







# Sleeve gastrectomy versus Roux-en-Y-gastric bypass in patients with body mass index over 50 kg/m<sup>2</sup>: international multicentre cohort

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## Abstract

**Background:** Patients with initial body mass index > 50 kg/m<sup>2</sup> are vastly under-represented in randomized clinical trials demonstrating similar weight loss and diabetes remission rates after sleeve gastrectomy and Roux-en-Y gastric bypass.

**Methods:** Propensity score matching 1 : 1 was used to compare outcomes regarding weight loss and diabetes control after sleeve gastrectomy and Roux-en-Y gastric bypass in patients with body mass index > 50 kg/m<sup>2</sup> between 2012 and 2022 in a cohort from 13 centres in six European countries. The primary endpoint was percentage total bodyweight loss; secondary endpoints were diabetes remission rate and rate of persistent body mass index > 40 kg/m<sup>2</sup>.

**Results:** In total, 3976 of 8160 patients were matched and included in the analysis (1988 in each group). Median age at baseline was 40.0 (range 16–76) years in the sleeve gastrectomy group and 39.5 (15–71) years in the Roux-en-Y gastric bypass group. Median body mass index at baseline was 56.2 (range 50.0–100.0) and 54.3 (50.0–83.9) kg/m<sup>2</sup>, respectively ( $P < 0.001$ ). The follow-up rate was 70.5% at 1 year and 24.4% at 5 years. Percentage total bodyweight loss at 1 and 5 years after sleeve gastrectomy was 30.2 (2.2–63.7) and 25.4 (–4.8 to 56.0)%, respectively, versus 31.2 (7.4–54.5) and 28.2 (–6.6 to 62.9)% in the Roux-en-Y gastric bypass group ( $P < 0.001$  between groups in both time points). The prevalence of persistent body mass index > 40 kg/m<sup>2</sup> after 1 and 5 years was 42.7 and 57.6%, respectively, after sleeve gastrectomy versus 24.5 and 39.2% after Roux-en-Y gastric bypass ( $P < 0.001$  between groups in both time points). A 5-year follow-up, the prevalence of a pathological haemoglobin A1c level (> 6.5%) was 12.9% after sleeve gastrectomy and 11.6% after Roux-en-Y gastric bypass ( $P = 0.323$ ).

**Conclusion:** This study suggests that Roux-en-Y gastric bypass results in greater weight loss than sleeve gastrectomy in patients with body mass index > 50 kg/m<sup>2</sup>, whereas improvements in diabetes appear comparable between procedures.

**Keywords:** weight loss, diabetes remission, obesity class IV

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## Introduction

A recent report<sup>1</sup> from the USA suggested a drastic increase in prevalence of people living with obesity, with the steepest increase in those with body mass index (BMI) > 50 kg/m<sup>2</sup>. Among the various bariatric procedures available, laparoscopic sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) are currently the most commonly used worldwide<sup>2</sup>.

Long-term data from two randomized clinical trials (RCTs)<sup>3,4</sup> comparing the efficiency of SG versus RYGB showed similar outcomes for both procedures in terms of weight loss over a 10-year follow-up<sup>5,6</sup>. Mid-term results from a third, large RCT<sup>7</sup> have also indicated high perioperative safety for both procedures. However, the majority of patients included in these studies<sup>5–8</sup> had BMI < 50 kg/m<sup>2</sup>. Previous RCTs<sup>5,6</sup> further reported a high rate of conversion surgery, exceeding 30%, in the SG group, primarily owing to secondary gastro-oesophageal reflux disease (GORD) and/or insufficient weight loss.

Suboptimal weight loss and/or weight regain are common after SG<sup>3–6</sup>, but they have also been reported following RYGB, especially in patients with high initial BMI<sup>9</sup>. However, RCTs or real-world data from prospective registry studies comparing outcomes of SG and RYGB in cohorts with an initial BMI > 50 kg/m<sup>2</sup> remain scarce.

The aim of this study was to compare the efficacy of SG and RYGB for weight loss and diabetes improvement after 1 and 5 years in patients with initial BMI > 50 kg/m<sup>2</sup>, using data from a multicentre European cohort.

