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SURGICAL ENDOSCOPY
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Effect of standard vs extended Roux limb length on weight loss outcomes after laparoscopic Roux-en-Y gastric bypass

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Abstract

Background: Increasing the length of the Roux limb in open Roux-en-Y gastric bypass (RYGB) effectively increases excess weight loss in superobese patients with a body mass index (BMI) >50 kg/m^2. Extending the RYGB limb length for obese patients with a BMI < 50 could produce similar results. The purpose of this study was to compare the outcomes of superobese patients undergoing laparoscopic RYGB with standard (≤100-cm) with those undergoing the procedure with an extended (150-cm) Roux limb length over 1-year period of follow-up.

Methods: Retrospective data over 2.5 years were reviewed to identify patients with a BMI < 50 who underwent primary laparoscopic RYGB with 1-year follow-up (n = 58). Forty-five patients (sRYGB group) received limb lengths ≤100 cm, including 45 cm (n = 1), 50 cm (n = 2), 60 cm (n = 6), 65 cm (n = 1), 70 cm (n = 1), 75 cm (n = 3), and 100 cm (n = 31). Thirteen patients (eRYGB group) received 150-cm limbs. Postoperative weight loss was compared at 3 weeks, 3 months, 6 months, and 1 year.

Results: Comparing the sRYGB vs the eRYGB group (average ± SD), respectively: There were no significant differences in age (41.5 ± 11.0 vs 38.0 ± 11.9 years), preoperative weight (119.2 ± 11.9 vs 127.8 ± 12.5 kg), BMI (43.7 ± 3.0 vs 45.2 ± 3.5 kg/m^2), operative time (167.1 ± 72.7 vs 156.5 ± 62.4 min), estimated blood loss (129.9 ± 101.1 vs 166.8 ± 127.3 cc), or length of stay (median, 3 vs 3 days; range, 2–18 vs 3–19). Body weight decreased over time in both groups, except in the sRYGB group between 3 and 6 months and 6 and 12 months after surgery and in the eRYGB group between 6 and 12 months. BMI also decreased over time, except in the eRYGB group between 6 and 12 months. Absolute weight loss leveled out between 6 and 12 months in both groups, with no increase after 6 months. Percent of excess weight loss did not increase in the eRYGB group after 6 months. An extended Roux limb did not significantly affect body weight, BMI, absolute weight loss, or precent of excess weight loss at any time point when the two groups were compared. A trend toward an increased proportion of patients with >50% excess weight loss (p = 0.07) was observed in the extended Roux limb group.

Conclusions: In this series, no difference in weight loss outcome variables were observed up to 1 year after laparoscopic RYGB. Thus, extending Roux limb length from ≤100 cm to 150 cm did not significantly improve weight loss outcome in patients with a BMI <50 kg/m^2.

Key words: Laparoscopic surgery — Roux-en-Y gastric bypass — Roux limb length — Weight loss outcome — Morbid obesity — Bariatric surgery

The mainstay of surgical therapy for the treatment of morbid obesity is the Roux-en-Y gastric bypass (RYGB). The laparoscopic approach has resulted in significant decreases in operative time, blood loss, and length of hospital stay, as well as improvements in complication rates, time to return to normal activity, and quality of life after surgery [7, 8]. The RYGB procedure, whether laparoscopic or open, is primarily a restrictive one, but it also affords a malabsorptive component to weight loss; outcomes favor the RYGB over purely restrictive procedures, such as the placement of an adjustable gastric band or vertical banded gastroplasty [3, 13].

