bypass with One-Anastomosis Gastric Bypass with a Biliopancreatic Limb of 200 or 160 cm: 1-Year Results of the Tehran Obesity Treatment Study (TOTS)

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Abstract

Purpose One-anastomosis gastric bypass (OAGB) has raised concerns about nutritional complications possibly attributed to the biliopancreatic limb (BPL) length. We aimed to assess the results of a conservative approach of OAGB compared with the original OAGB and Roux-en-Y gastric bypass (RYGB) in a 1-year follow-up study.

Materials and Methods This retrospective study was conducted based on prospectively maintained data in a cohort of patients who underwent either RYGB with a Roux limb of a 150 cm and a BPL of 50 cm ($n = 145$), OAGB with a 200-cm BPL ($n = 272$), or OAGB with a 160-cm BPL ($n = 383$), from March 2013 to 2017 at three university hospitals by a single surgical team.

Results Groups were comparable regarding age and sex. Mean preoperative body mass indexes of the RYGB, OAGB-160, and OAGB-200 groups were 44.5 ± 5.8, 45.6 ± 6.3, and 46.7 ± 6.4 kg/m^2, respectively. One-year follow-up rates were 83.4%, 85.3%, and 82.5% for the RYGB, OAGB-200, and OAGB-160 groups, respectively. One-year percent total weight loss values were 33.8 ± 6.7 after OAGB-160 and 35.3 ± 6.9 after OAGB-200 ($P = 0.056$), which were significantly greater compared with 30.9 ± 8.9 after RYGB ($P < 0.001$). All groups were comparable regarding remission of type 2 diabetes mellitus, hypertension, dyslipidemia, and fatty liver. Mean operative time was longer with RYGB than with either OAGB techniques. Groups were comparable for postoperative complications except for the incidence of protein-calorie malnutrition (PCM), occurring in 11 patients (4.7%) after OAGB-200, 7 of whom required revisional surgery, in one patient (0.3%) after OAGB-160 who responded to parenteral alimentation, but in no patients after RYGB.

Conclusion After 1 year, OAGB with a 160-cm BPL was as effective as OAGB with a 200-cm BPL and RYGB, but safer than OAGB-200. This approach also avoided the need for revisional surgery following postoperative malnutrition.

Keywords One-anastomosis gastric bypass · Roux-en-Y gastric bypass · Biliopancreatic limb length · Complication · Safety · Effectiveness

Introduction

Obesity is now a public health threat and has reached epidemic proportions worldwide. In parallel, the prevalence of severe obesity has increased steadily over the past decades [1]. Bariatric surgery is now established as the main treatment of severe obesity to induce sustained weight loss and remission of obesity-related comorbidities [2]. On the other hand, the number of patients undergoing bariatric surgery is also on the rise reflecting both the increased demand for and accessibility of surgery and necessitating continuous optimization of surgical techniques [3].

Roux-en-Y gastric bypass (RYGB) has remained the standard bypass procedure owing to its remarkable long history

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and widespread practice. However, it bears technical complexity and a steep learning curve [3]. Over the past two decades, one-anastomosis gastric bypass (OAGB) has attracted considerable attention as the second most common gastric bypass procedure after RYGB [3]. It has presented itself as a less challenging and safe alternative with equivalent or even better weight loss results than RYGB [4, 5]. Nevertheless, OAGB is still in its early adoption phase in many centers including in North America [3].

In the historically labeled "malabsorptive" bariatric procedures, the bypassed proportions of small bowel and the biliopancreatic limb (BPL) influence the absorption capacity and are presumably responsible for weight loss and comorbidity improvement. In OAGB, a 200-cm BPL was first suggested by Rutledge in 2001 [6], which has remained the most popular technique for this procedure. After recent reports of higher nutritional deficiencies with this OAGB technique [7, 8], efforts have been ongoing to propose a safer modification, including the use of shorter BPL lengths.

The purpose of this study was to compare 1-year results of classic RYGB with OAGB of either a 200- or a 160-cm BPL, in terms of weight loss, comorbidity remission, and postoperative complications.

