The effect of different lengths of the efferent limb in patients undergoing one anastomosis gastric bypass surgery on weight loss, resolution of co-morbidities and nutritional deficiencies

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Abstract

Purpose: In this study, we assessed the effect of the length of the efferent limb on weight loss in patients undergoing One Anastomosis Gastric Bypass (OAGB) surgery for morbid obesity. The secondary endpoints evaluated in this study include the nutritional deficiencies that may occur when changing the length of the efferent limb, the resolution of obesity-related co-morbidities, as well as postoperative morbidity and occurrence of complications (e.g., port-site and internal hernias).

Methods: This prospective study was conducted on 46 patients with morbid obesity who underwent laparoscopic OAGB. Patients were followed up for one year.

Results: The data showed that there is a negative statistical correlation ($p < 0.05$) between the efferent limb length and the excess body weight loss at 3-, 6-, and 12 months post-OAGB. Besides, there was a negative statistical significance ($p < 0.05$) between the percentage of efferent limb length to the total small bowel length (TSBL) and the excess body weight loss at 3-, 6-, and 12 months post-OABG. On the other hand, there were no statistical associations ($p > 0.05$) between the efferent limb length (or the percentage of efferent limb length to total small bowel length) and nutritional deficiencies (albumin, total calcium, and iron) at 12 months post OAGB in this study.

Conclusions: In conclusion, measuring the TSBL in each patient undergoing OAGB would be more accurate than the classic estimation given by the anatomy books. The length of the efferent limb is inversely correlated with postoperative excess body weight loss.

Keywords: One anastomosis gastric bypass; Weight loss; Efferent limb length; Bariatric surgery

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Competing interests: The authors declare that they have no conflict of interest.

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Ethical Approval: All procedures performed in this study were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Ethics committee approval no. MD-78-2020.

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

INTRODUCTION

Many surgeons consider the Roux-en-Y gastric bypass (RYGB) to be the gold standard by which all other bariatric surgeries are evaluated (1). Although gastric bypass surgery successfully reduces comorbidities and body weight, it is limited by the fact that part of this weight is regained on long-term follow-up. Up to 40% of patients with superobesity (BMI>50 kg/m2) had inferior overall outcomes following gastric bypass, mainly due to weight regain (2).

All gastric bypass procedures work by restricting food intake in the newly formed gastric pouch and preventing some of it from being absorbed by the body due to the bypassing of the duodenum and portion of small intestine (3). Absorption of nutrients is significantly affected in the afferent limb because the food bolus does not contact the biliopancreatic secretions until the efferent limb. As a result, adjusting the length of both limbs might affect the severity of malabsorption (4). Bariatric surgeons, particularly with the superobese population, where failure rates after gastric bypass are greater, should focus on the length of the efferent limb rather than the afferent limb while performing a gastric bypass in order to achieve more weight loss due to malabsorption (4).

There is inconclusive evidence on the ideal length of afferent and efferent limbs with (OAGB), and the reported lengths range from 150cm (afferent limb) on the shorter side to variable lengths using considerably longer limbs for heavier patients (5,6). Many authors have reported using 200cm afferent limb length as standard length. However, it is not yet known if the longer afferent limb length is associated with protein-calorie deficiency post-OAGB (7,8). Because of this lack of information, it has been challenging to implement a standardized afferent limb length (9).

It has been proposed by Lee et al. that increasing the bypassed (afferent) limb may aid in weight reduction for the morbidly obese, but this strategy does not seem to have any lasting effects for the moderately obese (10). However, studies conflicted on how long the bypass limb should be for patients with superobesity, with lengths ranging from 250cm up to 400cm (11). Individualizing bypass limbs for patients based on their body mass index (BMI) is ideal (12). Patients with a higher BMI or super-morbid obesity who undergo "tailored" OAGB may have more weight reduction and a corresponding improvement in metabolic dysfunction without increase in complications (10). When the efferent limb is shortened, it increases the risk of malabsorption and nutritional deficiencies, while when the afferent limb is lengthened, it improves weight loss (13). Rather than measuring the efferent limb at the end of the operation, it is more practical to measure the total small bowel length (TSBL) and then choose the limb lengths accordingly (14).

Methods

The study was approved the local ethics committee of the Kasr-Al-Aini hospitals (Ethics committee approval no. MD-78-2020). All participants signed the written informed consent before enrollment in the study.