To improve weight loss outcome in superobese patients with a body mass index (BMI) >50 kg/m^2, several surgeons have modified the malabsorptive aspect of the RYGB. Attempts to examine the effects of increasing Roux limb length were exemplified in a nonrandomized study by Bruder et al. in which the Roux limb of patients twice their ideal weight was increased from 45 cm to 90 cm,

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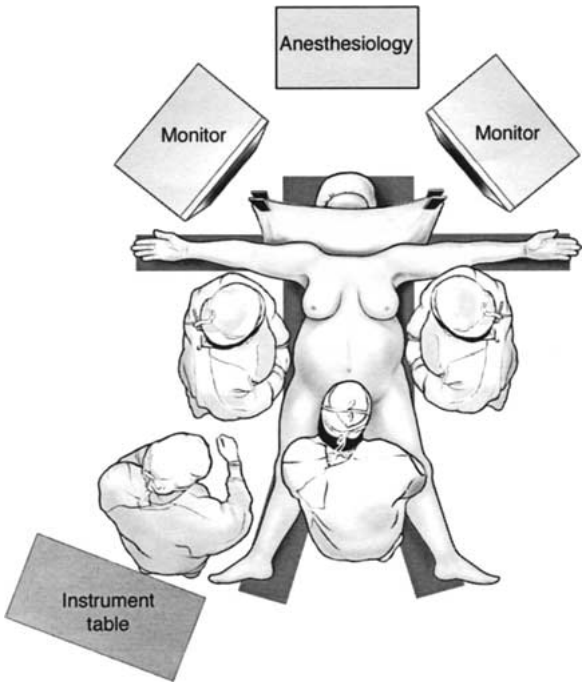

Fig. 1. Operating room setup.

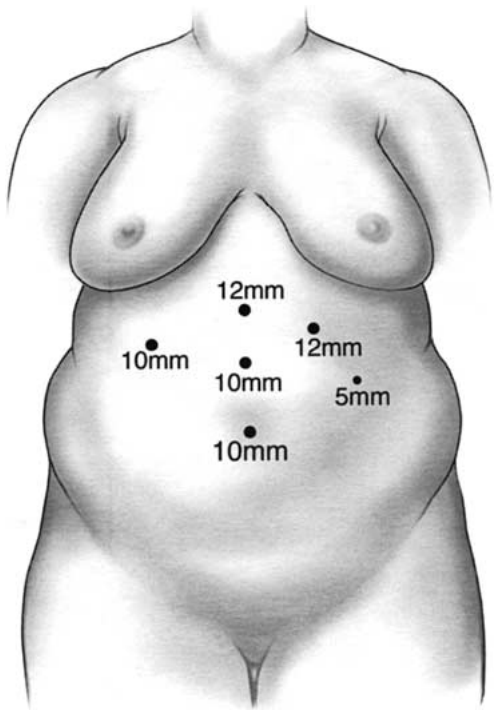

Fig. 2. Trocar placement for laparoscopic Roux-en-Y gastric bypass.

with a resultant increase of only 6% in excess weight loss and no significant change in complications [2]. Subsequently, in a prospective randomized study, Brolin et al. observed a significant improvement in excess weight loss (from 50% to 64%) after they increased the Roux limb from 75 cm to 150 cm in superobese patients (BMI $>$ 50 kg/m^2); there were no significant differences in the complication rate [1]. It is thus unclear whether increasing the Roux limb length in patients with BMI $<$ 50 kg/m^2 will result in improved weight loss.

The purpose of this study was to compare the outcomes of patients with a BMI $\geq$ 50 kg/m^2 who received standard ($\leq$100-cm) Roux limbs with those who received extended (150-cm) limbs.

Materials and methods

Patients

Over 450 laparoscopic Roux-en-Y gastric bypass operations were performed by our group in the past several years. Only 132 patients had a BMI $\leq$ 50 kg/m^2; these patients underwent primary laparoscopic Roux-en-Y gastric bypass between September 1998 and February 2001. A total of 58 adult patients (49 women, nine men) with an average age of 40.7 $\pm$ 11.2 years had sufficiently documented 1-year follow-up. Their BMI ranged between 34.9 and 50 kg/m^2. All operations were performed by one of us (M.G., W.B.I., A.P.) at the Mount Sinai Medical Center in New York City. All patients had failed attempts at medical control of their obesity.