Methods

Study Design and Participants

This retrospective study was conducted based on prospectively maintained data within the framework of Tehran Obesity Treatment Study (TOTS), which is a single-institution ongoing cohort of patients with severe obesity undergoing bariatric surgery, at three university hospitals in Tehran, Iran. Detailed rationale and methods of the TOTS have been described previously [9]. From March 2013 to March 2017, eligible patients with a body mass index (BMI) of ≥ 40 kg/m^2 or $\geq$ 35 kg/m^2 in the presence of at least one obesity-related comorbidity were recruited. Patients were grouped according to the type of surgery they received: 145 patients underwent RYGB with a Roux limb of 150 cm and a BPL of 50 cm (RYGB group), 272 patients underwent OAGB with a 200-cm BPL (OAGB-200 group), and 383 patients underwent OAGB with a 160-cm BPL (OAGB-160 group).

Anthropometrics and Laboratory Measurements

Data on medical records and physical examinations were obtained preoperatively and postoperatively according to the study protocol [9]. Anthropometrics included weight, height, and waist circumference measurements according to WHO guidelines [10]. Body composition was assessed using a portable bioelectrical impedance analyzer (InBody 370, Biospace, Seoul, Korea). Participants were asked to comply with the following criteria prior to impedance analysis: fasting overnight or for a minimum of 4–5 h, no exercise for at least 12 h, no alcohol for at least 24 h, balanced hydration, and lying in a supine position for at least 5 min prior to examination. Resistance to the alternating current flow (500 μA at 50/60 kHz) was measured with the patient standing on the analyzer's platform and interpreted using the "standard" option of the manufacturer's software. Fat mass (FM, in kilograms), fat-free mass (FFM, in kilogram), total body water (TBW, in kilogram), and percent body fat mass (%FM) were obtained. Liver ultrasound was performed for all patients in the immediate period before and at 1 year after surgery, by a skilled radiologist to assess fatty liver grade from 0 to 3, based on echogenicity. Biochemical assessments included fasting plasma glucose (FPG), triglycerides (TG), total cholesterol (TC), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) were performed for all participants at the study baseline and at 1-year postoperatively. Serum micronutrient levels including hemoglobin, ferritin, iron, calcium, phosphate, zinc, and vitamins B_{12} and D were not routine tests considered at every postoperative visit and, therefore, not available for all patients.

Intraoperative

Patients' education was provided by the surgeon at the last preoperative visit, including a thorough explanation regarding surgical methods, outcomes, and possible complications, and after a multidisciplinary evaluation of each patient. All the patients underwent laparoscopic gastric bypass as described previously by the authors [9]. The study is divided into three consecutive time periods according to the surgical methods selected in each period. During the first 6 months of the study and up to August 2013, RYGB had been considered as the only approach, while since September 2013, OAGB has been predominantly used and RYGB has been seldom used, only in the presence of severe hiatal hernia or preoperative gastroesophageal reflux. A 200-cm BPL had been used for all patients with OAGB, for up to 3 years and before the occurrence of one mortality following severe PCM and profound liver failure; and since then, a BPL of 160 cm has been used with OAGB. Hence, the decision on the BPL length with OAGB was not dependent on the patient's age, gender, preoperative BMI, obesity-related comorbidities, or dietary habits.

An experienced bariatric surgeon (A. Kh) performed all the operations with a standard five-port laparoscopic technique under general anesthesia [9]. Alimentary limb and biliopancreatic limb were measured uniformly. For this purpose, a mark was performed in the graspers used for the bowel measurement indicating 5 cm, assuring the homogeneity in all the patients.

For OAGB, a long gastric tube was created using Endo GIA stapler (Endo GIA Auto suture, Covidien, Mansfield, MA, USA) from the incisura angularis to the angle of His over a 36-F bougie. Antecolic loop gastrojejunostomy was performed 160 or 200 cm distal to the ligament of Trietz with an Endo GIA stapler and reinforced with continuous sutures.

RYGB was performed with the construction of a vertical pouch of stomach and anastomosis to an antecolic 150-cm Roux limb of the jejunum and a side-to-side jejunojejunostomy with a 50-cm biliopancreatic limb. Jejunojejunal mesenteric windows were routinely closed in RYGB, using 3–0 running nonabsorbable sutures.