This prospective study was conducted on 46 patients with morbid obesity who were operated at Kasr-Al-Aini Teaching Hospital, Cairo University in the period from June 2020 till September 2021. All 46 patients included in this study underwent laparoscopic OAGB for treatment of their morbid obesity. Only adult patients were included with BMI>35 Kg/m^2, with associated co-morbidities, or BMI>40 Kg/m^2 with or without co-morbidities, after failed conservative management for six months. We excluded patients with contraindications for laparoscopic surgery, inflammatory bowel disease, substance abusers, cognitive impairment, psychiatric illness, chronic steroid users, smokers, those with history of bariatric or abdominal surgeries, and pregnancy or lactation.

Study endpoints:

The primary end point of this study is to assess the effect of the length of the efferent limb on weight loss in patients undergoing OAGB surgery for morbid obesity. The secondary endpoints evaluated in this study include the nutritional deficiencies (e.g., serum albumin and serum calcium) that may occur when changing the length of the efferent limb, the resolution of obesity-related co-morbidities, as well as post-operative morbidity and occurrence of complications (e.g., port-site and internal hernias).

Operative technique:

A long, narrow, sleeved gastric pouch was formed as the first step of every procedure.

Although all anastomoses in this study were done at 200 cm from the duodeno-jejunal junction (Rutledge technique), yet the TSBL (from ligament of Treitz to ileocaecal valve) was measured in every patient in order to identify the efferent limb length and the percentage of the bypassed (afferent) limb. This was achieved using a sterile 10 cm nylon tape and two intestinal atraumatic graspers. The measurement was done along the anti-mesenteric border of non-stretched small bowel (Figure 1). Throughout the measuring process, the proximal limb was always placed on the patient's left side and distal limb on the patient's right side to avoid torsion of the intestinal mesentery. Extra caution was taken during this step of the procedure so as to avoid unnecessary complications such as intestinal serosal tears or even perforations. If the surgeon at any point was not comfortable doing this step, or the patient was at any surgical or anesthetic risk, this step was omitted and the patient was excluded from the study.

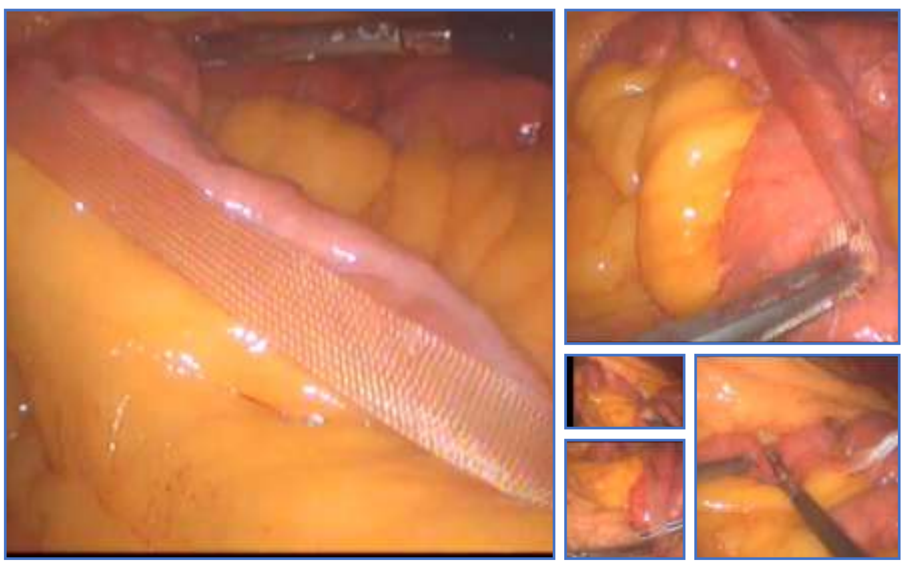


Figure 1: Live intra-operative photos illustrating using sterile 10 mm nylon tape to measure total small bowel length.

Then, the gastro-jejunostomy was done, a methylene blue leak test was performed, and wounds were closed after achieving good hemostasis.

Statistical analysis:

Statistical analysis was carried out using SPSS version 21. Categorical variables were presented as frequencies and percentages. Quantitative date were summarized as means ± standard deviation (SD). Independent t-test was used to test the relationship between different quantitative parameters. Chi-square (X2) test was used to test the relationship between different qualitative parameters. The level of statistical significance was defined a probability value of less than 5%.

