Long-term weight loss and metabolic benefit from Roux-en-Y gastric bypass in patients with superobesity

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Abstract

Background: Although Roux-en-Y gastric bypass (RYGB) is widely performed worldwide, its efficacy in patients with a body mass index (BMI) greater than 50 kg/m² remains controversial. The aim of the present paper was to assess long-term (10 years or more) weight loss and metabolic results of RYGB in patients with superobesity (SO; BMI > 50 kg/m²), compared with patients with morbid obesity (MO; BMI 35–50 kg/m²).

Methods: This study involved retrospective analysis of a prospectively followed cohort of adult patients operated on for a primary RYGB between 1999 and 2008. Long-term weight loss and metabolic parameters were compared between SO and MO patients, with a sex-specific subgroup analysis in SO patients. Multiple logistic regression assessed independent predictors of poor long-term weight loss.

Results: Among the 957 included patients, 193 (20.2 per cent) were SO (mean BMI 55.3 kg/m² versus 43.3 kg/m² in MO). Upon 10-year follow-up, which was complete in 86.3 per cent of patients, BMI remained higher in SO patients (mean 39.1 kg/m² versus 30.8 kg/m², P < 0.001) although total bodyweight loss (per cent TBWL) was similar (28.3 per cent versus 28.8 per cent, P = 0.644). Male SO patients had a trend to higher 10-year per cent TBWL, while initial BMI greater than 50 kg/m² and low 5-year per cent TBWL were independent predictors of long-term TBWL less than 20 per cent. Diabetes remission was observed in 39 per cent SO and 40.9 per cent MO patients (P = 0.335) at 10 years, and all patients had a significant lipid profile improvement.

Conclusion: Substantial improvement in co-morbidities was observed in all patients 10 years after RYGB. Total weight loss was similar in SO and MO patients, leaving SO patients with higher BMI. Suboptimal TBWL 5 years after surgery in SO, especially female patients, may warrant prompt reassessment to improve long-term outcomes.

Introduction

The proportion of patients suffering from obesity is constantly rising worldwide. According to the latest national health report in Switzerland, 42 per cent of the adult population is either overweight or obese. In the meantime, the incidence of severe obesity is increasing; median BMI among patients undergoing bariatric surgery worldwide is estimated at 41.7 kg/m², whereas it reaches 49.1 kg/m² in Germany.

Presently, bariatric surgery remains the standard for the treatment of morbid obesity (MO), as it provides superior weight and metabolic results and improves long-term life expectancy when compared with conservative methods. Roux-en-Y gastric bypass (RYGB) is one of the most commonly performed bariatric procedures, with a proven lasting effect in weight control and metabolic profile improvement in patients suffering from obesity. Nutritional deficiencies after RYGB are common and need rigorous follow-up and supplementation, still they are rarely severe or refractory to treatment as opposed to those following malabsorptive procedures such as distal Roux-en-Y bypass (dRYGB), bili-pancreatic diversion with/without duodenal switch (BPD-DS), or one-anastomosis gastric bypass (OAGB). This favourable risk–benefit balance makes RYGB the procedure of choice in many expert bariatric centres and explains probably why malabsorptive procedures represent only 1–2 per cent of all bariatric interventions performed annually. Nevertheless, the efficacy of RYGB remains a matter of debate in patients with superobesity (SO) (BMI > 50 kg/m²). Some series present similar outcomes for patients with MO (BMI 35–50 kg/m²) and SO, whereas others show inferior weight loss for SO patients. Two studies suggested inferior weight loss in SO compared with MO patients more than 10 years after RYGB, although 10-year follow-up rates are rather poor.

As some well established (BPD-DS and dRYGB) and other more recent (OAGB and single anastomosis duodeno-ileal bypass (SADI)) malabsorptive procedures are often proposed to maximize weight loss, robust data are needed for the long-term effects of the standard RYGB procedure in SO patients. This is of
particular clinical relevance as a two-step approach (sleeve gastrectomy followed by BPD-DS/OAGB/SADI-S, or even RYGB) is a valid option for SO patients, whereas upfront RYGB offers limited conversion strategies in cases where poor results are observed. There is, of course, the possibility of modifying limb length in RYGB (by elongating biliopancreatic (BP) limb of the Roux-en-Y bypass for example) to increase its efficiency; however, results are scarce concerning both weight loss benefits and potential metabolic complications, such as protein malnutrition.