Follow-up

After discharge, all patients were started on a liquid diet for 2 weeks followed by a semi-solid diet for 4 weeks before resuming a normal diet. All patients received daily oral multivitamin and mineral supplementations during the first postoperative year as follows: one Pharmaton® capsule daily (Boehringer Ingelheim Inc., Ingelheim am Rhein, Germany, containing 2 mg copper, 10 mg ferrous sulfate, 100 mg folic acid, 1 mcg vitamin B_{12}, vitamins A, B group, C, D, and E, nicotinamide, and biotin) and one CalciCare tablet daily (200 IU vitamin D, 400 mg calcium, 100 mg magnesium, and 4 mg zinc). Optimization of medical therapy for any related comorbidities was individually made according to our endocrinologist's recommendations.

Definitions

Type 2 diabetes mellitus (T2DM), hypertension, and dyslipidemia were defined according to their respective standard definitions [11–13]. Protein-calorie malnutrition (PCM) was considered as presentation of progressive hypoalbuminemia, lower extremities edema, and generalized fatigue despite routine postoperative supplementation and adequate intake.

Weight loss at 12 months after surgery was expressed as change in BMI (ΔBMI), percent total weight loss (%TWL), and percent excess weight loss (%EWL), calculated based on the ideal BMI of 25 kg/m^2 or weight corresponding to a BMI of 25 kg/m^2.

Remission of T2DM was defined as FPG below < 126 mg/dL and HbA1c < 6.5% in the absence of antidiabetic medication. Complete remission of hypertension was defined as blood pressure < 140/90 mmHg in the absence of antihypertensive medication. Complete remission of dyslipidemia was defined as TG < 200 mg/dL, TC < 240 mg/dL, LDL < 160 mg/dL, and HDL ≥ 40 mg/dL in the absence of lipid-lowering therapy. Remission of fatty liver was defined as an improvement into normal according to liver ultrasound. Deficiencies of micronutrients were defined based on the amounts below the low limit of reference values [14].

Statistical Analysis

Normally distributed and skewed quantitative variables are respectively expressed as mean ± standard deviation (SD) and median (interquartile range). Categorical variables are expressed as frequencies and percentages. Three groups were compared at baseline and at 12 months postoperatively using the one-way analysis of variance (ANOVA) with Bonferroni post hoc pairwise comparisons for normally distributed variables, the non-parametric Kruskal-Wallis test for skewed variables, and chi-squared test for categorical variables. Analyses were performed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA) and a P value < 0.05 was considered significant.

Results

From a total of 800 patients, 84.1% were females. The mean age was 39.3 ± 10.7 years and mean preoperative BMI was 45.8 ± 6.3 kg/m^2. Baseline characteristics of the study patients according to their surgical group are depicted in Table 1. Groups were comparable regarding age and sex. Mean preoperative BMI of the OAGB-200 group was similar to the OAGB-160 but higher than the RYGB group. The study groups were comparable regarding the proportion of patients with preoperative BMI 35–40, 40–50, and ≥ 50 kg/m^2. Baseline prevalence of hypertension was higher in the RYGB group compared with that in the OAGB-160, but was similar between the two OAGB groups. Study groups were comparable for baseline prevalence of T2DM and its duration. The three groups had also similar baseline prevalence of dyslipidemia. Prevalence of baseline ultrasonographic fatty liver in the RYGB group was lower than in OAGB-160, but similar between the two OAGB groups.

One-year follow-up rates were 83.4%, 85.3%, and 82.5% for the RYGB, OAGB-200, and OAGB-160 groups, leaving 121, 232, and 316 patients for analysis, respectively. One-year ΔBMI, TWL, and EWL were greater in both OAGB groups compared with that in RYGB. OAGB-160 patients demonstrated smaller ΔBMI and TWL, but similar EWL after 12 months compared with OAGB-200 patients. BIA analysis demonstrated greater ΔFM in both OAGB compared with that in RYGB as well as greater ΔFM in the OAGB-200 compared with that in the OAGB-160 group. T2DM, hypertension, dyslipidemia, and fatty liver improved significantly and similarly in all the study groups (Table 2).