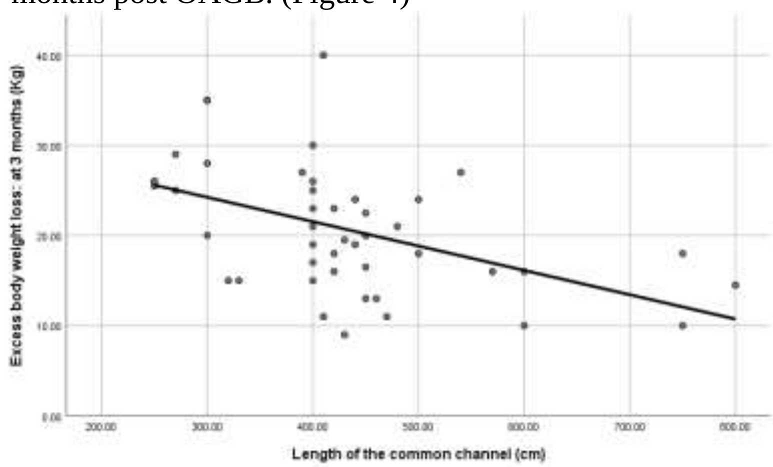
Results

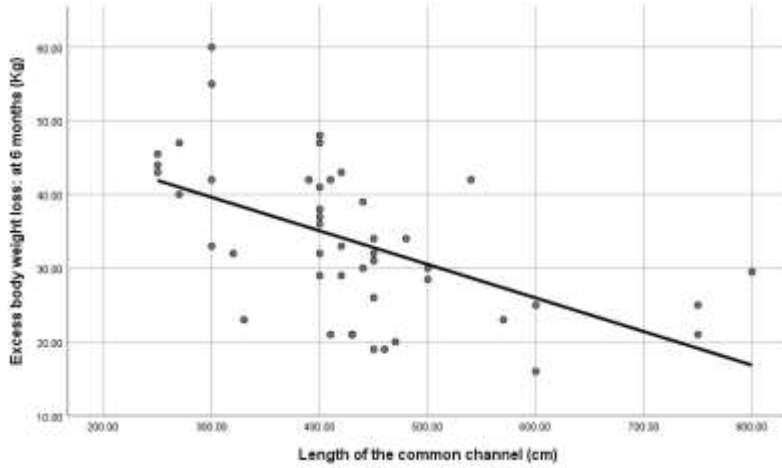
Forty-six patients were included, with a mean age of 38.87 years old and female predominance (76.1%). The mean preoperative BMI was 50.79 ±9.44 Kg/m^2. All 46 patients involved in this study underwent the conventional (Rutledge) technique for OAGB, where the single anastomosis was done 200cm distal to the duodeno-jejunal junction. In each patient included in this study, the TSBL, as well as the afferent (200 cm in all patients; Rutledge technique) and efferent limb lengths were measured. The percentage of afferent limb/total small bowel length, and the percentage of the efferent limb/total small bowel length were then calculated in each patient (Table 1).

Table 1: Pre- and Intra-Operative Characteristics of The Included Patients (n =46)

	Mean/No.	**Standard Deviation/%**
Age (years)	38.87	10.39
Height (cm)	165.83	9.75
Pre-operative (Baseline) weight (Kg)	138.77	23.71
Pre-operative (Baseline) BMI (Kg/m^2)	50.79	9.44
Ideal body weight (Kg)	69.49	8.41
Excess pre-operative body weight (Kg)	69.28	23.52
Female	35	76.1%
Conventional (Rutledge) technique	46	100.0%
Total small bowel length (cm)	630.87	124.38
Afferent loop length (cm)	200.00	0.00
Efferent limb length (cm)	430.87	124.38
The percentage of the afferent loop length to total small bowel length (%)	32.81	5.95
The percentage of the efferent limb length to total small bowel length (%)	67.19	5.95