The aim of this study was to assess long-term weight loss and metabolic outcomes after RYGB in patients with SO compared with MO, and identify potential risk factors associated with suboptimal weight loss in the long term.

**Methods**

All consecutive patients undergoing a primary laparoscopic RYGB between 1998 and 2008 in the two reference centres were included in a prospectively maintained database. They were divided into two groups according to their BMI at baseline: patients with SO and MO. The local ethics committee approved the study (protocol number 304/15), and consent was obtained from all patients for the use of clinical data for research purposes. The study was reported according to the STROBE guidelines for cohort studies.

Surgical technique was standardized at both institutions during the study interval, with a gastric pouch of 15 ml, anastomosed with a 21-mm circular stapler to a 150-cm retrocolic and retrogastric Roux-en-Y alimentary limb in SO patients and 100 cm in MO patients, except in 13 patients who had an antecolic Roux-en-Y limb. The jejuno-jejunostomy was performed with a side-to-side anastomosis at 30–50 cm from the angle of Treitz. Mesenteric windows (mesocolic, Petersen, and jejuno-jejunal) were closed (except in two early patients) using intermittent absorbable sutures for the next 171 patients, and running non-absorbable sutures for the next 171 patients, and running non-absorbable sutures for the remaining 75 patients. Postoperative morbidity was recorded up to 30 days after surgery, and according to the Clavien–Dindo five-scale system.

**Table 1 Baseline demographic characteristics and co-morbidities for all patients**

| All patients | SO (n = 193) | MO (n = 764) | P
|--------------|-------------|-------------|---
| Age (years), mean(s.d.) | 40.2(10.8) | 40.0(10.7) | 0.810
| Weight (kg), mean(s.d.) | 153.9(23.1) | 119.7(15.3) | <0.001
| BMI (kg/m²), mean(s.d.) | 53.5(3.3) | 43.3(3.0) | <0.001
| Sex ratio (M:F) | 63(32.6):130 | 171(22.4):573 | 0.011
| | (67) | (77.6) |
| Diabetes | 118(61.1) | 424 (55.5) | 0.295
| Hypertension | 117(60.6) | 407 (53.3) | 0.017
| Coronary artery disease | 10 (5.2) | 27(3.5) | 0.256
| Hypercholesterolaemia | 113(58.5) | 515 (67.1) | 0.021
| Hypertriglyceridaemia | 65(33.7) | 301 (39.4) | 0.025
| Hyperuricaemia | 70(36.3) | 250 (32.7) | <0.001
| Osteoarticular pain | 129(66.8) | 547 (71.6) | 0.223
| Sleep apnoea syndrome | 124 (64.2) | 338 (44.2) | <0.001
| Gastroesophageal reflux | 87 (45.7) | 400 (52.4) | 0.005
| Depression | 39 (20.2) | 163 (21.3) | 0.676

Values are n (%) unless otherwise indicated. Mean(s.d.) age of patients was 40 years, with a BMI of 55.3(5.3) kg/m² in SO and 43.3(3.0) kg/m² in the MO group. SO, superobesity; MO, morbid obesity; BMI, body mass index.

**Table 2 Baseline demographic characteristics and co-morbidities for male and female patients with superobesity**

| SO subgroup | Male SO (n = 63) | Female SO (n = 130) | P
|--------------|----------------|-------------------|---
| Age (years), mean(s.d.) | 40.4(10.6) | 40.1(10.9) | 0.854
| Weight (kg), mean(s.d.) | 172.8(22.2) | 144.8(17.2) | <0.001
| BMI (kg/m²), mean(s.d.) | 56.1(6.2) | 55.0(4.8) | 0.185
| Diabetes | 40 (63.5) | 78 (60.0) | 0.131
| Hypertension | 45 (27.4) | 72 (55.4) | <0.001
| Coronary artery disease | 7 (11.1) | 3 (2.3) | 0.009
| Hypercholesterolaemia | 35 (55.6) | 78 (60.0) | 0.070
| Hypertriglyceridaemia | 25 (59.7) | 40 (30.8) | 0.007
| Hyperuricaemia | 27 (42.9) | 43 (33.1) | 0.133
| Osteoarticular pain | 38 (60.3) | 91 (70.0) | 0.407
| Sleep apnoea syndrome | 50 (79.4) | 74 (56.9) | <0.001
| Gastroesophageal reflux | 35 (55.6) | 52 (40.0) | 0.092
| Depression | 8 (12.7) | 31 (23.8) | 0.195