## Methods

### Patients

This was a retrospective analysis of prospectively collected data for consecutive patients with primary BMI > 50 kg/m<sup>2</sup> who underwent RYGB or SG at 13 participating centres from 2012 to 2022. Data from Sweden were based on anonymized data from the Scandinavian Obesity Surgery Registry, a national research and quality registry including data from nearly all patients undergoing metabolic bariatric surgery (MBS) nationwide. This registry is continuously validated with high validity of the included data<sup>10</sup>. Data from two German centres were collected prospectively from the national quality and research registry of the German Society of General and Visceral Surgery. Data from Switzerland were collected prospectively in the local anonymized databases of the participating centres. Data from Austria, Poland, and Turkey were collected retrospectively from the local hospital information systems. The distribution of procedures and participating centres is summarized in [Table S1](#).

The manuscript was prepared according to SQUIRE<sup>11</sup>. Informed consent was waived with respect to the use of anonymized data. This study was approved by the Zurich Ethics Committee, Switzerland (BASEC-Nr 2022-00659). All centres approved the study.

### Data extracted

Data extracted from the national registries included baseline characteristics, such as age, sex, BMI, diabetes status (diabetes defined as haemoglobin (Hb) A1c level  $\geq$  6.5%), insulin dependence (but not dosage or other medication), and type of surgical procedure (SG or RYGB). Follow-up data at 1, 2, and 5 years included BMI, diabetes status, percentage total bodyweight loss (%TBWL), insufficient weight loss (defined as BMI > 40 kg/m<sup>2</sup> for a cohort with primary BMI > 50 kg/m<sup>2</sup>) and

follow-up rates<sup>9</sup>. Because of inconsistent data sets, especially missing values for weight and height, as well as fasting glucose levels, the authors decided to assess only BMI, weight loss, and diabetes status in this analysis.

### Outcomes

The primary endpoint was %TBWL at 1 and 5 years after surgery. Secondary endpoints included remission of type 2 diabetes (T2D), defined by HbA1c level < 6.5%<sup>12</sup>, and persistent BMI > 40 kg/m<sup>2</sup> at 1 and 5 years following SG and RYGB. %TBWL was analysed in quartiles (< 10, 10–20, 20–30, and > 30%).

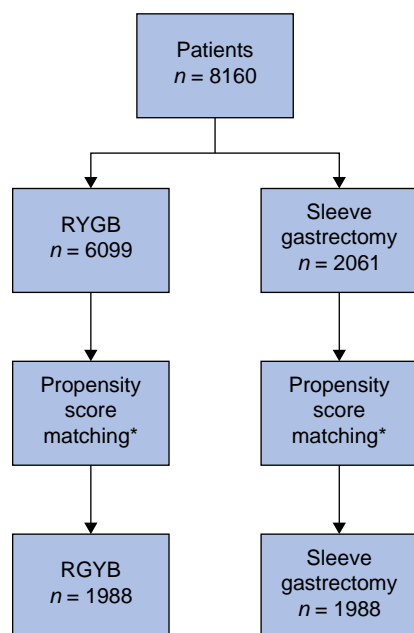
### Statistical analysis

Descriptive data are reported as mean(standard deviation), unless otherwise stated. The main analysis comprised a comparison of propensity score-matched groups of patients undergoing SG and RYGB. The propensity variable for 1:1 matching with the nearest neighbour was calculated by logistic regression analysis incorporating the selected co-variables. A caliper of < 0.05 of the standard deviation of the logit of the propensity score was accepted. Co-variables for propensity score matching were age, sex, T2D, and BMI as they were the most important factors regarding the outcome variables, and were the most complete data available for the majority of the patients. Validation of the matching criteria was assessed with standardized mean differences and shown as Cohen's d. Comparisons between the cohorts were performed using the  $\chi^2$  test, Fisher's exact test, Mann-Whitney U test or one-way analysis of variance, in accordance with data scale and distribution. The level of statistical significance was set at 0.05 (2-sided). All statistical analyses were also carried out for the baseline cohort (including patients with missing follow-up) and only for the subgroup of patients with completed 5-year follow-up to control for possible selection bias ([supplementary tables](#)). Patients with missing baseline data for the matching criteria were excluded from the analysis. All statistical analyses were undertaken using SPSS® version 29 (IBM, Armonk, NY, USA).

