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ORIGINAL ARTICLE

Micronutrient Status in Patients Following Bariatric Surgery, an Experience From A Developing Country

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ABSTRACT

Background: The scourge of obesity has plagued the developing world, culminating in an exponential rise in related illnesses including diabetes, hypertension, and cardiovascular disease. Bariatric Surgery is the most effective way to achieve substantial weight loss for obese individuals, but its impact on long term micronutrient status needs to be studied in the population of the developing world, as access to a healthy diet remains abysmal. This study aims to assess micronutrient levels in patients who have undergone bariatric surgery and compare the difference in postoperative nutritional complications between Sleeve Gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB).

Methodology: This single-center cross-sectional study included 60 patients who underwent bariatric surgery: 30 each for SG and RYGB at Khyber Teaching Hospital, Peshawar. All consenting patients who underwent bariatric surgery and were at a minimum of 6 months post-op were included in this study, whereas patients suffering from malabsorptive disease were excluded. The duration of the study was from January to July, 2023. The data analysis was conducted on SPSS version 25.

Results: The mean age of the patients was 40.95 ± 8.34 with a higher proportion of females (68.3%) as compared to males (31.7%). The incidence of total micronutrient deficiencies increased following bariatric surgery (N=62 preoperatively vs N=88 postoperatively). A higher incidence of anemia was reported in RYGB patients as compared to SG (53.33% vs. 16.67%, P=0.003) at 6 months follow up. In addition, both hemoglobin (12.06 ± 0.78 g/dl for RYGB vs. 13.34 ± 1.12 g/dl for SG, P <0.001) and calcium levels (8.3 ± 0.65 for RYGB vs. 8.7 ± 0.53 for SG, P=0.014) were lower in patients who underwent RYGB at 6 months after surgery. Furthermore, in comparison to SG, RYGB patients had lower postoperative levels of Vitamin B12 (451.90 ± 192.87 for RYGB vs. 555.37 ± 188.42 for SG, P=0.040).

Conclusion: This study concluded that high risk of micronutrient deficiencies before and after bariatric surgery, necessitating routine screening and supplementation. SG may improve B12 levels and reduce anemia, while RYGB offers better weight loss outcomes.

Keywords: Obesity, Bariatric surgery, Roux-en-Y gastric bypass, Sleeve gastrectomy, Nutritional deficiency, Micronutrients.

INTRODUCTION

Bariatric surgery is one the many gifts of modern medicine, it offers a very effective method of combating obesity which is one the greatest problems being faced worldwide. According to the Global Obesity Observatory, the prevalence of obesity in Pakistan is 12.1% for adult men and 13.9% for adult women[1]. The global burden is much higher though, it is estimated that more than 2 billion people suffer from obesity worldwide[2], these figures are expected to rise, continuing an upward trend that extends as far back as the 1970s.

Obesity is an excess of fat in the body, the adverse effects of obesity are largely mediated through increased visceral fat rather than subcutaneous fat[3]. It is associated with low grade systemic inflammation driven by several factors released from adipose tissue and it is this inflammation which is responsible for its harmful effects which include leukocytosis, increased platelet count, increased risk of thromboembolic events[4]. Obesity also increases the risk of type 2 Diabetes Mellitus, cardiovascular diseases, metabolic syndrome, chronic kidney disease, hyperlipidemia, hypertension, nonalcoholic fatty liver disease, certain types of cancer, obstructive sleep apnea, osteoarthritis, and depression[5]. Thus, the need for effective treatment for obesity is imperative.

Bariatric surgery is an extremely effective way of achieving weight loss which further provides a number of benefits including diabetes remission and reduced cardiovascular disease risk[6]. A number of studies have reported a reduction in mortality after bariatric surgery in the range of 40-50%[7]. Therefore, bariatric surgery is a very important modality in the treatment of obesity.

In Pakistan, the approach towards obesity remains classical; dietary modification, hypoglycemic and lipid lowering drugs are the mainstay, bariatric surgery is very scarce largely due to the lack of infrastructure and skill required for performing laparoscopic surgeries[8]. The recent years have seen some development and currently a number of centers are performing these surgeries.