The data showed that there is a negative statistical correlation ($p < 0.05$) between the efferent limb length and the excess body weight loss at 3-, 6-, and 12 months post-OAGB (Figure 2). Similarly, there was a negative statistical significance ($p < 0.05$) between the percentage of efferent limb length to the total small bowel length and the excess body weight loss at 3-, 6-, and 12 months post-OABG (Figure 3). There was also a positive statistical correlations ($p < 0.05$) between the percentage of afferent limb length to the total small bowel length and the excess body weight loss at 3, 6, and 12-months post OAGB. (Figure 4)





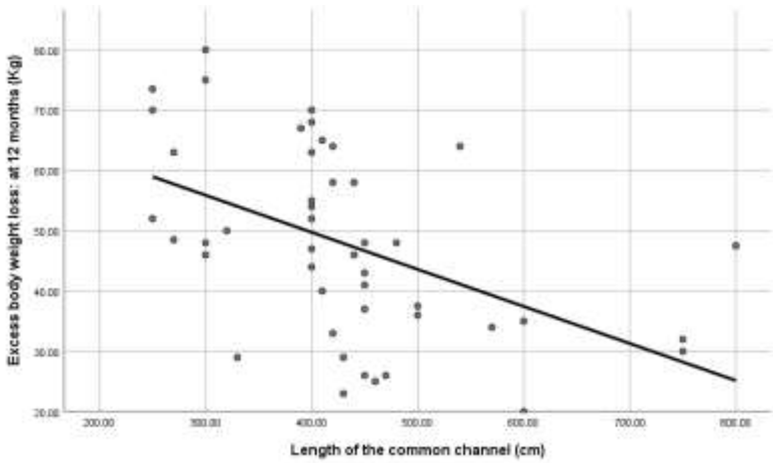
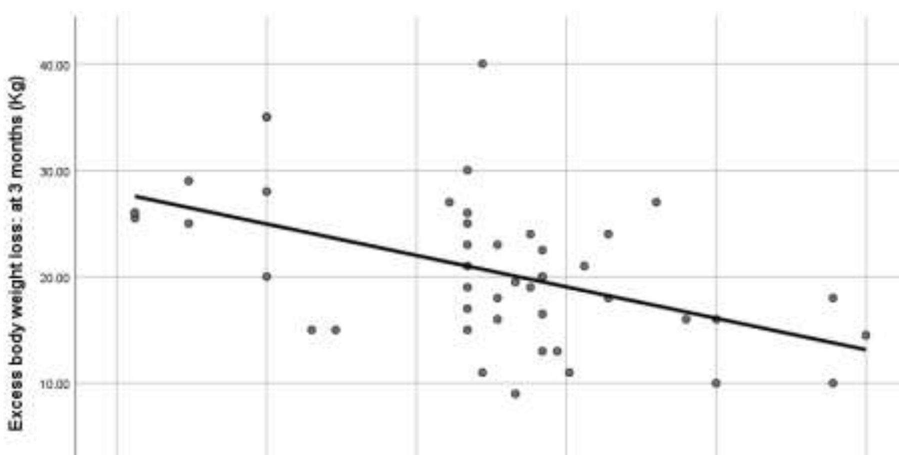
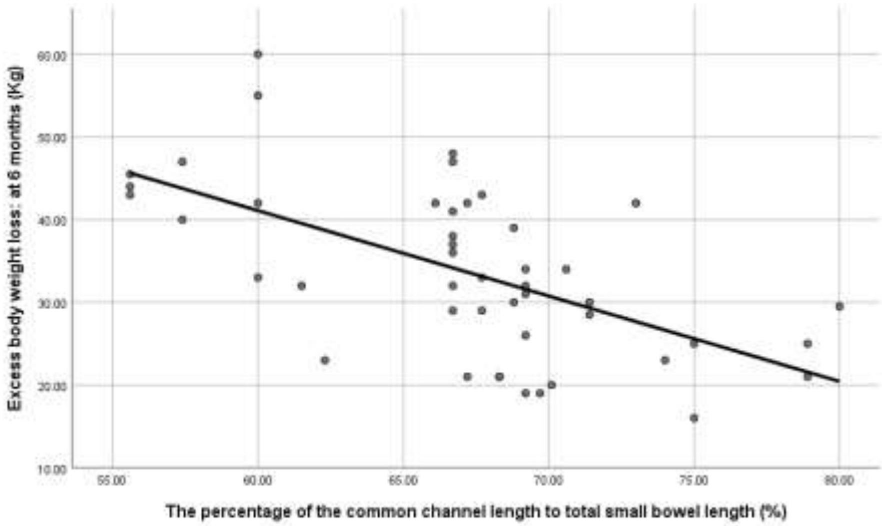