Mean operative time was longer with RYGB than with either OAGB techniques. There were no complications requiring reoperation in the RYGB group whereas 4 (1.7%) patients in the OAGB-200 and 5 (1.6%) patients in the OAGB-160 groups returned to the operation room, although the difference between groups was not significant (P = 0.408). Three patients

Table 1 Baseline characteristics of the study patients according to their surgical approach

	Surgical group			P*	$P^{\dagger}$ (RYGB versus OAGB-160)	$P^{\dagger}$ (RYGB versus OAGB-200)	$P^{\dagger}$ (OAGB-160 versus OAGB-200)
	RYGB (n = 145)	OAGB-160 (n = 383)	OAGB-200 (n = 272)				
Continuous variables							
Age (years)	38.0 ± 10.9	40.2 ± 10.7	38.9 ± 10.7	0.082			
Weight (kg)	119.9 ± 19.7	120.4 ± 19.4	124.6 ± 20.9	0.014	> 0.999	0.069	0.022
BMI (kg/m^2)	44.5 ± 5.8	45.6 ± 6.3	46.7 ± 6.4	0.003	0.212	0.002	0.097
Duration of T2DM (years)	6.1 ± 7.3	8.2 ± 6.9	6.1 ± 6.4	0.079			
FPG (mg/dL)	111.5 ± 44.4	118.1 ± 52.5	111.1 ± 38.3	0.121			
HbA1c (%)	5.6 ± 1.3	6.2 ± 1.6	6.0 ± 1.3	0.002	0.001	0.101	0.310
TC (mg/dL)	189.6 ± 35.5	187.6 ± 39.7	178.9 ± 38.1	0.005	> 0.999	0.020	0.013
LDL (mg/dL)	111.7 ± 29.3	111.0 ± 33.0	103.3 ± 31.2	0.004	> 0.999	0.030	0.007
HDL (mg/dL)	48.0 ± 12.1	47.1 ± 11.2	47.0 ± 12.1	0.658			
TG[a] (mg/dL)	145.0 (101.5–196.0)	138.0 (106.0–189.0)	137.0 (101.2–184.5)		0.745	0.570	0.785
Categorical variables							
Gender, female	116 (80.0)	326 (85.1)	231 (84.9)		0.935	0.533	0.371
BMI subgroups, n (%)							
35–40 kg/m^2	26 (18.0)	47 (12.3)	32 (11.8)		0.494	0.095	0.100
40–50 kg/m^2	96 (66.2)	258 (67.4)	163 (59.9)				
≥ 50 kg/m^2	23 (15.9)	78 (20.4)	77 (28.3)				
HTN, n (%)	63 (43.4)	115 (30.0)	91 (33.4)		0.008	0.072	0.363
T2DM, n (%)	51 (35.2)	133 (34.7)	110 (40.4)		0.906	0.359	0.154
Dyslipidemia	131 (90.3)	322 (84.1)	244 (89.7)		0.076	0.860	0.039
Fatty liver, n (%)	109 (75.2)	330 (86.2)	229 (84.2)		0.003	0.025	0.482

BMI, body mass index; *HTN*, hypertension; *T2DM*, type 2 diabetes mellitus; *FPG*, fasting plasma glucose; *HbA1c*, glycated hemoglobin; *TG*, triglycerides; *TC*; total cholesterol; *LDL*, low-density lipoprotein; *HDL*, high-density lipoprotein

[a] Triglycerides is reported as median (IQR 25–75)

Categorical variables are presented as n (%)

*P for ANOVA < 0.05 is considered statistically significant

† P value < 0.016 is considered statistically significant for comparison of categorical variables

were confirmed as having developed peritonitis and intra-abdominal abscesses due to gastrointestinal leakage, based on computed tomography scan after orally administered gastrografin. Two patients from the OAGB-200 group were successfully treated with drainage and intravenous antibiotics. One patient in the OAGB-160 group underwent urgent peritoneal lavage and antimicrobial therapy, however, expired at 28 days postoperatively following a *Pseudomonas aeruginosa* ventilator-associated pneumonia. No PCM occurred in the RYGB group. One patient from the OAGB-160 group presented with PCM and successfully responded to parenteral alimentation. From the eleven patients presenting with PCM in the OAGB-200 group, 7 required revisional surgery after failing to respond to supportive therapy. One of the patients developed profound liver failure, severe hypoalbuminemia, and pancytopenia and expired a few days after revisional surgery [8]. Sudden cardiac arrest was the cause of death in another patient in the OAGB-160 group, 8 months after surgery (Table 3).