Preoperatively, the patients underwent esophagogastroduodenoscopy, nutrition consultation, and psychiatric evaluation. Retrospective chart review was done to gather the following information: age, gender, surgeon, length of stay, operative details, comorbidities, results of esophageal swallow studies, postoperative complications, initial body weight and height, and postoperative weight at 3 weeks, 3 months, 6 months, and 1 year.

Surgical technique

In brief, the patient is placed in supine position with the legs abducted; foot plate attachments are used to support the patient when in reverse Trendelenburg position (Fig. 1). Six ports are used; the first 10-mm one is placed in the umbilicus via an open technique. Pneumoperitoneum is obtained with 15 mmHg carbon dioxide (CO_2) (Fig. 2).

With the use of a 30° 10-mm laparoscope, a defect is created at a point 6 cm distal to the gastroesophageal junction along the lesser curvature. The dissection is carried posterio-laterally to enter the lesser sac and enable transection of the stomach with a 45 $\times$ 3.5 mm Endo-GIA linear stapler (US Surgical Corporation, Norwalk, CT, USA). Additional linear staplers are used to complete the lateral border of the pouch. Next, the flip-top anvil of a 25 circular end-to-end stapler (CEEA; US Surgical Corporation) is advanced into and through the end of the gastric pouch with the aid of a modified nasogastric tube–anvil apparatus.

After the omentum is divided, the bowel is measured from the ligament of Treitz with a premeasured umbilical tape under medium stretch. An antecolic end-to-end gastrojejunostomy is created by passing the circular stapler transabdominally into the lumen of the distal jejunum and attaching it to the anvil residing in the gastric pouch. The anastomosis is tested for leakage via intraluminal distention with methylene blue–tinted saline. Any leaks are reinforced with 2-0 silk sutures until all tests show no further leakage. Pouch volume is estimated at $\leq$20 cc.

The Roux limb is then measured on medium stretch in a similar fashion, and a stapled end-to-side jejunojejunostomy is created. The standard Roux length (sRYGB) group has a Roux limb length of 45–100 cm, with a distance from the ligament of Treitz to the jejunojejunostomy of 20–50 cm. The extended length (eRYGB) group has a Roux limb of 150 cm, with the distance of the ligament of Treitz to the jejunojejunostomy spanning 100 cm (Fig. 3). All port sites $>$5 mm are closed using a suture passer technique.

Postoperative care

Routine postoperative upper gastrointestinal (GI) radiologic studies were not performed unless there was doubt as to the integrity of the proximal anastamosis or there were technical problems during the

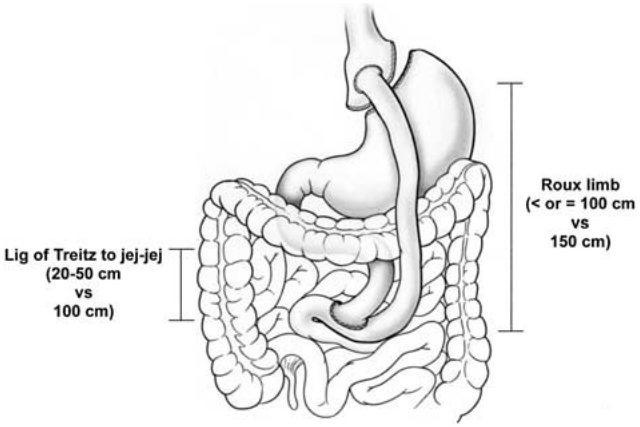

Fig. 3. Limb lengths: In sRYGB group patients, the distance from the ligament of Treitz to the jejunojejunostomy is 20–50 cm and the Roux limb is 100 cm. In eRYGB patients, the distance from the ligament of Treitz to the jejunojejunostomy is 100 cm and the Roux limb is 150 cm.

procedure, such as a leak. In addition, an upper GI study was ordered if the patient was febrile or experienced tachycardia postoperatively. Otherwise, the patient was allowed to ingest a low-sugar, clear-liquid diet on the 1st postoperative day and then advanced to a pureed diet on the 2nd day. The patient is usually discharged on postoperative day 2 or 3 on chewable vitamins and calcium carbonate pills.