Although, Bariatric surgery is an effective 'cure' for obesity and its related comorbidities, it is not without side effects. Bariatric surgeries lead to a decrease in the amount of ingested calories, ranging from 700 to 900 kcal, especially during the first six months after the procedure[9]. Although this leads to substantial weight loss it has an additional effect of creating micronutrient deficiencies in a large number of the patients[10]. To prevent this, patients are supplemented with vitamins and mineral as per guidelines but according to certain reports micronutrient deficiencies still occur[10].

To our knowledge no research has been conducted assessing micronutrients levels in patients following bariatric surgery in Pakistan creating a research gap that needs to be filled for the improvement of patient care. There is also limited data available on Sleeve gastrectomy worldwide, a type of bariatric surgery which has increased in frequency recently. Thus, we have decided to evaluate micronutrient levels following bariatric surgery in our target population of Peshawar, Pakistan.

This study aims to assess micronutrient levels in patients who have undergone bariatric surgery and compare the difference in postoperative nutritional complications between Sleeve Gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB). To assess micronutrient status in patients who underwent bariatric surgery and compare the difference in postoperative nutritional complications between Sleeve Gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB).

MATERIAL AND METHODS

Study Design and Setting: This was a single-center, cross-sectional observational study conducted at the Department of Surgery, Khyber Teaching Hospital (KTH), Peshawar, Pakistan.

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KTH is a tertiary care teaching facility with a dedicated bariatric surgery unit serving a large patient population from Khyber Pakhtunkhwa and nearby regions. The study aimed to assess the micronutrient status of patients who had undergone bariatric surgery and to compare nutritional outcomes between two surgical procedures: Sleeve Gastrectomy (SG) and Roux-en-Y Gastric Bypass (RYGB).

Study Duration: The study was conducted over a period of seven months, from January to July 2023. This time frame allowed for adequate patient follow-up and ensured the inclusion of subjects who were at least six months postoperative, a duration considered sufficient for observing early nutritional changes following bariatric surgery.

Study Population and Eligibility Criteria: A total of 60 patients were enrolled in the study, with 30 patients each in the SG and RYGB groups. Patients were selected based on the following inclusion criteria: adults aged between 18 and 60 years, having undergone either SG or RYGB at KTH, and having completed a minimum of six months post-surgery. Additionally, only patients who provided written informed consent were included. Patients with pre-existing malabsorptive disorders (e.g., inflammatory bowel disease, celiac disease), chronic liver or renal dysfunction, or incomplete medical records were excluded to avoid confounding factors affecting nutrient absorption and metabolic status.

Sample Size Determination: The sample size was calculated using OpenEpi version 3.01. Assuming a population proportion of 4.1% (based on a comparable study from Saudi Arabia due to the absence of national data), a 95% confidence level, and a 5% margin of error, the minimum required sample size was calculated to be 60. This included 30 patients each in the SG and RYGB groups. The calculated sample size was deemed sufficient to detect clinically meaningful differences between the groups.

Sampling Technique: A non-probability purposive sampling technique was employed. Eligible patients were identified from the hospital's bariatric surgery database. Those meeting the inclusion criteria were contacted via phone or in person during routine follow-up visits. Participants were briefed about the purpose and methodology of the study, and only those who provided written informed consent were included.

Ethical Approval and Patient Consent: The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Khyber Teaching Hospital. Ethical considerations were strictly adhered to, in accordance with the Declaration of Helsinki (2013). Each participant provided informed written consent after being explained the purpose, potential risks, and benefits of the study. Confidentiality of all patient data was maintained throughout the study.

Data Collection Procedure: The data collection process was divided into two components: demographic data and clinical/biochemical parameters. Demographic data including age, sex, marital status, income level, and education status were collected using a self-administered questionnaire. Clinical data were obtained from hospital records and electronic medical files.

All patients underwent laboratory investigations at baseline (preoperative) and six months after surgery. The biochemical parameters measured included Body Mass Index (BMI), serum iron (µg/dL), serum calcium (mg/dL), serum vitamin B12 (pg/mL), 25-hydroxy-vitamin D (nmol/L), and hemoglobin (g/dL). Blood samples were collected in fasting condition and analyzed using standardized methods in the hospital's biochemistry laboratory using calibrated analyzers (e.g., Roche Cobas 6000).

