




Weight Regain After Bariatric Surgery—A Multicentre Study of 9617 Patients from Indian Bariatric Surgery Outcome Reporting Group

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Abstract

Background There is little robust data on weight regain (WR) after bariatric surgery making it difficult to counsel patients regarding long-term outcomes of different bariatric procedures. The purpose of this study was to see WR in medium and long term after SG, RYGB, and OAGB in Indian population.

Methods In a multicentre study, data on preoperative and postoperative weights over 5 years were collected. Multiple definitions were applied to find the proportion of patients with significant WR increase of 25% of lost weight from nadir (definition 1), weight gain of > 10 kg from nadir (definition 2), and BMI gain of > 5 kg/m² from nadir (definition 3). The proportion of those with significant WR was compared across sub-groups.

Results A total of 9617 patients were included. Median WR at 5 years was 14.1% of lost weight, 1.92 kg/m², and 5 kg. Significant WR using definition 1 was 35.1%, 14.6%, and 3% after sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), and mini-one anastomosis gastric bypass (OAGB) respectively. Severe albumin deficiency was highest in OAGB (5.9%) patients followed by SG (2.9%) and RYGB (2.2%) at 5 years ($p = 0.023$). Haemoglobin levels < 10 g/dL were seen in 8.2%, 9.0%, and 13.9% of SG, RYGB, and OAGB patients respectively ($p = 0.041$).

Conclusions In the first comparative study of WR, OAGB had lesser WR in comparison to SG and RYGB but had the most impact on Hb and albumin levels in the long term. Definition selection for reporting WR has a significant impact on the results. There is a need for standardising the reporting of WR in bariatric literature.

Keywords Bariatric surgery · Obesity surgery · Weight regain · Sleeve gastrectomy · Gastric sleeve · Gastric bypass · Roux-en-Y gastric bypass · Mini-one anastomosis gastric bypass

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Introduction

Bariatric surgery is now recognised to be the best treatment strategy for sustained weight loss. The data on medium and long-term outcomes is scarce with only very few studies reporting on ≥ 5-year results and most have relatively small numbers [1]. Studies that compare different bariatric procedures in the mid and long term are even fewer [2]. There are further very few studies [3–7] that have patients with ≥ 5-year outcomes after one anastomosis gastric bypass (OAGB), a relatively common procedure in India [8]. A recent review by the American Society for Metabolic and Bariatric Surgery [9] identified lack of 5-year outcomes a significant problem with published data on this procedure.

Most of the weight loss after bariatric surgery happens within the first year [10], and most patients experience some loss of clinical response in terms of weight loss and resolution of co-

morbidities in the medium to long term. This loss of clinical response, often loosely labelled as weight regain (WR), is an Achilles' heel of bariatric surgery and may lead to a patient seeking revisional bariatric procedures that are recognised to be riskier and less efficacious [11]. Despite this being such an important problem, there is no consensus on the definition of WR. Multiple definitions of WR have been used in the scientific literature further making any comparisons difficult [12].

It is also known that a proportion of patients undergoing bariatric surgery become anaemic and that certain procedures are associated with a higher risk of anaemia than the others [13]. Similarly, hypoalbuminaemia, often used as a surrogate of nutritional status of patients, is often associated with OAGB [14]. This makes understanding long-term weight loss, WR, anaemia rates, and albumin levels with different bariatric procedures a subject of significance.

The purpose of this study was to understand medium and long-term weight loss outcomes, WR, anaemia rates, and albumin deficiency with SG, RYGB, and OAGB in high-volume bariatric surgery centres in India.

Material and Methods

This retrospective study was part of a data collection exercise conducted by the Indian Bariatric Surgery Outcome Reporting Group. High-volume bariatric surgery centres in India were requested to share information on medium and long-term outcomes (weight loss, anaemia rates, and hypoalbuminaemia rates) after sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), and one anastomosis gastric bypass (OAGB).

Surgeons reported a variation in the basic anatomical details of different procedures. For SG, the bougie sizes ranged between 34 and 38 Fr, and the distance from the pylorus ranged from 2 to 6 cm. For RYGB, the approximate pouch size ranged from 20 to 60 mL. The length of the biliopancreatic limb ranged from 50 to 125 cm and alimentary limb from 70 to 150 cm. When it came to OAGB, surgeons used a bougie size of 32–38 Fr for pouch construction and a biliopancreatic limb ranging from 150 to 210 cm.