Immediate follow-up is set for 3 weeks after surgery to address any acute issues. At this time, ursodiol is administered in a dosage of 300 mg twice daily for the next 6 months in patients who have not had a prior cholecystectomy. Chromagen forte is also prescribed at 150 mg twice daily; this supplement consists of vitamin B12, vitamin C, folate, ferrous fumarate, and elemental iron to prevent megaloblastic anemia. Follow-up at 3 months, 6 months, and 1 year require laboratory testing for protein, vitamin, and mineral deficiencies. Protein deficiency does not occur in primary laparoscopic RYGB patients.

Calculations

BMI is defined as weight in kilograms divided by height in meters squared.

The ideal body weight (IBW) is gender-specific and derived from tables published by the Metropolitan Life Insurance Company [9]. For men (lb), IBW = 51.65 + (1.85 * ((height in inches) – 60)); for women (lb), IBW = 48.67 + (1.65 * ((height in inches) – 60)).

Percentage of excess body weight loss (% EWL) is defined as the amount of weight loss divided by the difference between the initial weight and the IBW.

Data analysis

All data are expressed as mean ± (SD) unless otherwise specified. Perioperative data were compared using the unpaired Student's *t*-test. Weight loss data comparisons were performed using analysis of variance (ANOVA) with nonparametric Games-Howell post hoc analysis. Proportion analysis was performed using chi-squared contingency tables. Differences observed were considered statistically significant at $p < 0.05$.

Results

Demographics

Fifty-eight patients with BMIs between 39.9 and 50 kg/m^2 underwent laparoscopic Roux-en-Y gastric bypass. The sRYGB group consisted of 45 patients; the eRYGB group consisted of 13 patients with similar age, preoperative weight, and BMI (Table 1). The choice of Roux limb length was based on surgeon preference at the time of the operation.

Table 1. Demographics

	Standard Roux (≤100-cm)	Extended Roux (150-cm)	*p*
N	45	13	
Age (yr)	41.5 ± 11	38 ± 11.9	NS
Preop weight (kg)	119.4 ± 15	127.8 ± 16.7	NS
Preop BMI (kg/m^2)	43.6 ± 3.2	45.3 ± 3.9	NS

BMI, body mass index; NS, not significant

Table 2. Operative data

	Standard Roux (≤100-cm)	Extended Roux (150-cm)	*p*
n	45	13	
OR time (min)	167.1 ± 72.7	156.5 ± 62.4	NS
EBL (cc)	129.9 ± 101.1	166.8 ± 127.3	NS
Length of stay (d)	3 (2–18)	3 (3–19)	NS

OR, operating room; EBL, estimated blood loss; NS, not signigicant

Operative data

Perioperative data for the two groups are shown in Table 2. Mean operative time and estimated blood loss (EBL) were similar. One leak was identified intraoperatively in an sRYGB patient, who then underwent immediate repair.

Complications

One patient in the sRYGB group developed a leak from the gastrojejunostomy, requiring a prolonged hospital stay. Two other patients had wound infections. There were no perioperative complications in the eRYGB patients. Postoperative length of stay was the same for both groups (Table 2).

Weight loss outcome data

The mean body weights in each group over a 1-year period are shown in Fig. 4. In the sRYGB group, body weight decreased significantly until after 3 months postsurgery: 93.7 ± 14 kg (a) to 84.4 ± 16 kg (a, b) to 76.9 ± 1 4.3 kg (b). Although there was no difference between 3- vs 6-month body weight (a; $p = 0.06$) and 6- vs 12-month body weight (b; $p = 0.07$), mean weight at 3 months was significantly decreased at 12 months. In the eRYGB group, there was also no further decrease in body weight after 6 months (84.1 ± 4.4 to 82 ± 16.3 kg). No differences in body weight between the groups were observed at any time point.