Operational Definitions and Biochemical Thresholds: Micronutrient deficiencies were classified using established clinical cutoffs. Vitamin B12 deficiency was defined as serum levels less than 197 pg/mL, vitamin D deficiency was defined as 25-hydroxy-vitamin D levels below 50 nmol/L, and iron deficiency was defined as serum ferritin below 15 ng/mL. Anemia was defined as hemoglobin levels less than 12 g/dL for women and less than 13 g/dL for men.

Postoperative Management Protocol: All patients received standardized postoperative care, which included nutritional counseling by qualified hospital dietitians. Patients were educated about dietary habits, protein intake, and the importance of regular supplementation. Those identified with deficiencies were prescribed appropriate oral or injectable supplements such as ferrous sulfate, calcium carbonate, cholecalciferol, or intramuscular hydroxocobalamin (vitamin B12), based on the type and severity of the deficiency. Follow-up visits were scheduled at 3 and 6 months post-surgery for clinical assessment and monitoring.

Data Management and Statistical Analysis: All data were entered into SPSS version 25.0 for statistical analysis. Descriptive statistics were used to summarize patient characteristics. Continuous variables such as BMI, vitamin B12, iron, hemoglobin, and calcium were presented as mean ± standard deviation (SD) for normally distributed data, while medians with interquartile ranges (IQR) were used for non-normally distributed variables. Categorical variables such as presence or absence of deficiencies were presented as frequencies and percentages.

For within-group comparisons of preoperative and postoperative values, paired samples t-tests were used for parametric variables (e.g., BMI, hemoglobin, B12), and the Wilcoxon signed-rank test was applied for non-parametric data (e.g., vitamin D, calcium, iron). Between-group comparisons (SG vs RYGB) were conducted using independent samples t-tests for parametric data and Mann-Whitney U tests for non-parametric data. Categorical variables were compared using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

Quality Control and Data Reliability: To ensure the accuracy and reliability of results, data were cross-verified from both patient records and laboratory databases. Laboratory analyses were conducted under strict internal quality control protocols, and equipment was regularly calibrated to minimize analytical errors. Any discrepancies in data entry were resolved through double-checking by two independent investigators.

RESULTS

This study included a total of 60 patients who underwent bariatric surgery, divided equally into two groups: Sleeve Gastrectomy (SG, n=30) and Roux-en-Y Gastric Bypass (RYGB, n=30). The overall mean age was 40.95 ± 8.34 years, with a higher proportion of females (68.3%) compared to males (31.7%). A majority of patients belonged to the middle-income group (50,000–100,000 PKR/month), while 21.7% had higher education, and 77.3% were married. There were no significant demographic differences between SG and RYGB groups, ensuring comparability of surgical outcomes across both subgroups. Postoperative data showed a substantial increase in total micronutrient deficiencies, rising from 62 cases preoperatively to 88 postoperatively. The most notable increases were seen in vitamin D deficiency (from 61.7% to 83.3%, $P < 0.001$) and iron deficiency (from 38.3% to 53.3%, $P < 0.001$). Although vitamin B12 deficiency increased slightly (3.3% to 10%), it did not reach statistical significance ($P = 0.055$). Similarly, anemia increased from 23.3% to 35%, but this was not statistically significant ($P = 0.481$). Furthermore, there were significant postoperative reductions in BMI, iron, and calcium levels across the full cohort. The mean BMI dropped from 47.68 ± 7.71 to 37.67 ± 7.35 kg/m² ($P < 0.001$). There was a slight increase in vitamin D levels (32.20 ± 26.75 to 37.00 ± 32.75 nmol/L, $P = 0.001$), likely reflecting supplementation. Iron levels declined significantly from 77.00 to 69.50 µg/dL ($P < 0.001$), and calcium levels dropped from 8.90 to 8.50 mg/dL ($P < 0.001$). Hemoglobin and vitamin B12 showed no significant changes overall. These observations are detailed in Table 1. Figure 1 demonstrates the changes in prevalence of micronutrient deficiencies and anemia before and after bariatric surgery in both Sleeve Gastrectomy (SG) and Roux-en-Y Gastric Bypass (RYGB) groups. Vitamin D deficiency increased markedly in SG patients (from 63.3% to 93.3%) and moderately in RYGB (60% to 73.3%). Iron deficiency rose in both groups, while anemia showed a dramatic rise in RYGB patients (20% to 53.3%) compared to a smaller increase in SG (16.7% to 26.7%). Vitamin B12 deficiency remained low in SG (3.3%) but rose to 16.7% in RYGB. The figure highlights that RYGB carries a higher risk of anemia and B12 deficiency, while SG is more associated with worsening vitamin D status.