Participating centres recommended 3–4 times follow-up in the first year, 1–2 times in the second year, and annually thereafter. Dietary advice was given at each follow-up either by a nutritionist or by the bariatric surgeon themselves. There was also a variation in nutritional supplementation recommendation amongst the centres. All OAGB and RYGB patients were recommended lifelong supplementation. Some (11/25) centres used specific bariatric multivitamins with or without additional iron and calcium supplements as needed. Others (14/25) used over the counter multivitamins along with iron and calcium supplements. Most (23/25) centres recommended lifelong multivitamin/mineral supplementation to sleeve patients. The recommendations varied from centre to centre in terms of the preparation.

Calculations

WR was calculated from the minimum recorded weight.

Percent WR was defined as $(5 \text{ years recorded weight} - \text{minimum recorded weight}) \times 100 / (\text{preoperative weight} - \text{minimum recorded weight})$

We have used three different definitions of significant WR to be able to compare our outcomes with the literature.

Definition 1: Regain of more than 25% of lost weight from the nadir weight [12, 15]

Definition 2: Regain of more than 10 kg from the nadir weight [16–21]

Definition 3: Regain of more than 5 BMI points from the nadir weight [12, 22]

Exclusions

Patients with less than 3-year data were excluded as the purpose of this study was to understand medium and long-term outcomes. We also excluded data on procedures other than SG, RYGB, and OAGB as this paper only focusses on outcomes with these three procedures commonly performed in India. Patients with missing data points were kept for the descriptive statistics and comparison of means but were excluded from the correlation/regression analysis.

Statistical Methods

Categorical variables are expressed as number of patients and percentage of patients and compared across the groups using Pearson's chi-square test for independence of attributes/Fisher's exact test as appropriate. Continuous variables are expressed as descriptive statistics and compared across groups using paired *t* test for parametric data and Mann-Whitney *U* test/Kruskal Wallis test for non-parametric data. Over time comparison has been done using Wilcoxon sign rank test. Association between continuous variables is captured using Spearman's rank correlation coefficient. The statistical software SPSS version 20 has been used for the analysis. A *p* value of < 0.05 was considered significant.

Results

Basic Demographics

Twenty-six high-volume bariatric surgery centres with 32 bariatric surgeons (Table 1) shared their data for this exercise. A total of 9617 patients with minimum 3 years of follow-up (5458 (56.8%) SG, 2965 (30.8 %) RYGB, and 1194 (12.4 %) OAGB patients) were included in the final analysis. Follow-up data was available

Table 1 List of participating centres and surgeons

| City | Centre | Surgeon |
|------------------------|---|------------------------|
| Ahmedabad | Asian Bariatrics Pvt Ltd | Mahendra Narwaria |
| | Columbia Asia Hospital | Manish Khaitan |
| | Hope Obesity Centre | Digvijaysingh Bedi |
| Bengaluru | Aster CMI Hospital | H V Shivaram |
| Chennai | Apollo Hospitals | Raj Palaniappan |
| | Lifeline Hospitals | J S Rajkumar |
| Coimbatore | Gem Hospital and Research Centre | P Pravin Raj |
| Cuttack | Shanti Memorial Hospital | Sreejoy Pattnaik |
| Hyderabad | Gleneagles Global Hospital | Lakshmi Kona Kumari |
| | Livlife Hospitals | Nandakishore Dukkipati |
| | Kirloskar Hospitals | Surendra Ugale |
| Indore | Mohak Bariatrics and Robotics | Mathias Fobi |
| | | Mohit Bhandari |
| | | Pallawi Priya |
| Kolkata | Belle Vue Clinic | Sarfraz J Baig |
| | ILS Hospital | Om Tantia |
| Mumbai | Apollo Hospital | Abhay Agarwal |
| | Hinduja Hospital | Abhay Agarwal |
| | Nanavati Superspeciality Hospital | Jaydeep H Palep |
| | Sevenhills Hospitals | Nidhi Khandelwal |
| | Wockhardt Hospitals | Abhay Agarwal |
| New Delhi | Apollo Institute of Metabolic and Bariatric Surgery | Ramen Goel |
| | | Atul Peters |
| | | Parveen Bhatia |
| | | Deep Goel |
| | | Randeep Wadhawan |
| | | Arun Prasad |
| | | Manish Baijal |
| | | Pradeep Chowbey |
| | | Rajesh Khullar |
| | | Vandana Soni |
| Sir Ganga Ram Hospital | Parveen Bhatia | |
| | Vivek Bindal | |
| | | Sudhir Kalhan |

for 7937 (82.5%), 5282 (54.9%), 5781 (60.1%), and 3231 (33.5%) patients at 1, 2, 3, and 5 years respectively. Procedure wise breakdown and follow-up are given in Table 2.