Mean BMI data are shown in Fig. 5. In the sRYGB group, BMI decreased over 1 year at every time point.

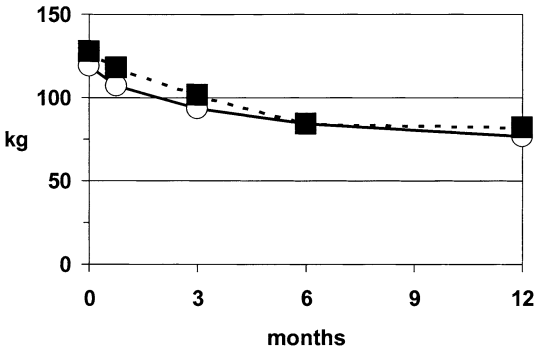

Fig. 4. Body weight (kg): standard length (*open circles*) vs extended length (*filled squares*). There were no differences between the groups at any time point. *Standard length:* no decrease from 3 to 6 months and from 6 to 12 months (significant decrease from 3 to 12 months). *Extended length*: no decrease from 6 to 12 months. Significant decreases across all other time points in both groups (ANOVA, Games-Howell post hoc, $p < 0.05$).

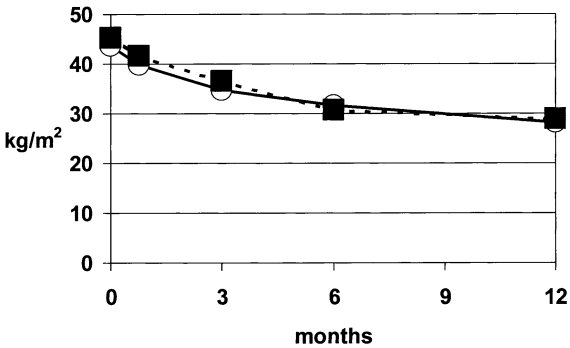

Fig. 5. BMI (kg/m^2): standard length (*open circles*) vs extended length (*filled squares*). There were differences between the groups at any time point. *Standard length:* significant decreases at all time points. *Extended length:* significant decreases up to 6 months but not to 12 months (ANOVA, Games-Howell post hoc, $p < 0.05$).

However, in the eRYGB group, BMI did not change significantly after 6 months (30.8 ± 1.7 to 29 ± 5.4 kg/m^2). No between-group differences in BMI were observed at any time point.

Absolute weight losses were no different between the groups at any time point and did not increase in either group after 6 months (Fig. 6).

The percentage of excess weight lost was similar in each group at each time point (Fig. 7). There was no increase in this percentage in the eRYGB group after 6 months (58.2 ± 3.1 to 66.3 ± 22.1%).

As shown in Fig. 8, there was no difference between the groups in the proportion of patients with >50% excess weight loss. At 6 months, the higher proportion in the eRYGB group was not statistically significant ($p = 0.07$).

Discussion

The Roux-en-Y gastric bypass is the gold standard for weight loss surgery. In 1976, Scopinaro et al. introduced the biliopancreatic bypass [11]. Hess and Hess and subsequently Marceau et al. modified the operation to

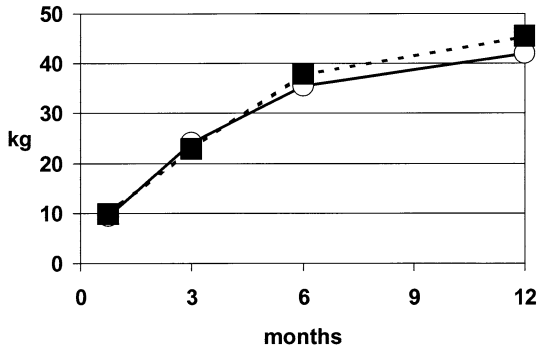

Fig. 6. Absolute weight loss (kg): standard length (*open circles*) vs extended length (*filled squares*) There were no differences between the groups at any time point. In both groups, there were significant decreases up to 6 months but not to 12 months (ANOVA, Games-Howell post hoc, $p > 0.05$).