## Results

Overall, data for 8160 patients were retrieved from the database (2061 SG, 6099 RYGB). After propensity score matching, 3976 patients remained as the study cohort (1988 in each group) ([Fig. 1](#)). There were no statistically significant and clinically relevant differences at baseline regarding age (median 39.9 years), sex distribution (65.1% women), or prevalence of T2D (26.4%) ([Table 1](#)). Median baseline BMI was 55.5 (range 50.0–100.0) kg/m<sup>2</sup> overall, 56.2 (50.0–100.0) kg/m<sup>2</sup> in the SG group and 54.3 (50.0–83.9) kg/m<sup>2</sup> in the RYGB group ( $P < 0.001$ ). Follow-up rates at 1 and 5 years were 70.5 and 24.4% overall; they were 71.1 and 69.9% at 1 year ( $P = 0.212$ ), and 21.2 versus 27.6% at 5 years ( $P = 0.001$ ), after SG and RYGB, respectively.

At 1 year after operation, median BMI had decreased from 55.5 (50–100) to 38.3 (22.0–64.7) kg/m<sup>2</sup> overall, from 56.2 (50–100) to 39.3 (22.0–64.7) kg/m<sup>2</sup> in the SG group, and from 54.3 (50–83.9) to 37.5 (23.7–59.7) kg/m<sup>2</sup> in the RYGB group ( $P < 0.001$  for SG versus RYGB) ([Table 2](#)). Accordingly, %TBWL was 30.7% overall, 30.2% after SG and 31.2% after RYGB ( $P < 0.001$ ). At 1 year, 943 of 2803 patients (33.6%) overall had BMI > 40 kg/m<sup>2</sup>, including 603 of 1413 (42.7%) in the SG group and 340 of 1390 (24.5%) in the RYGB group ( $P < 0.001$ ). T2D persisted at 1 year in 203 of 2412 patients (8.4%) overall, 82 (8.8%) in the SG group and 121 (8.2%) in the RYGB group ( $P = 0.312$ ).



**Fig. 1** Study flow chart

\*Co-variables for propensity score matching were age, sex, T2D, and BMI. RYGB, Roux-en-Y gastric bypass.

At 5 years, median BMI was 40.0 (20.0–67.2) kg/m<sup>2</sup> overall, 41.6 (22.0–67.2) kg/m<sup>2</sup> in the SG group and 38.7 (20.0–63.8) kg/m<sup>2</sup> in the RYGB group ( $P < 0.001$ ) (Table 3). Accordingly, %TBWL was 27.0% overall, 25.4% after SG and 28.2% after RYGB ( $P < 0.001$ ). At 5 years, obesity with BMI  $> 40$  kg/m<sup>2</sup> persisted in 458 of 970 patients (47.2%) overall, including 243 of 422 (57.6%) in the SG group and 215 of 548 (39.2%) in the RYGB group ( $P < 0.001$ ). The prevalence of T2D was 116 of 849 patients (13.7%) overall, 41 (12.9%) in the SG group and 75 (11.6%) in the RYGB group ( $P = 0.323$ ).

BMI distributions for SG and RYGB at 5 years are shown in Fig. 2. The proportion of patients achieving TBWL  $< 10\%$  at 5 years was 2.8% in the RYGB group versus 9.5% in the SG group ( $P < 0.001$ ); 18.5 versus 23.6%, respectively, achieved 10–20% TBWL; 34.9 versus 32.5% achieved 20–30% TBWL; and 43.9 versus 34.4% achieved  $> 30\%$  TBWL ( $P < 0.001$ ) (Fig. 3).

### Supplementary analyses

Baseline characteristics and outcomes in the overall cohort of 8160 patients showed trends in %TBWL, BMI, and the rate of patients with suboptimal weight loss similar to those observed in the propensity score-matched cohort (Tables S2–S4). Results for the subgroup of patients with complete 5-year follow-up did not differ from those for the overall cohort (Tables S5 and S6).

**Table 1** Baseline characteristics

Patient characteristics	Total cohort (n = 3976)	Sleeve gastrectomy (n = 1988)	RYGB (n = 1988)	SMD (Cohen's d)
Age median (range)	39.9 (15–76)	40.0 (16–76)	39.5 (15–71)	0.063
<b>Sex</b>				0.002
Male	1388 (34.9%)	693 (35.0%)	693 (34.9%)	
Female	2588 (65.1%)	1293 (65.0%)	1295 (65.1%)	
BMI at baseline (kg/m <sup>2</sup> ), median (range)	55.5 (50.0–100.0)	56.2 (50.0–100.0)	54.3 (50.0–83.9)	0.370
<b>Diabetes at baseline</b>	1050 of 3976 (26.4%)	526 of 1988 (26.5%)	524 of 1988 (26.4%)	0.002
Insulin-dependent (1159 patients available)	70 of 1159 (6.0%)	49 of 903 (5.4%)	21 of 256 (8.2%)	

Values are n (%) unless otherwise stated. RYGB, Roux-en-Y gastric bypass; SMD, standardized mean difference; BMI, body mass index.