As demonstrated in Table 4, 1-year postoperative data regarding micronutrients are available only for a subset of patients in each group. Study groups were comparable with regard to baseline micronutrient deficiencies. All groups showed similar rates of anemia and iron deficiency both at baseline and 12 months after surgery. The prevalence of all other deficiencies after 12 months of surgery was similar between the three study groups, except for low albumin which occurred in 9 patients (8.5%) after OAGB-200, 1 patient (0.4%) after OAGB-160, and none after RYGB.

Discussion

These results support both the role of OAGB in the surgical treatment of severe obesity as well as our hypothesis that an OAGB technique with a shorter BPL would be as effective in terms of weight and comorbidity benefits. We further

Table 2 Comparison of 12-month weight loss and remission of comorbidities

	RYGB ($n = 121$)	OAGB-160 ($n = 316$)	OAGB-200 ($n = 232$)	P*	$P^{\dagger}$ (RYGB versus OAGB-160)	$P^{\dagger}$ (RYGB versus OAGB-200)	$P^{\dagger}$ (OAGB-160 versus OAGB-200)
Changes of anthropometric indices, mean ± SD							
ΔBMI (kg/m^2)	− 13.9 ± 4.7	− 15.5 ± 4.1	− 16.5 ± 4.3	< 0.001	0.002	< 0.001	0.012
TWL (%)	30.9 ± 8.9	33.8 ± 6.7	35.3 ± 6.9	< 0.001	0.001	< 0.001	0.056
EWL (%)	73.1 ± 23.2	78.1 ± 18.2	79.3 ± 17.1	0.012	0.039	0.011	> 0.999
ΔFM (kg)	− 29.1 ± 10.6	− 31.1 ± 9.7	− 34.5 ± 9.9	< 0.001	0.351	< 0.001	0.001
Remission of comorbidities, *n* (%)							
HTN	40 (78.4)	76 (83.5)	68 (86.1)		0.329	0.078	0.310
T2DM	37 (82.2)	94 (87.8)	89 (91.7)		0.308	0.077	0.319
Dyslipidemia	54 (49.5)	113 (43.3)	84 (40.2)		0.308	0.155	0.550
Fatty liver	67 (55.4)	201 (63.6)	140 (60.3)		0.114	0.368	0.436

BMI, body mass index; *TWL*, total weight loss; *EWL*, excess weight loss; *FM*, fat mass; *HTN*, hypertension; *T2DM*, type 2 diabetes mellitus

Categorical variables are presented as *n* (%)

**P* for ANOVA< 0.05 is considered statistically significant

† *P* value < 0.016 is considered statistically significant for comparison of categorical variables

demonstrated that OAGB-160 would considerably decrease the morbidity burden of OAGB associated with the use of 200-cm BPL.

The role of OAGB in bariatric surgery is increasingly being established [3]. We observed in our study that both OAGB techniques resulted in superior 1-year weight loss results compared with RYGB. This finding is in agreement with the latest evidence on these two bypass techniques, including that from a 2014 study in France indicating significantly greater excess BMI loss of 89% at 2 years after OAGB-200 compared with that of 71% after classic RYGB [15], followed by a 2019 randomized controlled trial (RCT) indicating comparable excess BMI loss at 2 years after RYGB versus OAGB-200 [5] and a 5-year RCT indicating greater excess BMI loss at 1, 2, and 5 after OAGB (BPL length ranged between 200 and 350 cm) compared with that after RYGB [16], and consequently, a meta-analysis of the evidence in 2019 showed 7.3% (95% confidence interval 4.5 to 10%) more EWL with OAGB than with RYGB [4].