Values are n (%) unless otherwise indicated. SO, superobesity; MO, morbid obesity; BMI, body mass index.

**Table 3 Postoperative outcomes in patients with superobesity and morbid obesity**

| | SO (n = 193) | MO (n = 764) | P
|---|---|---|---
| Anastomotic leak | 5 (2.6) | 10 (1.3) | 0.200
| Gastrojejunostomy | 2 | 8 | 1.000
| Jejunoo-jejunostomy | 1 | 1 | 0.362
| Gastric remnant | 2 | 3 | 0.262
| Surgical site infection | 8 (4.1) | 34 (4.4) | 1.000
| Superficial | 6 | 23 | 0.999
| Deep | 3 | 10 | 0.732
| Haemorrhagic complications | 7 (3.6) | 27 (3.5) | 0.954
| Venous thromboembolic events | 3 (1.6) | 10 (1.3) | 0.733
| Overall morbidity rate | 21 (10.9) | 90 (11.8) | 0.801
| Major complications (more than Clavien score IIIA) | 6 (3.1) | 22 (2.9) | 0.813
| Operative duration (min), mean(s.d.) | 160 (42.2) | 143 (38.2) | <0.001
| Postoperative stay (days), mean(s.d.) | 6.1 (7.2) | 4.7 (3.9) | 0.005

Values are n (%) unless otherwise indicated. SO, superobesity; MO, morbid obesity.

**Table 4 Long-term complications and reoperations in patients with superobesity and morbid obesity**

| | SO (n = 193) | MO (n = 764) | P
|---|---|---|---
| Intestinal obstruction | 7 (3.6) | 38 (4.9) | 0.562
| Internal hernia | 12 (6.2) | 60 (7.8) | 0.540
| Marginal ulcer | 2 (1) | 12 (1.5) | 0.743
| Incisional hernia | 2 (1) | 5 (0.6) | 0.629
| Recurrent abdominal pain | 5 (2.6) | 20 (2.6) | 0.103
| Anastomotic stricture | 6 (3.1) | 33 (4.3) | 0.540
| Intussusception | 0 | 3 (0.4) | 1.042
| Hiatus hernia | 0 | 4 (0.5) | 0.581
| Candy cane | 1 (0.5) | 5 (0.6) | 1.005
| Symptomatic gallstones | 2 (1) | 2 (0.3) | 0.184
| Patients requiring reoperation | 21 (10.8) | 105 (13.7) | 0.341
| Patients requiring endoscopic dilatation | 7 (3.6) | 34 (4.4) | 0.688

Values are n (%) unless otherwise indicated. SO, superobesity; MO, morbid obesity.
is considered ‘suboptimal weight loss’\cite{27}, in the present study it was defined as less than 20 per cent TBWL 10 years after surgery\cite{28}. Subgroup analyses were performed by sex, to assess potential differences in long-term outcomes in SO men and women. In terms of metabolic follow-up, the absolute values of glucose, triglycerides, total cholesterol, high-density lipoprotein (HDL) cholesterol, and low-density lipoprotein (LDL) cholesterol were prospectively recorded during the follow-up. Diabetes was diagnosed as fasting

\begin{figure}
\centering
\includegraphics[width=\textwidth]{Figure1.png}
\caption{Weight evolution of patients with morbid obesity versus superobesity during the 10-year follow-up}
\end{figure}