**Table 2** Results at 1 year

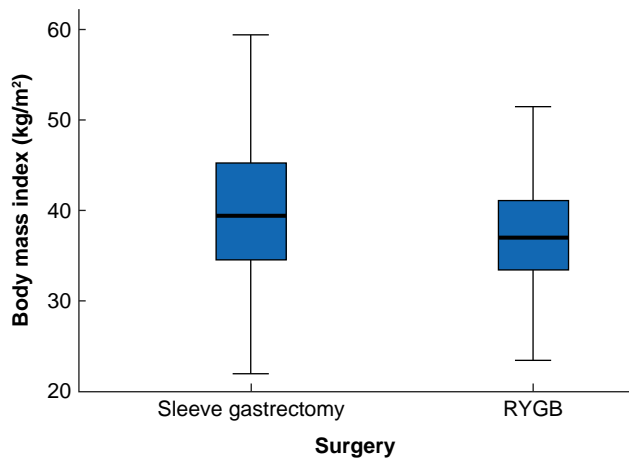
	Total cohort (n = 2803)	Sleeve gastrectomy (n = 1413)	RYGB (n = 1390)	P*
BMI at 1 year (kg/m <sup>2</sup> ), median (range)	38.3 (22.0–64.7)	39.3 (22.0–64.7)	37.5 (23.7–59.7)	$< 0.001$ †
Diabetes at 1 year (2412 patients available)	203 of 2412 (8.4%)	82 of 930 (8.8%)	121 of 1482 (8.2%)	0.312
%TBWL at 1 year, median (range)	30.7 (2.2–63.7)	30.2 (2.2–63.7)	31.2 (7.4–54.5)	$< 0.001$ †
BMI $> 40$ kg/m <sup>2</sup> at 1 year	943 of 2803 (33.6%)	603 of 1413 (42.7%)	340 of 1390 (24.5%)	$< 0.001$
BMI $> 50$ kg/m <sup>2</sup> at 1 year	100 of 2803 (3.6%)	80 of 1413 (5.7%)	20 of 1390 (1.4%)	$< 0.001$
Follow-up rate at 1 year (%)	70.5	71.1	69.9	0.212

Values are n (%) unless otherwise stated. RYGB, Roux-en-Y gastric bypass; BMI, body mass index; %TBWL, percentage total bodyweight loss. \* $\chi^2$  test or Fisher's exact test, except †Mann-Whitney U test.

**Table 3** Results at 5 years

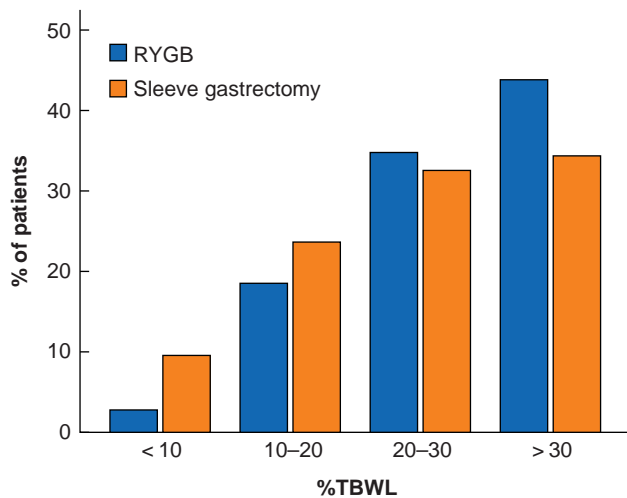
	Total cohort (n = 970)	Sleeve gastrectomy (n = 422)	RYGB (n = 548)	P*
BMI at 5 years (kg/m <sup>2</sup> ), median (range)	40.0 (20.0–67.2)	41.6 (22.0–67.2)	38.7 (20.0–63.8)	$< 0.001$ †
Diabetes at 5 years (849 patients)	116 of 849 (13.7%)	41 of 318 (12.9%)	75 of 647 (11.6%)	0.323
%TBWL at 5 years, median (range)	27.0 (–6.6 to 62.9)	25.4 (–4.8 to 56)	28.2 (–6.6 to 62.9)	$< 0.001$ †
BMI $> 40$ kg/m <sup>2</sup> at 5 years	458 of 970 (47.2%)	243 of 422 (57.6%)	215 of 548 (39.2%)	$< 0.001$
BMI $> 50$ kg/m <sup>2</sup> at 5 years	75 of 970 (7.7%)	57 of 422 (13.5%)	18 of 548 (3.3%)	$< 0.001$
Follow-up rate at 5 years (%)	24.4	21.2	27.6	0.001