Descriptive Statistics

Out of 9617 patients, 57.6% were females. The median age, preoperative weight, and BMI were 41 years (range, 6–92 years), 115 kg (64–320 kg), and 43 kg/m² (27.5–131.5 kg/m²) respectively. Median preoperative haemoglobin and albumin levels were 12.7 g/dL (6.10–18.8 g/dL) and 3.98 mg/dL (1.3–7.3 mg/dL).

Table 3 lists the basic demographics of patients broken down by procedures.

Weight Loss Outcomes

Table 4 provides and compares weight loss outcomes at different time intervals. Median %TWL at 3 years was 28.71, 29.99, and 33.33 respectively after SG, RYGB, and OAGB ($p < 0.001$). Median %EWL at 3 years was 68.78, 68.54, and 79.01 respectively ($p < 0.001$).

At 5 years, median %TWL after SG, RYGB, and OAGB was 24.05, 27.82, and 32.62 respectively ($p < 0.001$). Percentage EWL was 57.28, 60.85, and

Table 2 Procedure wise follow-up of patients

| | Total inclusions | 1 year, <i>N</i> (%) | 2 years, <i>N</i> (%) | 3 years, <i>N</i> (%) | 5 years, <i>N</i> (%) |
|-------|------------------|----------------------|-----------------------|-----------------------|-----------------------|
| SG | 5458 | 4418 (80.9%) | 2912 (53.3%) | 3316 (60.7%) | 1945 (35.6%) |
| RYGB | 2965 | 2478 (83.5%) | 1530 (51.6%) | 1830 (61.7%) | 1092 (36.8%) |
| OAGB | 1194 | 1053 (88.2%) | 848 (71%) | 643 (53.8%) | 203 (17%) |
| Total | 9617 | 7937 (82.5%) | 5282 (54.9%) | 5781 (60.1%) | 3231 (33.5%) |

SG, sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass; OAGB, one anastomosis gastric bypass

70.37 respectively after SG, RYGB, and OAGB ($p < 0.001$).

Weight Regain

According to definitions 1, 2, and 3, the proportion of those with significant WR was 26.2% (847/3238), 20.6% (668/3240), and 11.3% (365/3231) in the whole cohort. Median WR at 5 years was 14.1% of lost weight, 1.92 kg/m² BMI points, and 5 kg.

Table 5 presents WR data in the three groups and compares them. Median percent WR from the nadir weight after SG, RYGB, and OAGB was 18.6%, 10.67%, and 1.98% respectively ($p < 0.001$). Median absolute WR in kilogram was 6.0 kg, 4.0 kg, and 1.0 kg from the nadir weight respectively in SG, RYGB, and OAGB groups ($p < 0.001$). Median BMI regain from the nadir BMI was 2.34, 1.46, and 0.35 kg/m² respectively. SG had significantly higher WR compare to RYGB and OAGB.

Percent of those with significant WR using definition 1 was 35.1%, 14.6%, and 3.0% after SG, RYGB, and OAGB respectively ($p < 0.001$). Using definition 2, the numbers were 27.3%, 11.8%, and 3% respectively ($p < 0.001$). Applying definition 3, percentage of those with significant WR in SG, RYGB, and OAGB patients was 15.9%, 5.0%, and 1.0% respectively ($p < 0.001$) (Table 5). Significantly, more patients regained a significant amount of weight in the SG group compared to the RYGB and OAGB group ($p < 0.001$).