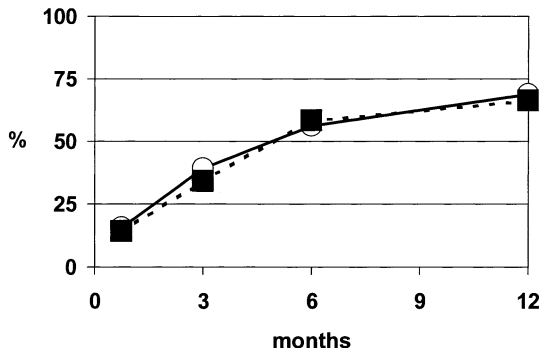

Fig. 7. Excess weight loss (%): standard length (*open circles*) vs extended length (*filled squares*). There were no differences between the groups at any time point. *Extended length:* significant decreases up to 6 months but not to 12 months (ANOVA, Games-Howell post hoc, $p < 0.05$).

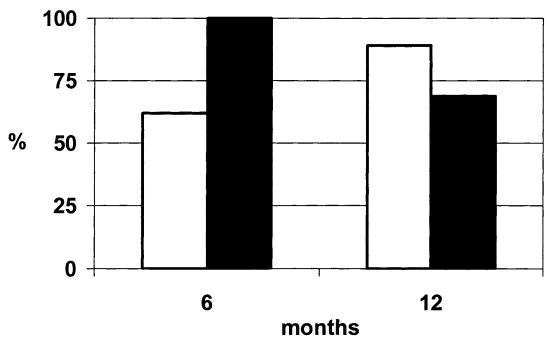

Fig. 8. Proportion of patients with >50% excess weight loss: standard length (*open circles*) vs extended length (*filled squares*). There were no significant differences between the groups at any time point. A trend was seen toward a greater proportion of excess weight loss earlier (at 6 months) in the long-limb group (chi-squared contingency table, $p = 0.07$).

add a pylorus-preserving component to an operation that combined a moderate restriction of caloric intake with a more significant limit on the absorption of calories from fat, as well as the absorption of protein; this was known as the "biliopancreatic diversion with duodenal switch" (BPD-DS) [4–6]. Unlike the jejuno-ileal bypass and the biliopancreatic diversion with duodenal switch, the Roux-en-Y gastric bypass is largely a re-

strictive procedure. In an attempt to add a malabsorptive component to further optimize weight loss, the extended-limb gastric bypass has been developed. Because of the small size of the gastric pouch and limitations on protein intake, the malabsorption cannot exceed a certain limit. This limit is directly related to the risk of protein malnutrition and symptoms such as diarrhea.

Brolin et al. studied the differences in outcomes in superobese patients with a BMI > 50 kg/m^2 in a randomized prospective fashion, doubling the Roux limb length from 75 to 150 cm in the open RYGB [1]. The resultant weight loss in both groups differed as early as 1 year after surgery, with a mean weight loss of 118 vs 140 lb, respectively. Statistically significant weight loss was seen only at 2 and 3 years after surgery, with a maximal weight loss of 117 vs 168 lb, respectively. Despite the extensive weight loss, the resultant BMIs of the superobese patients in the short vs long Roux limbs were, respectively, 44 and 40 at 1 year and maximally 45 and 35 at 2 years, never reaching the ideal goal of a BMI < 30 kg/m^2.