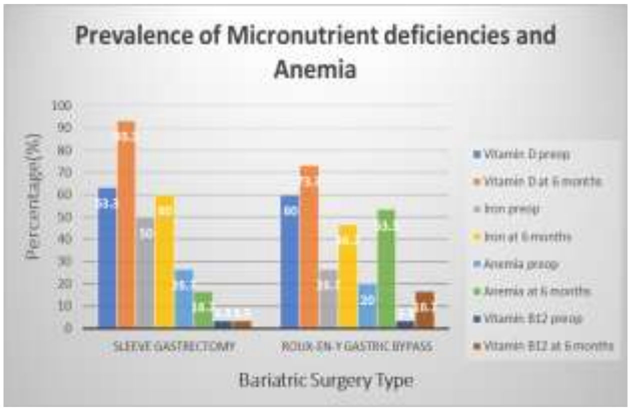

Figure 1: Micronutrient and Hematological Deficiencies at 6 Months in SG vs RYGB

When comparing the two surgical techniques, RYGB showed greater weight reduction than SG. SG patients' BMI decreased from 45.98 to 38.58 kg/m², and RYGB patients from 49.37 to 36.76 kg/m², both with P < 0.001. The excess weight loss (EWL%) was significantly higher in RYGB (39.90%) compared to SG (28.42%, P < 0.001), indicating superior short-term weight loss with RYGB. In terms of micronutrients, vitamin B12 levels increased significantly in SG patients (P = 0.002) and declined significantly in RYGB patients (P < 0.001), suggesting better nutrient retention with SG. Vitamin D levels decreased in SG (P = 0.001) but rose nonsignificantly in RYGB (P = 0.195). Iron levels dropped in both groups, with significance in both SG (P = 0.004) and RYGB (P < 0.001). Hemoglobin improved in SG (P = 0.022) but worsened in RYGB (P < 0.001). Calcium levels remained stable in SG but declined significantly in RYGB (P < 0.001). These comparisons are summarized in Table 2.

Table 1: Comparison of Preoperative and Postoperative Parameters in the Full Cohort

Variables	Baseline Mean ± SD or Median ± IQ	6 months Mean ± SD or Median ± IQ	P
BMI (kg/m^2)	47.68 ± 7.71	37.67 ± 7.35	<0.001
Vit B12 (pg/mL)	496.27 ± 184.63	503.63 ± 196.10	0.440
Vit D (nmol/L)	32.20 ± 26.75	37.00 ± 32.75	0.001
Hemoglobin (g/dl)	12.88 ± 0.73	12.70 ± 1.15	0.164
Iron (µg/dL)	77.00 ± 38.25	69.50 ± 31.75	<0.001
Calcium (mg/dL)	8.90 ± 0.38	8.50 ± 0.78	<0.001
Vit D deficiency ®	37 (61.7%)	50 (83.3%)	<0.001
Vit B12 deficiency ®	2 (3.3%)	6 (10%)	0.055
Iron deficiency	23 (38.3%)	32 (53.3%)	<0.001
Anemia ®	14 (23.3%)	21 (35%)	0.481

Table 2: Preoperative vs Postoperative Nutritional Profile by Surgical Type

Variable	SG		P	RYGB		P
	Baseline	6 months		baseline	6 months	
BMI (kg/m^2)	45.98 ± 7.18	38.58 ± 7.12	<0.001	49.37 ± 8.00	36.76±7.60	<0.001
Vit B12 (pg/mL)	505.13±179.73	555.37±188.42	0.002	487.4±192.05	451.90±192.87	<0.001
25-OH-Vit D (nmol/L)	41.00 ± 34.80	32.75 ± 22.75	0.001	34.00 ± 32.50	39.50 ± 33.25	0.195
Iron (µg/dL)	70.00 ± 43.25	61.60 ± 43.50	0.004	78.00±32.25	72.00 ± 26.75	<0.001
Hemoglobin (g/dL)	12.90 ± 0.78	13.34 ± 1.12	0.022	12.86 ± 0.69	12.06 ± 0.78	<0.001
Calcium (mg/dL)	8.9 ± 0.30	8.7 ± 0.53	0.273	8.9 ± 0.68	8.3 ± 0.65	<0.001