Values are n (%) unless otherwise stated. RYGB, Roux-en-Y gastric bypass; BMI, body mass index; %TBWL, percentage total bodyweight loss. \* $\chi^2$  test or Fisher's exact test, except †Mann-Whitney U test.



**Fig. 2** Body mass index distribution 5 years after sleeve gastrectomy and RYGB

Median values, interquartile ranges, ranges, and outliers are represented by bold lines, boxes, error bars, and circles, respectively. RYGB, Roux-en-Y gastric bypass.



**Fig. 3** Distribution of %TBWL after sleeve gastrectomy and RYGB

%TBWL, percentage total bodyweight loss; RYGB, Roux-en-Y gastric bypass.

## Discussion

In this large multicentre cohort study examining the effectiveness of SG and RYGB in patients with BMI > 50 kg/m<sup>2</sup>, the initial weight loss at 1 year —31.2% TBWL after RYGB and 30.2% after SG— showed no clinically relevant difference between the groups and is consistent with previous reports<sup>5–7,13</sup>. At 5 years, RYGB resulted in a lower BMI (38.7 versus 41.6 kg/m<sup>2</sup>) and correspondingly greater %TBWL (28.2 versus 25.4%). This is presumably clinically relevant, especially with respect to the rates of persistent BMI > 40 and > 50 kg/m<sup>2</sup> at both 1 and 5 years. Notably, the proportion of patients achieving insufficient weight loss was smaller after RYGB than SG. Despite these differences in weight outcomes, the prevalence of T2D remained similar between the two groups.

Although no difference was observed in maximum weight loss, 5-year weight loss was more favourable after RYGB, consistent with previous findings<sup>14,15</sup>. Both groups achieved clinically relevant and sufficient weight loss at both follow-up times, with

modest recurrent weight gain after both procedures at 5 years. Similarly, recurrence of T2D increased at 5 years compared with the 12-month follow-up.

These results are in line with the findings from the SM-BOSS and the SLEEVEPASS trials<sup>3–6</sup>, demonstrating the efficiency of both procedures in patients with BMI > 50 kg/m<sup>2</sup>. Other studies investigating weight loss after SG and RYGB in patients with BMI > 50 or > 60 kg/m<sup>2</sup> have reported similar outcomes. A retrospective study from Arapis *et al.*<sup>16</sup> found comparable weight loss for patients with BMI > 60 kg/m<sup>2</sup> after 4 years of follow-up, with no differences between SG and RYGB. A meta-analysis by Wang *et al.*<sup>17</sup> reported similar results with superior percentage excess weight loss (%EWL) for RYGB at 12 months, but no difference at 24 months. The largest study to date on this topic, by Jain *et al.*<sup>18</sup> in 2018, included > 3000 patients, with a large subgroup of > 450 patients with BMI > 50 kg/m<sup>2</sup>, and also found no difference in %EWL for SG and RYGB at 24-month follow-up.

The most notable difference between the groups in the present study was greater variance in %TBWL and higher rates of persistent BMI > 40 and > 50 kg/m<sup>2</sup> at both follow-up times in the SG group, indicating long-term weight loss superiority for RYGB. This suggests that mid-term (5-year) weight loss in patients with very high baseline BMI is substantially lower than in cohorts from prospective RCTs with a median BMI of ~40 kg/m<sup>23–8</sup>. Substantial weight loss is particularly important in patients with BMI > 50 kg/m<sup>2</sup>, as BMI > 40 kg/m<sup>2</sup> is associated with reduced life expectancy<sup>19</sup>, and MBS has been shown to effectively mitigate these risks<sup>20,21</sup>. As postoperative weight loss largely determines remission of obesity-related problems, achieving sufficient weight loss target is critical. Several studies<sup>3–7</sup> have demonstrated that RYGB results in greater remission of metabolic disorders such as hyperlipidaemia and T2D compared with SG<sup>3–7</sup>. Both procedures, however, have been shown to improve health-related quality of life and psychosocial functioning<sup>22</sup>.