In the current nonrandomized retrospective study, the weight loss was 42.1 kg (92.8 lb) in the standard-limb group vs 45.5 kg (100.4 lb) in the extended-limb group at 1 year, with resultant average BMIs of 28.1 and 29, respectively. There were no significant differences, nor even significant trend toward an observed benefit. Excess weight loss was 69% vs 66.3% at 1 year, which is consistent with the results reported by other investigators [10, 12]. Patients with an extended Roux limb reached equilibrium in body weight, BMI, absolute weight loss, and % EWL at 6 months, with no further improvement compared to the outcome at 1 year. In addition, all patients who had recorded weights at 6 months ($n = 6$ of 13) in the eRYGB group achieved a $>50\%$ excess weight loss, although this result is not significantly different from that of the sRYGB group ($p < 0.07$). These results suggest that extending the Roux limb may enable patients to achieve a plateau weight loss sooner. However, since there was no difference between the two groups at 6 or 12 months for any outcome variable, these observations may simply be the result of the small number of patients in the eRYGB group. Nevertheless, neither body weight nor absolute weight loss changed significantly in the standard-limb group after 6 months.

The discrepancy between Brolin et al.'s data and the current data is most likely a reflection of the observation that in the 1st year after bariatric surgery early weight loss is probably the result of the restrictive component of the weight loss procedure. Combined restrictive/malabsorptive procedures such as the one described by Scopinaro et al., as well as the BPD-DS of Hess and Hess and Marceau et al., provide continued weight loss due to the malabsorptive aspect of the procedure. It is somewhere between 6 months and 1 year that the curves split, leveling out for the restrictive procedure but showing continued weight loss for the combined procedure. Since the short-limb patients in the Brolin et al. study did not achieve a BMI < 40 kg/m^2, there is still physiologic room to achieve more weight loss. However, in the current study, all the standard-limb patients reached a BMI < 30 kg/m^2, and bowel adaptation may be occurring to stabilize the weight loss. Since the difference in Roux limb length in our study was only 50 cm, weight loss may not be significantly affected. Perhaps the degree of malabsorption would be increased if we used longer Roux limbs. Doing so, however, would also increase the risk of protein, mineral, and vitamin deficiencies. Although no symptoms of malabsorption were observed in either group of patients, more detailed analyses of any such deficiencies need to be studied closely.

There are several limitations to this study. This is a retrospective chart review of nonrandomized prospectively collected data. The smaller number of participants in each group can be explained by the fact that not all of our patients returned to the office for 1-year follow-up; and of those who did, not all did so at the designated times prior to the annual visit. Recorded data were therefore incomplete. Only 58 of a total of 132 potentially eligible patients satisfied the inclusion criteria, which required documented 1-year follow-up data. Also, since most of the eligible patients underwent the procedure within several months of the cutoff dates for enrollment in the study, 1-year follow-up had not yet been performed for many patients when we began our analysis.

Currently, because of the results of this and Brolin's et al.'s report [1], there are a couple of surgeons in our group who now routinely perform an extended-limb RYGB. The rationale for this choice stems from the argument that since there are no significant complications and no differences in relatively short-term weight loss outcome, there can only be potential longer-term benefits. Several members of the eRYGB group were patients of one of these surgeons. Thus, more data will eventually be available for future analysis, since this change is a more recent development. With reference to Brolin et al.'s data [1], we would expect significant improvement in weight loss at 2-year follow-up. However, at 1 year, there is not even a trend toward differences in outcome between the two groups, as was seen in the Brolin et al. study [1].

In summary, this retrospective nonrandomized study shows that in nonsuperobese patients with a BMI < 50 kg/m^2, a longer-limb RYGB does not result in increased weight loss up to 1 year when compared to the standard shorter-limb procedure. Long-term weight loss outcomes (>1 year) were not addressed in this study and will be reported at a later date. A prospective randomized trial is warranted to determine whether there are any differences and to examine the nature of those differences in weight loss between short- and long-limb gastric bypass patients.

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