\textbf{a} BMI values. \textbf{b} Excess BMI loss (EBMIL per cent). \textbf{c} Total bodyweight loss (TBWL per cent). All variables are represented by mean values in each time point. An asterisk (*) indicates significant a difference between MO and SO patients. SO, superobesity; MO, morbid obesity; BMI, body mass index.
plasma glucose greater than 7 mmol/l, and impaired glucose tolerance as higher than 5.6 to less than 7.0 mmol/l, according to the American Diabetes Association guidelines\(^2^9\). As glycated haemoglobin (HbA1c) was not routinely measured during the study interval, diabetes remission was considered as complete normalization of fasting glucose levels without any medication, whereas diabetes improvement was defined as better control of diabetes with similar treatment, or similar control with reduced treatment\(^8\). Patient follow-up was conducted in the outpatient clinic where weight, co-morbidities, and blood test results were assessed. Patients who were eligible for 10-year follow-up but not seen for more than 12 months despite active tracking efforts, were considered lost from follow-up and were excluded from long-term weight and metabolic co-morbidity analysis.

Standard statistical comparisons were performed with the chi-squared or Fisher’s exact test for categorical variables, and the Mann–Whitney U test for continuous variables. Missing data were omitted from analyses, according to the default setting of the statistics software used. To determine factors independently associated with suboptimal weight loss, a multivariable logistic regression was performed. Co-variates with a \(P < 0.010\) on a univariable level were included in the multivariable model, where \(P < 0.050\) was the threshold for significance. Furthermore, a subgroup analysis of SO patients was performed to investigate the potential impact of sex on long-term outcomes. All analyses were performed with the R studio (version 1.1.383, Boston, MA, USA) and SPSS\(^9\) (version 23.0, Chicago, IL, USA) software.

**Fig. 2 Metabolic profile evolution of patients with morbid obesity versus superobesity during the 10-year follow-up**

- **a** Fasting glycaemia values (mol/l).
- **b** Total cholesterol (mmol/l).
- **c** High-density lipoprotein (HDL) cholesterol (mmol/l).
- **d** Ratio total/HDL cholesterol.
- **e** Low-density lipoprotein (LDL) cholesterol (mmol/l).
- **f** Triglycerides (mmol/l).
- **g** Urates (mmol/l). All variables are represented by mean values. An asterisk (*) indicates significant a difference between MO and SO patients. SO, superobesity; MO, morbid obesity.
Results
During the study interval, 957 patients underwent primary laparoscopic RYGB in the two participating centres and 193 of them (20.2 per cent) had a baseline BMI more than 50 kg/m² (SO group). Of note, BMI more than 60 kg/m² was observed in 33 (3.5 per cent) patients in this series. A complete 10-year follow-up was available for 86.3 per cent of all patients.

Baseline characteristics of all patients are summarized in Table 1. Male sex was more prevalent in the SO group (32.6 per cent versus 22.4 per cent \( P = 0.011 \)). In addition, male SO patients had a poorer metabolic profile (hypertension, coronary artery disease, and hypertriglyceridemia) (Table 2). Although operating

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**Fig. 3** Weight evolution of male versus female patients with superobesity during the 10-year follow-up

a BMI values. b Excess BMI loss (EBMIL per cent). c Total bodyweight loss (TBWL per cent). All variables are represented by mean values in each time point. An asterisk (*) indicates significant a difference between male and female patients. M, male; F, female; BMI, body mass index.
time (160 versus 144 min, \( P < 0.001 \)) and length of hospital stay (6.1 versus 4.6 days, \( P = 0.045 \)) were significantly longer for SO patients, postoperative outcomes were similar (Table 3). During long-term follow-up, there were no differences in internal hernia incidence or any other surgical complications (Table 4).

**Long-term weight loss results in superobesity and morbid obesity patients**

All patients lost similar proportions of their initial weight at 10-year follow-up (TBWL 28.3 per cent for SO and 28.8 per cent for MO patients, \( P = 0.644 \)). Between 24 and 48 postoperative months SO patients had a significantly higher %TBWL, although no difference was observed from the fifth year on. At 10 years, mean BMI was 39.3 kg/m\(^2\) and 30.8 kg/m\(^2\) respectively (Fig. 1a–c). ‘Suboptimal weight loss’ (TBWL less than 20 per cent) was observed in 37 (25.3 per cent) of SO and 107 (17.8 per cent) of MO patients 10 years after surgery (\( P = 0.037 \)). At 10 postoperative years, 84 (57.5 per cent) patients in the SO group and 580 (96.8 per cent) in the MO group had a BMI less than 40 kg/m\(^2\); 51 (94.9 per cent) SO and 490 (82.1 per cent) MO patients had a BMI less than 35 kg/m\(^2\), whereas 9.6 per cent SO and 44.4 per cent MO patients achieved a BMI less than 30 kg/m\(^2\) (\( P < 0.001 \) for all comparisons).