Table 3 Descriptive statistics preoperative

| Procedures | SG | | RYGB | | OAGB | | <i>p</i> value |
|-------------|----------------|--------|----------------|--------|----------------|--------|----------------|
| | Mean ± SD | Median | Mean ± SD | Median | Mean ± SD | Median | |
| Age | 40.62 ± 12.17 | 39.00 | 43.98 ± 11.65 | 44.00 | 43.07 ± 11.42 | 42.00 | < 0.001 |
| Weight | 116.20 ± 24.82 | 112.50 | 120.79 ± 23.29 | 118.20 | 121.05 ± 25.15 | 118.00 | < 0.001 |
| BMI | 43.66 ± 8.27 | 42.33 | 44.93 ± 7.91 | 44.28 | 45.08 ± 8.82 | 44.26 | < 0.001 |
| HB | 12.62 ± 1.62 | 12.60 | 12.91 ± 1.48 | 12.90 | 12.64 | 12.60 | < 0.001 |
| Albumin | 4.06 ± 0.49 | 4.07 | 3.90 ± 0.43 | 3.90 | 3.96 ± 0.45 | 4.00 | < 0.001 |
| Females (%) | 60.4 | | 53.7 | | 54.1 | | < 0.001 |

BMI, body mass index; Hb, haemoglobin; SD, standard deviation; SG, sleeve gastrectomy; RYGB, Roux-en-Y gastric bypass; OAGB, one anastomosis gastric bypass

Effect of Preoperative BMI on Weight Patterns

In the superobese group, OAGB had higher %TWL and %EWL than SG and RYGB at 3 and 5 years (Fig. 1).

The superobese group had significantly higher weight regain compared to those with BMI ≤ 50 kg/m² according to definitions 2 ($p \leq 0.001$) and 3 ($p \leq 0.001$) but lower regain when definition 1 was applied ($p \leq 0.001$) (Fig. 2).

Relationship of Haemoglobin and Albumin with BMI trends

Figures 3 and 4 show haemoglobin and albumin levels with different procedures at different time periods. Severe albumin deficiency (defined as < 3.0 g/dL) was highest in OAGB (5.9%) patients followed by SG (2.9%) and RYGB (2.2%) at 5 years ($p = 0.023$). Haemoglobin levels < 10 g/dL were seen in 8.2%, 9.0%, and 13.9% of SG, RYGB, and OAGB patients respectively ($p = 0.043$).

Discussion

This first multicentre data collaboration on bariatric surgery from India demonstrates weight loss outcomes up to 5 years after SG, RYGB, and OAGB.

Table 4 Weight loss trends with different procedures

| Procedure | SG | | | RYGB | | | OAGB | | | <i>p</i> |
|--------------|-------|---------------|----------|-------|---------------|----------|-------|---------------|----------|----------|
| | Med | Mean ± SD | <i>N</i> | Med | Mean ± SD | <i>N</i> | Med | Mean ± SD | <i>N</i> | |
| %TWL 1 year | 26.73 | 27.20 ± 8.82 | 4416 | 27.56 | 27.43 ± 7.75 | 2478 | 29.42 | 28.88 ± 8.85 | 1053 | < 0.001 |
| %TWL 2 years | 28.49 | 28.98 ± 7.89 | 2910 | 29.57 | 29.19 ± 7.05 | 1530 | 32.45 | 32.58 ± 8.35 | 848 | < 0.001 |
| %TWL 3 years | 28.71 | 29.03 ± 8.62 | 3314 | 29.99 | 29.80 ± 7.14 | 1838 | 33.33 | 33.37 ± 8.53 | 643 | < 0.001 |
| %TWL 5 years | 24.05 | 24.36 ± 9.68 | 1943 | 27.82 | 27.02 ± 8.24 | 1092 | 32.62 | 32.53 ± 7.66 | 203 | < 0.001 |
| %EWL 1 year | 70.24 | 68.29 ± 24.73 | 4416 | 64.06 | 64.73 ± 17.76 | 2478 | 72.35 | 68.28 ± 16.85 | 1053 | < 0.001 |
| %EWL 2 years | 72.39 | 72.43 ± 17.79 | 2910 | 70.47 | 69.21 ± 12.22 | 1530 | 79.41 | 76.24 ± 12.72 | 848 | < 0.001 |
| %EWL 3 years | 68.78 | 71.07 ± 22.07 | 3314 | 68.54 | 69.86 ± 17.42 | 1838 | 79.01 | 76.70 ± 17.63 | 643 | < 0.001 |
| %EWL 5 years | 57.28 | 58.96 ± 24.45 | 1943 | 60.85 | 62.12 ± 22.13 | 1092 | 70.37 | 72.96 ± 19.37 | 203 | < 0.001 |
| Nadir BMI | 29.06 | 29.80 ± 4.72 | 4642 | 30.11 | 30.73 ± 4.17 | 2549 | 28.70 | 29.40 ± 3.56 | 1069 | < 0.001 |