Our findings regarding comparable remission of HTN and dyslipidemia between the two gastric bypass modalities were in agreement with the experience by Disse et al. of RYGB

Table 3 Operative factors and complications

Variable	RYGB ($n = 121$)	OAGB-160 ($n = 316$)	OAGB-200 ($n = 232$)	P
Operative time (min)	100.2 ± 36.1	69.2 ± 21.3	74.4 ± 14.8	< 0.001
Length of hospital stay[a] (days)	2 (2–3)	2 (2–2)	2 (2–3)	0.070
Bleeding requiring transfusion	2 (1.6)	18 (5.6)	10 (4.3)	0.186
Conversion	0	0	0	
Reoperation	0	5 (1.6)	4 (1.7)	0.408
Bile reflux	0	0	0	
Peritonitis due to leak	0	1 (0.3)	2 (0.9)	
Bleeding	0	3 (0.9)	2 (0.9)	
Marginal ulcer	0	0	0	
Intestinal obstruction	0	1 (0.3)	0	
PCM	0	1 (0.3)	11 (4.7)	< 0.001
PCM requiring revision	0	0	7 (3.0)	
30-day mortality	0	1 (VAP)	0	
Late mortality	0	1 (cardiac arrest)	1 (PCM)	

[a] Length of hospital stay is reported as median (IQR 25–75)

PCM, protein-calorie malnutrition; *VAP*, ventilator-associated pneumonia

Table 4 Prevalence of micronutrient deficiencies at baseline and 12 months postoperatively

Variables	*N*		RYGB	OAGB-160	OAGB-200	*P*
Anemia	534	Baseline	21/86 (24.4)	51/256 (19.9)	46/192 (24.0)	0.507
		12-month	34/86 (39.5)	98/256 (38.3)	85/192 (44.3)	0.431
Calcium	414	Baseline	0/68 (0.0)	3/198 (1.5)	3/148 (2.0)	0.509
		12-month	6/68 (8.8)	6/198 (3.0)	9/148 (6.1)	0.134
Vitamin D	424	Baseline	39/63 (61.9)	115/214 (53.7)	74/147 (50.3)	0.305
		12-month	51/63 (81.0)	166/214 (77.6)	112/147 (76.2)	0.750
Vitamin B_{12}	329	Baseline	5/47 (10.6)	22/165 (13.3)	20/117 (17.1)	0.500
		12-month	5/47 (10.6)	18/165 (10.9)	7/117 (6.0)	0.340
Phosphate	370	Baseline	0/54 (0.0)	2/182 (1.1)	1/134 (0.7)	0.728
		12-month	0/54 (0.0)	1/182 (0.5)	0/134 (0.0)	0.596
Zinc	341	Baseline	3/50 (6.0)	5/177 (2.8)	3/114 (2.6)	0.484
		12-month	1/50 (2.0)	8/177 (4.5)	7/114 (6.1)	0.507
Iron	342	Baseline	6/47 (12.8)	23/180 (12.8)	12/115 (10.4)	0.820
		12-month	4/47 (8.5)	21/180 (11.7)	15/115 (13.0)	0.717
Ferritin	397	Baseline	5/60 (8.3)	34/319 (10.6)	11/118 (9.3)	0.870
		12-month	9/60 (15.0)	70/319 (21.9)	31/118 (26.3)	0.406
Albumin	390	Baseline	0/41 (0.0)	0/243 (0.0)	0/106 (0.0)	N/A
		12-month	0/41 (0.0)	1/243 (0.4)	9/106 (8.5)	< 0.001

Variables are presented as *n* (%)

N, total number of patients with available data regarding each micronutrient

P value < 0.016 is considered statistically significant

versus OAGB with a fixed 200-cm BPL [15]. The RCT by Robert et al. indicated similar T2DM remission as well as similar serum level changes of TG, TC, LDL, and HDL 2 years after surgery [5]. The RCT by Lee et al. also demonstrated no significant difference in the reduction of SBP, DBP, and TG between RYGB and OAGB with a 200-cm BPL [17]. We observed a higher impact of OAGB with a 2000cm BPL on T2DM remission after 1 year, compared with the other two bypasses procedures, which was in accordance with Almalki et al. in Taiwan who reported better 1-year remission of T2DM with OAGB-200 compared with RYGB [18].

We can also infer from the existing literature that the operative time with OAGB is significantly shorter compared with RYGB, ranging from 35 to 147.7 min versus 88.9 to 205 min, which can be explained by additional jejunojejunal anastomosis and routine closure of the Petersen's space in RYGB. Moreover, previous studies have also reported a comparable length of hospital stay after both procedures, in agreement with our experience [4].