These findings highlight the need for improved multimodal therapeutic strategies in this patient population, for example by adding obesity management medications upfront or after surgery<sup>23,24</sup>. At least an effect of around 8–9% additional %TBWL has been demonstrated by administration of semaglutide after non-response to MBS<sup>25</sup>. Furthermore, procedures with higher weight loss potential such as one-anastomosis gastric bypass (OAGB) or single-anastomosis duodenoileal bypass with sleeve should be emphasized as they could be a valuable option in these patients<sup>26</sup>. Furthermore, considering conversion surgery from SG to bypass procedures should be an option<sup>27</sup>. Additionally, physicians and surgeons should emphasize long-term results in preoperative consultations to set realistic expectations, as individual outcomes may deviate from overall trends<sup>28</sup>.

In addition, weight-loss trajectories should be interpreted in the context of long-term adverse events. For RYGB, this includes secondary surgical interventions for complications such as internal hernia, which has reported rates of up to 15% if mesenteric defects are not closed<sup>29,30</sup>. For SG, secondary conversion to RYGB owing to persistent GORD or suboptimal weight loss has been reported in approximately 30–40% of patients in RCTs<sup>3–7</sup> at 5- and 10-year follow-up.

This study has several limitations. It comprised a retrospective analysis with data collected from multiple centres. The number of included patients per centre differed substantially. This may have introduced selection bias. The 5-year follow-up rate was approximately 25%, which is

comparable to that in other studies but represents an extra potential source of selection bias which may have influenced the results. To address this, the authors also undertook statistical analyses of the primary cohort before propensity score matching and of the subgroup of patients with complete 5-year follow-up; these showed similar results regarding weight loss and diabetes remission. The results from these cohorts were largely consistent with those of the propensity score-matched group, supporting the reliability of the observed effects, particularly given the large sample size. Therefore, the findings are likely clinically relevant and generalizable. Baseline BMI was higher in the SG group than in the RYGB group despite very strict propensity score matching. This effect was most likely driven by the large sample sizes; nevertheless, bias may exist here. The consistent differences in BMI during follow-up underline the similar weight loss potential. However, T2D remission was assessed solely on HbA1c levels. Data on use of insulin and other antidiabetic drugs, quality of life, and other associated co-morbidities were not available. This limitation restricts the assessment of their effects on associated medical problems, which is essential for clinical decision-making and optimization of therapeutic strategy.

Furthermore, information was lacking on conversion surgery after SG owing to initial data selection, which may have led to overestimation of the weight loss effect of SG. Additionally, because of the retrospective nature of the study, certain relevant outcomes could not be assessed, such as the incidence of secondary GORD after SG or internal herniation after RYGB.

This study was based on observational data. Although the results imply superior weight loss results for RYGB, causal conclusions cannot be drawn.

To the authors' knowledge, this is the largest multicentre study investigating patients with BMI > 50 kg/m<sup>2</sup> undergoing primary MBS, and it represents an attempt to address which procedure may be preferable and whether SG is sufficient as a stand-alone procedure in the long term. The data indicate that SG achieves short-term weight loss and T2D remission comparable to those of RYGB, but is associated with a higher risk of suboptimal weight loss. These results are in line with other previous cohort studies examining this question<sup>18,26</sup>. Some patients with very high BMI may not be suitable for primary RYGB and may undergo SG as part of a staged surgical strategy or could be treated with other bypass procedures such as OAGB<sup>26</sup>. Importantly, requiring subsequent conversion to a bypass procedure should not be viewed negatively. Adjunctive medical treatments may also improve results in this group.

Therefore, the authors believe that careful follow-up for this patient group is essential, and that planned conversion to a bypass procedure may help address recurrent weight gain after SG. They also advocate for a prospective RCT in this patient cohort. Additionally, a study comparing planned conversion to RYGB versus OAGB after SG in patients who are not eligible for primary bypass procedures would provide valuable evidence in the field of obesity medicine.

## Collaborators

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## Disclosure

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## Supplementary material

Supplementary material is available at [BJS Open](#) online.

## Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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