Figure 2: Scatter plot representing the correlation between the efferent limb length and excess body weight loss at 3-, 6- and 12-months post-operative





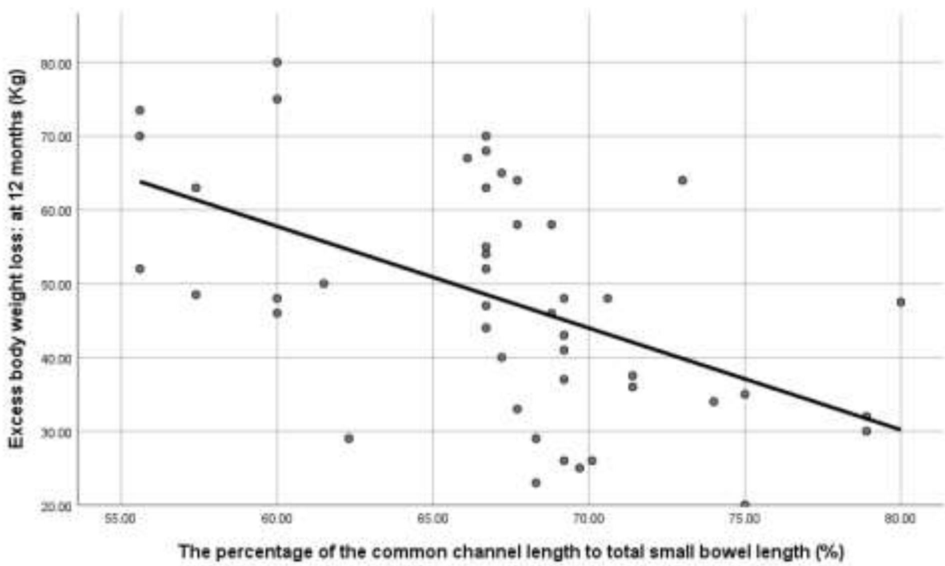


Figure 3: Scatter plot representing the correlation between the percentage of the common channel to the total small bowel length and excess body weight loss at 3-, 6- and 12-months post-operative