BMI, body mass index; *Hb*, haemoglobin; *TWL*, total weight loss; *EWL*, excess weight loss; *WR*, weight regain; *SD*, standard deviation; *SG*, sleeve gastrectomy; *RYGB*, Roux-en-Y gastric bypass; *OAGB*, one anastomosis gastric bypass; *Med*, median

SG accounted for the largest number of procedures in keeping with its global popularity [8]. Interestingly, OAGB accounted for 12.4% of the three most commonly performed procedures in this study compared to 1.8% worldwide [8]. This reflects the popularity of this procedure in India [23].

The age distribution of our cohort seems to follow the worldwide pattern with the 30–60-year age group being the commonest. The proportion of males in our study is a little higher (42.6%) than most series reported worldwide [24]. This may be attributed to the males being more economically productive and thus having an easier access to health care in the Indian population.

There seems to be a growing acceptance for adolescent bariatric and metabolic surgery in the country as reflected by the numbers in the cohort (136 patients under 18 years of age).

This study shows (Table 4) significant superior weight loss outcomes and less WR with OAGB compared to RYGB and SG, and with RYGB compared to SG. This is similar to

findings of a randomised study by Zhang et al [25] where authors found 76.2% EWL with RYGB compared to 63.2% (*p* = 0.02) with SG. Another study by Salminent et al. [26, 27] found 57.0% EWL at 5 years with RYGB compared to 49.0% with SG even though the difference did not reach statistical significance in that study with much fewer numbers than ours.

Superior weight loss outcomes with gastric bypass may, at least in part, be explained by greater alteration in the neurohormonal milieu in diversionary procedure and may explain the durability of the results. In a paper by Peterli and others, a higher trend towards postprandial GLP-1 and PYY was seen although the difference did not reach statistical significance [28].

Our results for weight regain are similar to those reported in the literature who have applied definitions used by us [15–18, 21, 29–31]. Seven of these studies are on sleeve gastrectomy [15–18, 21, 29, 30], one on RYGB [31], and none on OAGB.

Although a small percentage of patients did not experience any WR, most patients exhibited some WR at 5 years. When

Table 5 Weight regain with different procedures

| | | SG | RYGB | OAGB |
|--|-----------|-----------------|-----------------|-------------|
| % WR at 5 years | Mean ± SD | 22.38 ± 21.15 | 13.56 ± 14.7 | 5.95 ± 9.05 |
| | Median | 18.60 | 10.67 | 1.98 |
| | <i>N</i> | 1943.00 | 1092.00 | 203.00 |
| Weight regain at 5 years (kg) | Mean ± SD | 7.60 ± 6.92 | 4.81 ± 5.08 | 2.41 ± 3.28 |
| | Median | 6.00 | 4.00 | 1.00 |
| | <i>N</i> | 1945.00 | 1092.00 | 203.00 |
| BMI regain at 5 years (kg/m ²) | Mean ± SD | 2.89 ± 2.63 | 1.81 ± 1.92 | 0.89 ± 1.24 |
| | Median | 2.34 | 1.46 | 0.35 |
| | <i>N</i> | 1938.00 | 1090.00 | 203.00 |
| WR as per definition 1, <i>N</i> (%) | | 682/1943 (35.1) | 159/1092 (14.6) | 6/203 (3.0) |
| WR as per definition 2, <i>N</i> (%) | | 533/1945 (27.4) | 129/1092 (11.8) | 6/203 (3.0) |
| WR as per definition 3, <i>N</i> (%) | | 308/1938 (15.9) | 55/1090 (5.0) | 2/203 (1.0) |

SG, sleeve gastrectomy; *RYGB*, Roux-en-Y gastric bypass; *OAGB*, one anastomosis gastric bypass; *WR*, weight regain