Multivariable analysis revealed BMI greater than 50 kg/m\(^2\) (SO group) at baseline (OR 1.94, 95 per cent c.i. 1.01 to 3.70, \( P = 0.044 \)) and lower %TBWL at 5 postoperative years (OR 0.80, 95 per cent c.i. 0.76 to 0.85, \( P < 0.001 \)) as the only independent predictors of suboptimal 10-year weight loss (Table S1).

**Metabolic results in superobesity and morbid obesity patients**

Ten years after RYGB, 57 (39.0 per cent) SO patients and 244 (40.9 per cent) MO patients initially suffering from diabetes mellitus (DM), presented complete diabetes remission (\( P = 0.335 \)). Inversely, 4 (2.7 per cent) SO and 32 (5.4 per cent) MO patients presented de novo diabetes (\( P = 0.335 \)). Mean fasting glucose levels were higher at baseline for the SO group; however, the difference disappeared at 10 postoperative years (Fig. 2a). Patients with suboptimal weight loss (less than 20 per cent TBWL) at 10 years had inferior rates of complete diabetes remission (36.7 per cent versus 40.1 per cent, \( P = 0.029 \)). Evolution of lipid profile is shown in Fig. 2b–f, with MO patients presenting higher HDL and lower total cholesterol/HDL ratio 10 years after surgery. Uric acid levels remained higher for SO patients throughout the 10-year follow-up (Fig. 2g).

Of note, 10-year all-cause mortality rate was 5.7 per cent in SO and 2.1 per cent in the MO patients (\( P = 0.012 \)).

**Sex-specific weight results in superobesity patients**

Baseline characteristics of SO male and female patients are shown in Table 2. No difference in operating time, postoperative complications, or length of stay were observed between male and female SO patients (data not shown). Mean BMI remained similar up to the fifth postoperative year, when females started regaining more weight (Fig. 3a–b). Male SO patients showed a trend to higher per cent TBWL from the fifth and up to the 10th postoperative year, with significantly better results between 72 and 108 postoperative months (Fig. 3c). At 10 years, five (12.2 per cent) male and 32 (30.5 per cent) female SO patients presented poor weight loss (\( P = 0.022 \)), whereas five (12.2 per cent) male and nine (8.6 per cent) female patients achieved a BMI less than 30 kg/m\(^2\) (\( P = 0.504 \)).

**Discussion**

In the present series of RYGB, patients with SO represented 20 per cent of all cases. Although they had similar TBWL as patients with MO 10 years after surgery, preoperative BMI more than 50 kg/m\(^2\) was independently associated with suboptimal long-term weight loss. Female SO patients presented lower weight loss compared with male SO patients at 10 postoperative years. All patients had similar rates of DM remission at 10 years and managed to improve their lipid profile.

Preliminary mid-term institutional data (five postoperative years) suggested that although SO patients achieve similar or even higher absolute weight loss (BMI units, kg) than MO patients, their BMI tends to remain higher\(^\text{21}\). Therefore, when results are expressed with metrics referring to an ideal weight (per cent Excess Weight Loss (EWL), per cent EBMI, and BMI), they are largely dependent on baseline BMI. In the present study\(^\text{28}, \text{10}\), a 10-year TBWL less than 20 per cent was chosen to define suboptimal weight loss, as TBWL is the least influenced from baseline BMI and of great clinical relevancy, as patients’ perception of weight loss ‘success’ is largely based on their own preoperative status, and not on ideal weight references.