Table 3: Postoperative (6-Month) Nutritional Deficiencies Between SG and RYGB Groups

Variables	Sleeve Gastrectomy (N=30) Mean ± SD/ N+%.	Roux-en-Y Gastric Bypass (N=30) Mean ± SD/ N+%.	P
BMI pre-op(kg/m^2)	45.98 ± 7.18	49.37 ± 8.00	0.088
BMI at 6 months post-op (kg/m^2)	38.58 ± 7.12	36.76± 7.60	0.340
EWL (%)	28.42 ± 12.43	39.90 ± 10.82	<0.001
Vitamin D deficiency at 6 months (N(%))®	28 (93.33%)	22 (73.33%)	0.038
Iron deficiency at 6 months (N(%))®	18 (60%)	14 (46.67%)	0.301
Vitamin B12 deficiency at 6 months (N(%))®	1 (3.33%)	5 (16.67%)	0.085
Anemia at 6 months (N(%))®	5 (16.67%)	16 (53.33%)	0.003
Serum Iron pre-op (µg/dL)	70.00 ± 43.25	78.00 ± 32.25	0.193
Serum Iron at 6 months (µg/dL)	61.60 ± 43.50	72.00 ± 26.75	0.294
25-OH-VitD pre-op (nmol/L)	41.00 ± 34.80	34.00 ± 32.50	0.947
25-OH-VitD at 6 months (nmol/L)	32.75 ± 22.75	39.50 ± 33.25	0.695
Vitamin B12 pre-op (pg/mL)	505.13 ± 179.73	487.4 ± 192.05	0.713
Vitamin B12 at 6 months (pg/mL)	555.37 ± 188.42	451.90 ± 192.87	0.040
Hemoglobin pre-op (g/dL)	12.90 ± 0.78	12.86 ± 0.69	0.821
Hemoglobin at 6 months (g/dL)	13.34 ± 1.12	12.06 ± 0.78	<0.001
Calcium pre-op (mg/dL)	8.9 ± 0.30	8.9 ± 0.68	0.617
Calcium at 6 months (mg/dL)	8.7 ± 0.53	8.3 ± 0.65	0.014

Further analysis of 6-month postoperative nutritional deficiencies confirmed that SG was associated with fewer adverse outcomes. Vitamin D deficiency was paradoxically more frequent in SG (93.3%) than RYGB (73.3%, P = 0.038), while anemia was significantly more common in RYGB (53.3%) compared to SG (16.7%, P = 0.003). Vitamin B12 deficiency was higher in RYGB (16.67%) than SG (3.33%), though this was not statistically significant (P = 0.085). Iron deficiency rates were also numerically higher in SG but not statistically significant. These results suggest that RYGB patients are more prone to anemia and calcium-B12 deficiencies, while SG patients might have higher risk of vitamin D deficiency, potentially due to differences in fat metabolism or compliance with supplementation. These distinctions are shown in Table 3.

Both Sleeve Gastrectomy (SG) and Roux-en-Y Gastric Bypass (RYGB) were effective in achieving significant reductions in body mass index (BMI), confirming their efficacy as weight-loss interventions. However, RYGB demonstrated greater excess weight loss compared to SG, indicating superior weight-reduction outcomes in the short term. This benefit, however, was offset by a higher prevalence of nutritional complications. Patients who underwent RYGB were more likely to experience deficiencies in key micronutrients, particularly vitamin B12, calcium, and iron, and showed a significantly higher incidence of anemia at six months postoperatively.