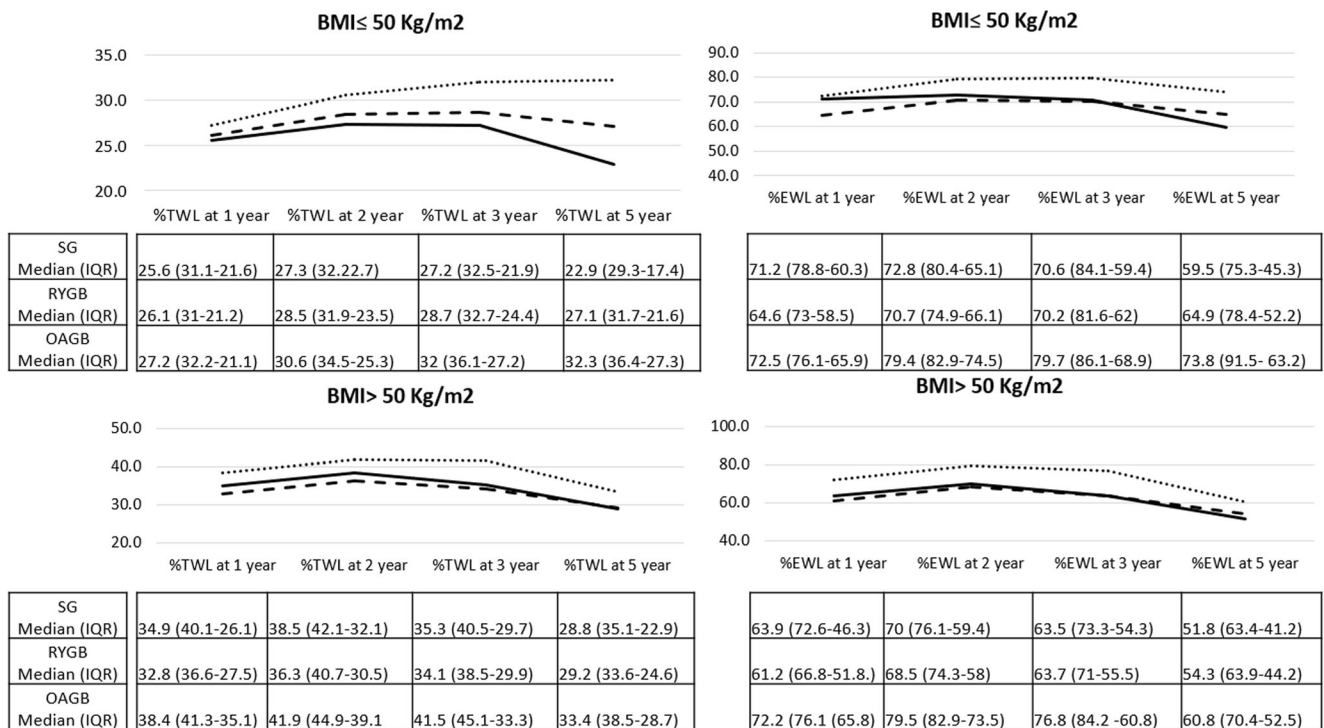


Fig. 1 Median %EWL and %TWL with different procedures in different BMI groups

analysed for procedure groups, the median regain was statistically significant for all three procedures examined in this study.

With each of the three definitions applied, SG has the highest WR followed by RYGB and OAGB. The apparent lower WR with OAGB may be due to comparatively fewer patients at the 5-year mark as reflected in the fact that 17.0% OAGB patients had the data for 5-year follow-up as opposed to 36.8% RYGB patients and 35.6% of SG patients. Our finding that SG patients had lowest TWL at 5 years and the higher tendency to WR has also been observed by others [25] though there is no study up to date in the scientific literature specifically examining and comparing WR with different procedures.

There was a higher variability in WR with SG patients compared to RYGB and OAGB. This means that despite higher WR than other procedures, there is a subset of SG patients who are doing remarkably well. We propose further studies to identify and define this subgroup. This will help us do a better procedure selection.