Although there was no significant difference in mean 10-year % TBWL between SO and MO groups, a higher proportion of SO patients achieving suboptimal weight loss in the long term was found. Previously, Christou\(^\text{et al.}\)\(^\text{9}\) reported 10-year rates of suboptimal weight loss in 34.9 per cent (SO) and 20.4 per cent (MO) patients using the Biron criteria (BMI more than 35 kg/m\(^2\) for MO and BMI more than 40 kg/m\(^2\) for SO patients)\(^\text{19}\), whereas Magro\(^\text{et al.}\) reported 20 per cent and 10.1 per cent in SO and MO patients, when more than 50 per cent EWL was used as a cut-off\(^\text{20}\); however, some further insight is needed in interpreting when defining ‘successful’ weight loss after bariatric surgery, as there is no universally accepted weight loss cut-off predicting co-morbidity evolution and patient satisfaction\(^\text{14}, \text{20}\). Obeid\(^\text{et al.}\) illustrated that despite the difference in per cent EWL between SO (52.9 per cent) and MO patients (61.3 per cent), obesity-related co-morbidities were significantly improved in all patients a decade after RYGB\(^\text{12}\).

In the present study, SO and MO patients had comparable rates of DM remission at 10 years, approximating 40 per cent of all patients who had DM initially, whereas a low rate of de novo DM was noted in both groups. This, along with the sustained improvement in lipid profile observed in all patients, confirms that a weight loss-independent metabolic benefit is seen after RYGB\(^\text{6,11}\) contributing to the subsequent reduction in cardiovascular mortality\(^\text{12,33}\). Of note, long-term surgical complications were comparable between SO and MO patients in the present series, but a significantly higher long-term mortality was confirmed in the SO population; this illustrates the deleterious impact of severe obesity on long-term survival.

One might argue that to deal with the massive weight excess in SO patients, more malabsorptive procedures than the standard (proximal) RYGB should be preferred. Although Brolin\(^\text{et al.}\) had suggested better results for more distal RYGB\(^\text{16}\), Risstad\(^\text{et al.}\) did not find superior weight loss after distal versus proximal RYGB in these patients\(^\text{18}\). Co-morbidities and specifically diabetes were well controlled in both groups, whereas distal RYGB patients had a significantly worse quality of life and social limitations due to loose stool and malabsorption\(^\text{14}\). In another RCT comparing RYGB with BPD-DS, 55.6 per cent of SO patients had suboptimal weight results 5 years after RYGB, compared with 14.3 per cent after BPD-DS\(^\text{18}\). These results corroborate with older data suggesting superior weight loss after BPD-DS in SO
patients\textsuperscript{15}; however, overwhelming diarrhoea, severe hyperparathyroidism, protein malnutrition, and even liver failure were exclusively reported after BPD-DS\textsuperscript{16}. In addition, although dRYGB\textsuperscript{14} and BPD-DS\textsuperscript{16} yielded better fasting glucose and HbA1c values than standard RYGB in SO patients, all markers remained well under the diabetes threshold for RYGB, dRYGB, and BPD-DS patients. The present study confirms a sustained TBWL of 28 per cent for SO patients 10 years after RYGB, which remains in the upper range of the reported 22.5–31.6 per cent for the general RYGB population in the literature\textsuperscript{5,8,11,12,23}. Still, 25.3 per cent SO patients (and up to 30.5 per cent among women) presented suboptimal weight loss (TBWL less than 20 per cent) 10 years after surgery; these patients had also inferior rates of DM remission. Thus, a more aggressive bariatric approach is worth discussing in cases of extreme obesity. Bolckmans et al. reported 40.7 per cent TBWL 10 years after BPD-DS\textsuperscript{36}; another series suggested similar 5-year weight loss after OAGB and RYGB (40.8 per cent versus 37.2 per cent respectively), with comparable rates of diabetes remission\textsuperscript{15}. In a recent case-match study of patients with severe obesity, SADI-S presented superior mid-term (more than 5 years) surgical outcomes as well as weight control than RYGB patients\textsuperscript{38}. A recent meta-analysis assessed current options in patients with weight regain after primary RYGB, suggesting dRYGB as the most efficient solution to tackle weight regain, followed by BPD/DS and SADI-S\textsuperscript{39}. However, robust data on long-term metabolic complications and patient-reported outcomes are still lacking; weight loss expectations need to be put in a realistic and clinically relevant perspective when counselling SO patients, considering the potentially invalidating side effects of malabsorptive procedures for the sake of supplementary weight loss.