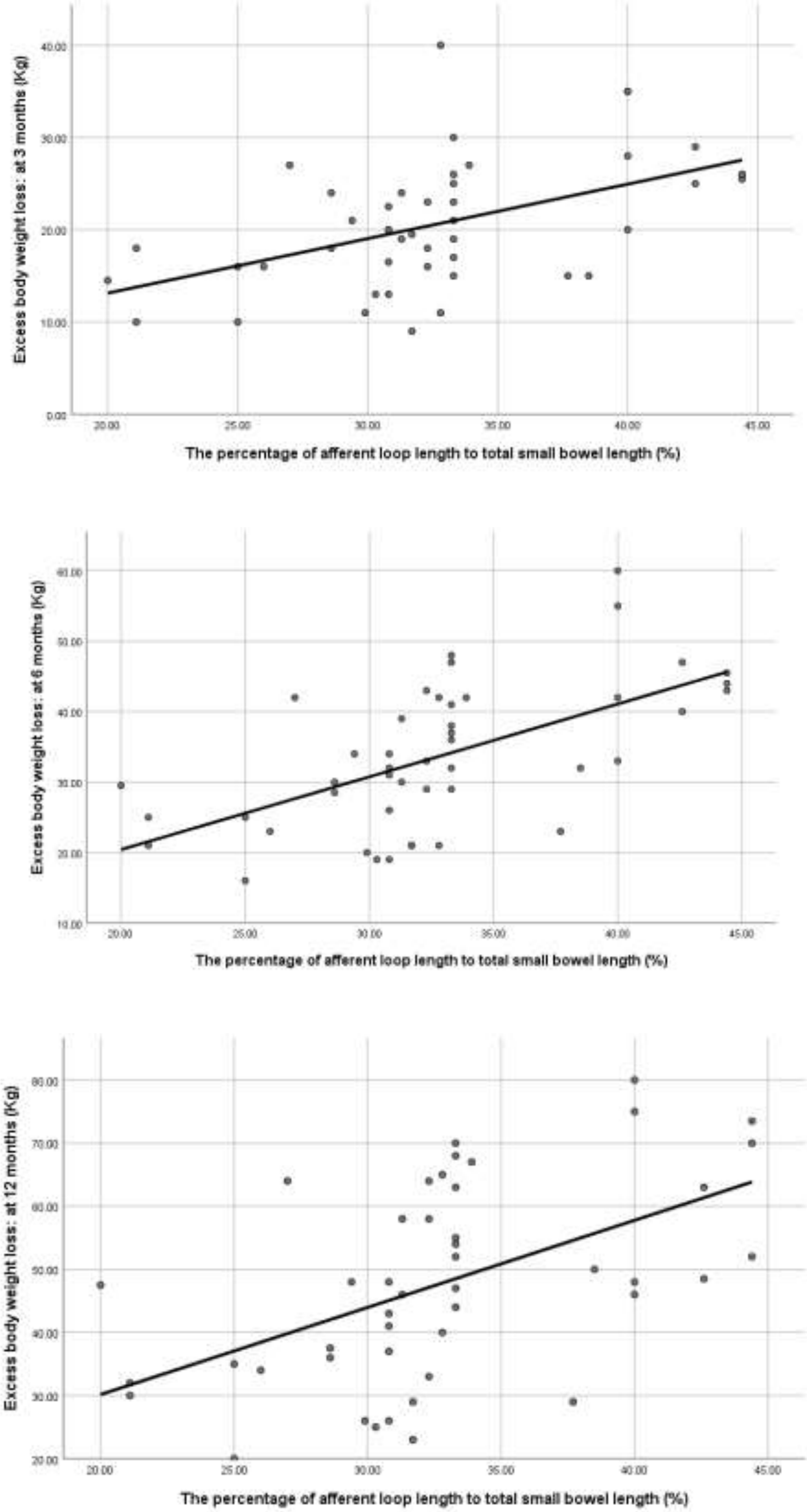


Figure 4: Scatter plot representing the correlation between the percentage of afferent limb to total small bowel length and excess body weight loss at 3-, 6- and 12-months post-operative

The data show no statistical associations (p value >0.05) between the efferent limb length (or the percentage of efferent limb length to total small bowel length) and nutritional deficiencies (albumin, total calcium and iron) at 12 months post-OAGB (Table 2). It is worth noting that hyperlipidemia and osteoarthritis (though the most common in incidence pre-operatively), showed the highest complete resolution rates at 83.3% and 73.3% respectively. No statistical associations (p >0.05) were found between the efferent limb length and the complete resolution of type II diabetes mellitus, hypertension and osteoarthritis. On the other hand, the results showed a negative statistical association (p <0.05) between the efferent limb length and the rate of complete resolution of hyperlipidemia (Table 2).

Table 2: Secondary Endpoints

		The percentage of the efferent limb length to total small bowel length (%)		**P value**
		Mean/No.	**Standard Deviation/%**	
Albumin at 12 months	**normal**	66.63	6.71	0.235
	deficiency	68.46	3.55	
Serum Total calcium at 12 months	**normal**	67.24	6.38	0.706
	deficiency	66.85	0.54	
Serum Iron at 12 months	**normal**	68.13	5.55	0.228
	deficiency	65.98	6.37	
Complete resolution of Type 2 diabetes mellitus	**yes**	458.57	90.63	0.205
	no	520.00	129.39	
Complete resolution of Hypertension	**yes**	497.78	69.78	0.977
	no	495.00	170.59	
Complete resolution of Hyperlipidemia	**yes**	453.60	71.81	0.003
	no	584.00	124.62	
Complete resolution of Bronchial asthma	**yes**	400.00	---	---
	no	450.00	0.00	
Complete resolution of Joint and back pain	**yes**	384.55	127.64	0.172
	no	425.00	26.73	

Discussion

In our study, all patients had their TSBL measured and underwent a 12-month postoperative follow-up to assess any excess body weight loss, nutritional deficiencies, and the resolution or improvement of co-morbidities associated with obesity. Overall, the length of these individuals' small intestines varied widely (from 450 cm to 1000 cm). This was consistent with the findings of Nordgreen et al., who found a somewhat broader range of TSBLs (360 cm to 1090 cm) in their investigation (15). TSBLs were found to vary from 285 cm to 845 cm in a more recent study by Teitelbaum et al. (16). However, another study by Raines et al. reported a range of larger TSBLs (630 cm to 1510 cm) (17).