We further found that though Hb levels stabilised after some time in SG patients, levels continued to drop in those undergoing either type of bypasses. Anaemia is a recognised problem after bariatric surgery, and gastric bypass patients are known to be more likely to develop anaemia than those undergoing SG [13]. That is why standard recommendations for

Fig. 2 Weight regain in superobese vs non-superobese

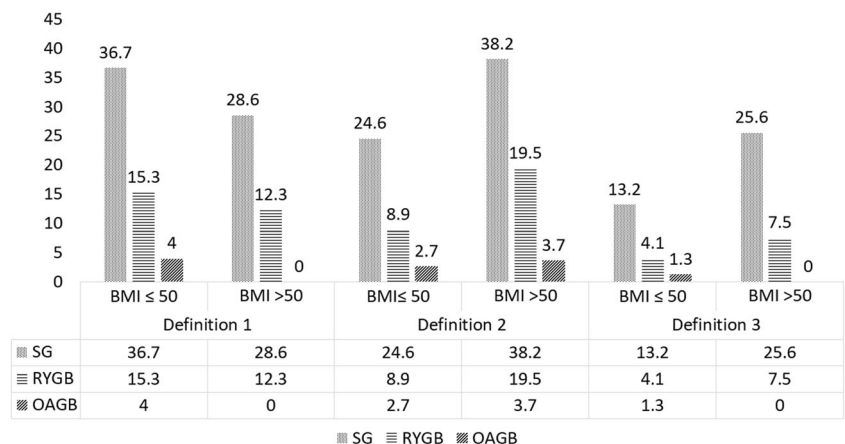
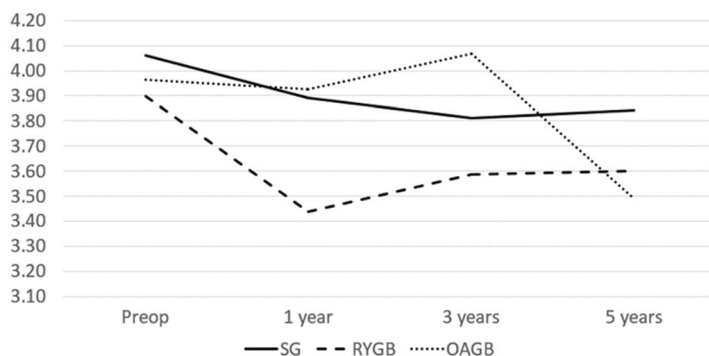


Fig. 3 Albumin levels with different procedures at different time periods



| | Preop | 1 year | 3 years | 5 years |
|--------------------|---------------|---------------|---------------|---------------|
| SG (mean +/- SD) | 4.06 +/- 0.49 | 3.89 +/- 0.54 | 3.81 +/- 0.55 | 3.84 +/- 0.54 |
| RYGB (mean +/- SD) | 3.90 +/- 0.43 | 3.44 +/- 0.50 | 3.59 +/- 0.45 | 3.60 +/- 0.45 |
| OAGB (mean +/- SD) | 3.96 +/- 0.45 | 3.93 +/- 0.46 | 4.07 +/- 0.64 | 3.49 +/- 0.36 |

nutritional supplementation after bariatric surgery recognise a higher need for many micronutrients in gastric bypass patients [32]. These findings should, however, lead to evaluation of micronutrient supplementation recommendation guidelines for different procedures in India and the compliance with them.

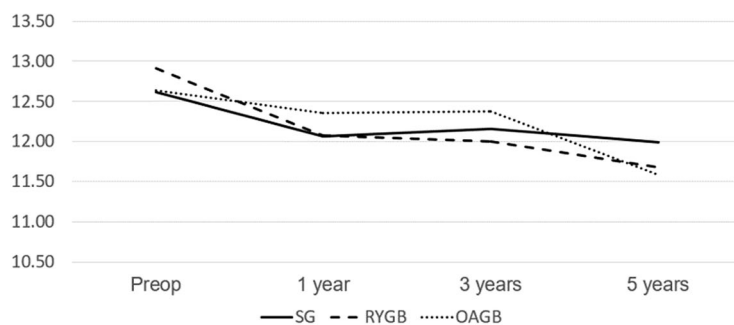
Similarly, though albumin levels eventually stabilised in both SG and RYGB patients, they continued to drop in OAGB patients. Even more worryingly, severe albumin deficiency was seen in a large number of patients, and the number was highest with OAGB (5.9% in comparison with SG (2.9%) and RYGB (2.2%)). This must lead to the evaluation of nutritional support practises following surgery as well as a discussion on the most appropriate limb length for patients undergoing OAGB in India. Surprisingly, SG had more rates of severe

albumin deficiency than RYGB. Although statistically significant, this may not be clinically significant. We are unable to explain the same. Prospective studies may be needed to study this properly.