This is one of the first studies reporting more favourable weight loss outcomes after RYGB in male SO patients compared with females. Although a robust pathophysiological explanation cannot be provided based on our results, the loss of lean mass in association with low oral protein intake may contribute to lower resting energy expenditure in female patients after bariatric surgery\textsuperscript{40}. As detailed data on body composition, dietary habits, and exercise are not available in the present series, this sex-specific analysis can only be considered hypothesis-generating.

Multivariate analysis confirmed an SO status and %TBWL at 5 years as independent predictors of suboptimal weight loss at 10 years. Previous long-term series reported maximal weight reduction during the first 2–5 years after RYGB, followed by a phase of weight maintenance or regain up to the 10th year\textsuperscript{6,8,11,52,20}; however, up to 10 per cent of patients may achieve their minimal weight 10 years after surgery\textsuperscript{7}. Even so, patients with suboptimal weight loss in the mid-term warrant close attention. Nutritional counselling, behavioural treatment, and a thorough assessment of the patient’s co-morbidities and functional status need to be undertaken to halt or reverse weight regain\textsuperscript{10}.

This study has some limitations. Although weight, metabolic biomarkers, and co-morbidities were prospectively recorded for all patients, other relevant outcomes such as nutritional deficiencies and compliance to supplementation were not systematically documented in the early years of our prospectively followed cohort. In addition, patient-reported outcomes were not systematically collected, so the actual weight loss ‘failure’ cannot be correlated with patients’ perception. These shortcomings are counterbalanced by the large number of included patients, the homogeneity of surgical management over the years, as well as the 86.3 per cent complete 10-year follow-up of the cohort, which is one of the highest reported in the bariatric literature. Moreover, the standard laparoscopic Roux-en-Y technique performed in this non-selected cohort of consecutive primary RYGB cases, allows for a safe extrapolation of the current results into general practice.

In conclusion, TBWL in SO is comparable to that in MO patients 10 years after RYGB, leaving SO patients with higher BMI values. Suboptimal outcomes 5 years after surgery in SO, especially in female patients, could warrant a multidisciplinary intervention to evaluate if, and by which means, the course of obesity can still be changed.

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**Disclosure**

The authors declare no conflict of interest.

**Supplementary material**

Supplementary material is available at BJS Open online.

**Data availability**

The authors declare that their data, analytic methods, and study materials may be made available to other researchers, upon request to the corresponding author.

**References**

1. DeMaria EJ, Pate V, Warthen M, Winegar DA. Baseline data from American Society for Metabolic and Bariatric Surgery-designated bariatric surgery centers of excellence using the bariatric outcomes longitudinal database. Surg Obes Relat Dis 2010;6:347–355
2. Office Féderal de la Santé Publique (OFSP), Switzerland. Excès de poids. https://bfs.admin.ch/bfs/home/statistiques/sante/determinants/exces-poids.html (accessed 15 September 2022)
3. Welbourn R, Hollyman M, Kinsman R, Dixon J, Liem R, Ottosson J et al. Bariatric surgery worldwide: baseline demographic description and one-year outcomes from the fourth IFSO global registry report 2018. Obes Surg 2019;29:782–795
4. Carlsson LMS, Sjöholm K, Jacobson P, Andersson-Assarsson JC, Svensson PA, Taube M et al. Life expectancy after bariatric surgery in the Swedish obese subjects study. N Engl J Med 2020;383:1535–1543
5. Schauer PR, Bhatt DL, Kirwan JP, Wolski K, Aminian A, Brethauer SA et al. Bariatric surgery versus intensive medical therapy for diabetes–5-year outcomes. N Engl J Med 2017;376:641–651
6. Adams TD, Davidson LE, Litwin SE, Kolotkin RL, Nanjee MN et al. Weight and metabolic outcomes 12 years after gastric bypass. N Engl J Med 2017;377:1143–1155
7. Higa K, Ho T, Tercero F, Yunus T, Boone KB. Laparoscopic Roux-en-Y gastric bypass: 10-year follow-up. Surg Obes Relat Dis 2011;7:516–525
8. Duvoisin C, Favre L, Allemann P, Fournier P, Demartines N, Suter M. Roux-en-Y gastric bypass: ten-year results in a cohort of 658 patients. Ann Surg 2018;268:1019–1025
9. Christou NV, Look D, Maclean LD. Weight gain after short- and long-limb gastric bypass in patients followed for longer than 10 years. Ann Surg 2006;244:734–740