Our study showed no statistical significance in the variation of TSBL in relation to age, height, baseline weight, or baseline BMI. However, it showed statistical significance in relation to sex, in terms of longer TSBLs in females compared to males. Similarly, Teitelbaum et al. found a positive correlation between TSBL and patient gender and height (p=0.001) (16). TSBL did not vary significantly between obese and non-obese participants in another investigation by Guzman et al. (18) In Guzman’s study, gender was the only variable that was shown to be significantly correlated with TSBL; men had longer small bowels than females (18). Raines et al. found a significant correlation between small bowel length and height (r=0.056, p=0.024); however, weight or BMI were not correlated with TSBL (17). Our study's smaller sample size could explain why we found different results than other studies.

The efferent limb lengths in our study varied from 250cm to 800cm depending on the TSBL. The average pre-operative BMI of the patients studied in our study was 50.8kg/m. The average percentage of excess body weight loss at 3-, 6- and 12 months postoperative was 32.1%, 51.9%, and 72%, respectively. Similarly, Rutledge et al. stated that the average percentage of weight loss was 20% at 1 month, 51% at 6 months, and 68% at 12 months postoperative (19). Ansar et al. conducted a study on 1309 patients who underwent OAGB over a period of seven years and showed an average percentage of excess body weight loss of 81.63% at 12 months postoperative (20). Kular et al. showed that the average percentage of weight loss was 63% at 12 months postoperative and 68% at 5 years postoperative (21). Poublon et al. compared OAGB and RYGB after failed restrictive bariatric surgery over a period of 5 years. Their findings showed that the percentage of total weight loss was significantly larger in the OAGB group than in RYGB at 12 months ($p=0.023$) and 24 months ($p=0.023$) of follow-up. Also, the intra-abdominal complications, including perforation, intra-abdominal abscess, bleeding, and leakage, occurred less frequently after revisional OAGB compared to RYGB (1.1% vs 4.9%, $p=0.025$). This study suggested that OAGB was superior to RYGB as a remedy for insufficient weight loss and weight regain after failed restrictive surgery with more weight loss and a lower early complication rate (22). In terms of weight reduction after a OAGB, all of these studies, including ours, find comparable outcomes.

Our study found a statistically significant ($p<0.05$) connection between efferent limb length and excess body weight reduction at 3, 6, and 12 months post-OAGB. The length of the efferent limb negatively correlated with postoperative weight reduction. Statistical significance ($p<0.05$) was also found between afferent limb length to TSBL and postoperative weight reduction. Postoperative excess body weight reduction was directly related to afferent limb length to TSBL. Our research found that the longer the afferent limb and the shorter the efferent limb, the greater postoperative weight reduction and the closest patients come to their desired weight following surgery. Similarly, afferent (bypassed) limb length was shown to have a significant impact on postoperative weight loss, as investigated by Charalampos et al. Patients with an afferent limb length of 2 meters lost 89.1% of their extra body weight after 36 months compared to 104.7 % in patients with 3 meters (23). Abdallah et al. compared a tailored bypass group (bypassing 1/3 TSBL) to a "fixed bypass" group (bypassing 200 cm from the duodenojejunal junction regardless of the TSBL). They concluded that the "tailored bypass" group was followed by a statistically significantly lower postoperative BMI and significantly higher excess body weight loss. The fixed bypass group was also associated with a significantly higher complication rate than the tailored bypass group in this study (22.5 vs 5%, $P = 0.04$) (24). On the other hand, studies by Ahuja et al. (25), Komaei et al. (26), and Pizza et al. (27) showed no statistical significance between postoperative weight loss and the length of the efferent limb. Although it stands to reason that the shorter the efferent limb (and the longer the afferent limb), the greater the postoperative weight loss, this hypothesis has to be tested with larger study populations and over longer time periods.