Although we have used hypoalbuminemia as a surrogate for protein deficiency, this study does not evaluate the incidence of significant protein-calorie malnutrition, a recognised problem with OAGB [33] or the true burden of micronutrient deficiency, likely to be higher with a gastric bypass.

Because of variability in reporting WR, comparison and true estimation of the problem become difficult. A recently published paper by King and others [34] has tried to see the correlation of different definitions of WR with clinical outcomes. They found that percent of lost weight and applying the definition of significant regain as >20% of maximum

Fig. 4 Haemoglobin levels with different procedures at different time periods



| | Preop | 1 year | 3 years | 5 years |
|--------------------|----------------|----------------|----------------|----------------|
| SG (mean +/- SD) | 12.62 +/- 1.62 | 12.06 +/- 1.59 | 12.15 +/- 1.56 | 11.99 +/- 1.47 |
| RYGB (mean +/- SD) | 12.91 +/- 1.48 | 12.08 +/- 1.43 | 12.01 +/- 1.35 | 11.68 +/- 1.38 |
| OAGB (mean +/- SD) | 12.64 +/- 1.62 | 12.36 +/- 1.70 | 12.38 +/- 1.94 | 11.58 +/- 1.48 |

weight loss could be best associated with clinical outcomes except for hyperlipidaemia. In a paper published in 2017, Lauti and other selected 6 definitions for review [12]. They found comparable and consistent results with three of these definitions. We have selected those three definitions based on these findings and found strikingly different results.

Applying BMI > 5 kg/m² points definition gives a lower number of significant regainers followed by definition 2 and definition 1 in our series. This may be because the median BMI in our cohort is lower than the other study [30].

Also, in the superobese group, patients are regaining more absolute weight but a lesser proportion of the lost weight compared to those with BMI ≤ 50 kg/m². Therefore, in higher BMI group, WR is highest with definition 3 and lowest with definition 1. This brings up the question about which definition should be applied to measure weight regain. We propose that we should define weight regain differently for different BMI groups. We propose that we define significant weight regain in patients as a gain of BMI > 5 points (definition 3) for patients with preoperative BMI ≤ 50 kg/m² and more than 25% of lost weight (definition 1) in patients with preoperative BMI > 50 kg/m².

However, weight regain is an outcome where the cutoffs may not be entirely applicable. Patient's perception and comorbidity resolution are important considerations that should be incorporated in the definition/scoring system for WR to be more meaningful.

There are several weaknesses of this study that need to be acknowledged. One of the biggest drawbacks of this study is that it is a retrospective comparison of a non-randomised cohort. Indeed, our data show significant baseline differences amongst the three groups. At the same time, this is a real-world data showing what patients can expect with different procedures in India in terms of weight loss and basic nutritional outcomes. Our follow-up of 60.1% and 33.5% at 3 and 5 years is poor, but follow-up is a recognised problem within bariatric literature and there are only a handful of studies in the literature with adequate follow-up of 80.0% or more [35]. Variation in techniques with different procedures also makes any comparison difficult, but in recent times, even randomised multicentre studies allow different centres to use their own techniques for different procedures [36]. Despite all these obvious limitations, this study does report on 5-year data on 3231/9617 patients. Given there is so little data on 5-year outcomes with bariatric surgery in general and from India in particular means the data in this study is clinically important for patients and practitioners of bariatric surgery in India and elsewhere.

Conclusion

This is the first report on medium and long-term outcomes with SG, RYGB, and OAGB in Indian patients. This is also the first scientific comparison of WR with these three

procedures in medium to long term. SG patients have lower weight loss at 3 and 5 years in comparison to RYGB and OAGB, but at the same time, SG seems to have the least impact on Hb and albumin levels in the long term.

OAGB seems to result in the least weight regain but has the highest incidence of anaemia and severe hypoalbuminaemia. OAGB also seemed to deliver better weight loss outcomes in comparison to SG and RYGB in the superobese patients. Definition selection for reporting WR had a significant impact on the numbers obtained, and there is a need for standardising the reporting of WR in bariatric literature.

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Author Contribution SJB, KM, and SS conceived the idea for the topic. SJB initiated the research and wrote the manuscript. PP collected most of the data and wrote the manuscript. SJB and PP contributed equally to the manuscript. KM and SS wrote and edited parts of the manuscript. All authors participated in the discussions on the topic. All authors have seen the final version and approve of it.

Compliance with Ethical Standards

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