10. Edholm D, Svensson F, Naslund I, Karlsson FA, Rask E, Sundbom M. Long-term results 11 years after primary gastric bypass in 384 patients. Surg Obes Relat Dis 2013;9:708–713

11. Mehaffey JH, LaPar DJ, Clement KC, Turrentine FE, Miller MS, Hallowell PT et al. 10-year outcomes after Roux-en-Y gastric bypass. Ann Surg 2016;264:121–126

12. Obeid NR, Malick W, Concors SJ, Fielding GA, Kurian MS, Ren-Fielding CJ. Long-term outcomes after Roux-en-Y gastric bypass: 10- to 13-year data. Surg Obes Relat Dis 2016;12:11–20

13. Mingrone G, Bornstein S, Le Roux CW. Optimisation of follow-up after metabolic surgery. Lancet Diabetes Endocrinol 2018;6:487–499

14. Risstad H, Svanevik M, Kristinsson JA, Hjelmesæth J, Asaheim ET, Hofas D et al. Standard versus distal Roux-en-Y gastric bypass in patients with body mass index 50 to 60: a double-blind, randomized clinical trial. JAMA Surg 2016;151:1146–1155

15. Ghiasi S, Higa K, Chang S, Ma P, Lloyd A, Boone K et al. Conversion of standard Roux-en-Y gastric bypass to distal bypass for weight loss failure and metabolic syndrome: 3-year follow-up and evolution of technique to reduce nutritional complications. Surg Obes Relat Dis 2018;14:554–561

16. Risstad H, Søvik TT, Engstrøm M, Aasheim ET, Fagerland MW, Olsén MF et al. Five-year outcomes after laparoscopic gastric bypass and laparoscopic duodenal switch in patients with body mass index of 50 to 60: a randomized clinical trial. JAMA Surg 2015;150:352–361

17. Robert M, Espalieu P, Pelascini E, Caiazzo R, Sterkers A, Pelascini E et al. Efficacy of safety and one anastomosis gastric bypass versus Roux-en-Y gastric bypass for obesity (YOMEGA): a multicentre, randomised, open-label, non-inferiority trial. Lancet 2019;393:1299–1309

18. Hariri K, Guevara D, Dong M, Kini SU, Herron DM, Buchs NC et al. Prevalence of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;239:205–213

19. Brissman M, Beamish AJ, Olbers T, Marcus C. Prevalence of insufficient weight loss 5 years after Roux-en-Y gastric bypass: metabolic consequences and prediction estimates: a prospective registry study. BMJ Open 2021;11:e046407

20. Corcelles R, Boules M, Froylich D et al. Total weight loss as the outcome measure of choice after Roux-en-Y gastric bypass. Obes Surg 2016;26:1794–1798

21. Olsson MF, Hagen ME, Khamphommala L et al. Long-term results 11 years after primary gastric bypass in the super obese: comparison of SG, RYGB, and OAGB. J Gastrointest Surg 2016;20:237–247

22. Moon RC, Nelson L, Teixeira AF, Jawad MA. Outcomes of Roux-en-Y gastric bypass in the super obese: comparison of body mass index 50–60 kg/m² and >60 kg/m² with the morbidly obese. Surg Obes Relat Dis 2016;12:292–296

23. Wood GC, Benotti PN, Lee CJ, Mirshahi T, Still CD, Gerhard GS et al. Evaluation of the association between preoperative clinical factors and long-term weight loss after Roux-en-Y gastric bypass. JAMA Surg 2016;151:1056–1062

24. Kraljević M, Schneider R, Wolnerhanssen B, Bueter M, Delko T, Peterli R. Different limb lengths in gastric bypass surgery: study protocol for a Swiss multicenter randomized controlled trial (SLIM). Trials 2021;22:352

25. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Epidemiology 2007;18:800–804