Very limited evidence exists on the outcomes of implementing shorter BPL lengths in OAGB. In 2018, Ahuja et al. reported comparable weight loss results and remission of comorbidities 1 year after OAGB with BPL lengths of 150, 180, or 250 cm. They also had two cases of readmission for severe protein deficiency after 10 and 11 months, with 250-cm and 180-cm BPLs, respectively, and one mortality due to severe protein deficiency, profound liver failure, and ascites with a 250-cm BPL [19]. Very recently, Boyle and Mahawar demonstrated similar safety and efficacy after 18–24 months after OAGB with a 150- and a 200-cm BPL. They also reported a similar incidence of hypoalbuminemia in patients of both groups, all of whom were managed conservatively and none required revisional surgery [20]. We experienced higher rates of readmission for parenteral nutrition and eventually revisional surgery after OAGB with a 200-cm BPL, compared with that with different BPL lengths in the two mentioned studies, which can, at least in part, be explained by selecting patients with higher preoperative BMI and uncontrolled comorbidities for longer BPLs [19, 20].

The ideal BPL length remains an area of ongoing debate. Some surgeons advocate for routine total bowel length measurement, which lengthens the operation and may introduce inadvertent bowel trauma but ensures that a sufficient absorptive surface remains and the risk of malnutrition is minimized. In an interesting study with 5 years of follow-up, Ruiz-Tovar and Carbajo operated on patients based on a formula for calculating BPL and common limb as a proportion of total bowel length [21]. The authors found that in fact, common limb length and, even more accurately, common limb length to total bowel length ratio predicts the best weight loss outcomes. This would place the emphasis on common limb length and limb length proportions to decide the location of anastomosis, which has been the idea behind single-anastomosis gastro-ileal bypass (SAGI) in which common limb length is measured caudally from the ileocecal valve [22]. Similarly, Komaei et al. supported bypassing 40% of the total bowel length as BPL compared with a 200-cm BPL with fewer nutritional complications [23]. Both of these require measurement of total bowel length and may only suit well-resourced high-volume centers where experience permits such practice. Besides, it was earlier shown by Kruschitz et al. that the greater weight loss following OAGB is associated with deterioration of several liver function parameters [24], and greater FM loss in the OAGB-200 group compared with that in RYGB and OAGB-160 further may imply that the longer BPL puts the liver in a state of stress by mobilizing more fat from adipose tissue, which is another reason why longer BPL lengths are increasingly discouraged [25]. Finding a safe BPL length would keep OAGB an attractive and simple operation for many surgeons and patients globally, and using a 160-cm BPL in our experience may thus be a reasonable modification to OAGB without the necessity to measure the total bowel length.

Despite including data from a well-defined continuous cohort with relatively large groups of patients, our study has several limitations that deserve attention. The first limitations are the retrospective nature of the study and the short (1-year) follow-up duration. Non-random patient allocation and consecutive selection of operation, not guided by clinical criteria or surgeon's preference, is a further limitation which explains some imbalance between the groups at baseline. Finally, there are numerous missing data regarding micronutrients both at baseline and after 1 year, which precludes any conclusion about possible differences in micronutritional risks between the procedures.

Conclusion

In a period of 12 months, we demonstrated that OAGB with a 160-cm BPL was as effective as classic OAGB and RYGB in terms of weight loss and metabolic benefits. In addition, OAGB with a shorter BPL resulted in virtually no postoperative malnutrition requiring revision as opposed to 3.0% after classic OAGB. These results suggest that where measurement of the total bowel length is not possible or desirable, a safe BPL length of 160 cm can offer an easy solution without any efficacy compromise. Further trials with longer follow-up periods, ideally randomized, will be necessary to definitively determine the effect of shorter BPLs in OAGB.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human Rights/Ethical Approval This study has been approved by the Human Research Review Committee of the Endocrine Research Center, Shahid Beheshti University of Medical Sciences, No. 2ECRIES 93/03/13.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional Human Research Review Committee (No. 2ECRIES 93/03/13) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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