Our study found that at 12 months postoperative, iron deficiency was the most common nutritional deficiency (43.5%), which was also reported by Rutledge et al. (28). However, no association was seen in our study between nutritional deficiencies and efferent limb length 12 months after surgery. One year after OAGB, patients in the fixed 200-cm afferent limb group had a substantially greater prevalence of vitamin A ($p = 0.030$), vitamin D3 ($p = 0.020$), and albumin ($p = 0.030$) deficiencies compared to those in the tailored afferent limb group, according to Komaei et al. However, there were no statistically significant differences between the two groups in terms of vitamin B12, iron, or total protein deficiencies after surgery (29). A survey of 118 surgeons from 30 countries found that 0.37–0.56% of patients receiving OAGB required surgical treatment for serious nutritional disorders. Surgeons who recommended an afferent limb length of >250 cm reported the highest incidence of this complication, whereas those who recommended a limb length of 150 cm or less reported the lowest incidence (9). Jedamzik et al. found that at 24 months post-operatively, patients with long afferent limbs had substantially lower systemic folic acid levels compared with short and intermediate limbs. No patients showed signs of severe protein malnutrition, and there were no statistically significant changes in vitamin D, A, E, B12, or iron levels (30). Variations in sample sizes, postoperative follow-up periods, and patients' baseline characteristics may all contribute to inconsistent findings among these studies. There is currently no conclusive evidence linking the varying limb lengths of OAGB surgery to postoperative malnutrition. This highlights the significance of TSBL measurement prior to performing the single anastomosis. It is also important to inform patients of the warning signals of nutritional deficiencies and to conduct careful and frequent clinical and biochemical follow-ups with them after surgery to assist prevent or detect any nutritional issues that may arise.

Our study also showed an incidence rate of pre-operative hyperlipidemia of 65.2%, osteoarthritis of 65.2% as well, type II Diabetes Mellitus (T2DM) of 47.8%, hypertension of 28.3%, and bronchial asthma of 8.7%. It also showed an incidence of complete postoperative resolution of hyperlipidemia of 83.3%, osteoarthritis of 73.3%, T2DM of 63.6%, hypertension of 69.2%, and bronchial asthma of 25%. Furthermore, Ruiz-Tovar et al., who compared OAGB to both RYGB and laparoscopic sleeve gastrectomy (LSG), emphasized the high rates of the full resolution of co-morbidities after OAGB. A significant percentage of remission from T2DM (p=0.027), hypertension (p=0.006), and dyslipidemia (p=0.001) was reported after OAGB compared to RYGB and LSG (31). Postoperative remission of obesity-related co-morbidities, particularly dyslipidemia, T2DM, and hypertension, was greatest with OAGB, according to a 7-year clinical study by Jammu et al. (32). Similar to our findings, Navarrete et al. compared OAGB and RYGB and found that patients who underwent OAGB had a significantly higher rate of resolution of obesity-related co-morbidities (33). It is important to note that various variables may contribute to the resolution of co-morbidities, particularly T2DM, following OAGB. Some examples include the patient's age, BMI, waist circumference, and C-peptide levels (34).

Our study showed no statistical significance between the efferent limb length and the complete resolution of T2DM, hypertension, or osteoarthritis. On the other hand, it showed statistical significance between the efferent limb length and the complete resolution of hyperlipidemia. In other words, the likelihood of full postoperative remission of hyperlipidemia increases with decreasing efferent limb length. These findings are in line with those reported by Ahuja et al., who found no statistically significant difference in the remission of T2DM and hypertension among three groups of patients having OAGB (150 cm afferent limb group, 180 cm afferent limb group, and 250 cm afferent limb group) (25). Nabil et al. revealed no statistically significant difference in the resolution of any comorbidities associated with obesity between the two groups investigated (Classic 200 cm afferent limb group and distal 400 cm efferent limb group) (35). More studies with larger sample sizes and a longer postoperative follow-up are needed to answer whether the postoperative resolution of co-morbidities could be related to the length of limbs in OAGB or not.

Conclusion

In conclusion, measuring the TSBL in each patient undergoing OAGB would be more accurate than the classic estimation given by the anatomy books. The length of the efferent limb is inversely correlated with postoperative excess body weight loss. On the other hand, there is a directly proportional relationship between the percentage of afferent limb length to TSBL and the postoperative excess body weight loss. There is no statistical significance between the efferent limb length and nutritional deficiencies at 12 months postoperative. The efferent limb length is significantly associated with the complete resolution of hyperlipidemia but not with other obesity-related co-morbidities, including T2DM, hypertension, and osteoarthritis. Transparent communication with our patients regarding experience, outcomes, and even complications peri-operatively is both mandatory and ethical.

Acknowledgments: None

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