In contrast, SG was more favorable in terms of micronutrient preservation. Patients who underwent SG maintained better hemoglobin and vitamin B12 levels, suggesting that the anatomical integrity of the gastrointestinal tract in SG may help retain nutrient absorption capacity. Despite this, vitamin D deficiency remained a persistent issue in both groups, with a surprisingly higher prevalence observed in SG patients by the six-month follow-up, likely due to factors like rapid fat loss and insufficient supplementation or sunlight exposure.

Additionally, calcium and iron absorption were significantly impaired in RYGB patients, attributable to the surgical bypass of primary absorption sites such as the duodenum and proximal jejunum. These findings collectively underscore the critical importance of individualized, procedure-specific nutritional counseling and aggressive micronutrient supplementation. Long-term follow-up is essential—especially for RYGB patients in resource-limited settings—to detect and manage deficiencies early and ensure optimal recovery and health outcomes.

DISCUSSION

This study aimed to assess and compare the impact of Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) on micronutrient deficiencies and weight loss outcomes over a 6-month period. The findings demonstrate that while both procedures are effective for weight loss, they are associated with a significant increase in the incidence of postoperative micronutrient deficiencies, particularly among patients undergoing RYGB.

Our study found that the incidence of overall micronutrient deficiencies increased from 62 preoperatively to 88 postoperatively. Notably, vitamin D and iron deficiencies were significantly more prevalent after surgery, aligning with previously published reports[12,13]. Bariatric surgery, particularly RYGB, is known to affect the absorption of fat-soluble vitamins (such as vitamin D) and minerals (such as iron) due to bypassing parts of the small intestine responsible for their absorption[14]. The marked increase in vitamin D deficiency from 61.7% to 83.3% postoperatively is concerning and highlights the need for aggressive supplementation and monitoring strategies, especially in populations with pre-existing low levels. Vitamin D deficiency is common in patients after bariatric surgery. However, obesity itself has also been associated with decreased vitamin D these findings are consistent with a study conducted by Goldner et al.[15]

Iron deficiency also increased significantly (38.3% to 53.3%), with a particularly high incidence of anemia among RYGB patients (53.3%) compared to SG (16.7%) at 6 months. This difference can be attributed to the anatomic changes in RYGB, which bypass the duodenum and proximal jejunum—critical sites for iron absorption—thus predisposing patients to early-onset iron deficiency anemia[16]. Our findings are consistent with a systematic review by Weng et al., which reported higher rates of anemia and iron deficiency after RYGB[17].

Hemoglobin and calcium levels were also significantly lower in RYGB patients compared to SG. Hypocalcemia in RYGB may be due to decreased absorption of calcium and vitamin D as a result of duodenal exclusion[18]. As calcium absorption is vitamin D-dependent, concurrent deficiencies compound the problem. Lower hemoglobin values among RYGB patients further underscore the necessity of routine anemia screening and early iron supplementation.

Vitamin B12 deficiency is another common concern in bariatric patients, particularly post-RYGB, where intrinsic factor production and gastric acid are reduced. Our data showed significantly lower B12 levels postoperatively in RYGB patients (451.90 ± 192.87 pg/mL) than SG patients (555.37 ± 188.42 pg/mL, P=0.040). Interestingly, B12 levels significantly increased in SG patients postoperatively (P=0.002), suggesting that SG may have a lesser impact on intrinsic factor secretion or that B12 supplementation is more effective in this group. These results are in line with other studies that have reported more pronounced B12 deficiency following RYGB due to altered gastrointestinal anatomy[19].

In terms of weight loss, RYGB showed significantly greater excess weight loss (EWL%) compared to SG (39.90% vs. 28.42%, P<0.001). This is consistent with the literature, which generally supports superior weight loss outcomes with RYGB, especially in the early postoperative period (20,21). However, this benefit must be weighed against the increased risk of nutritional deficiencies. Importantly, our analysis revealed a statistically significant association between EWL and vitamin D deficiency (P=0.031), suggesting that rapid weight loss might exacerbate fat-soluble vitamin depletion.

Sociodemographic characteristics, such as age, sex, income, and education level, showed no significant association with postoperative outcomes, indicating that procedure type may be the primary determinant of nutritional risk.

Overall, this study reinforces the importance of comprehensive preoperative assessment, individualized surgical selection, and postoperative monitoring. SG may be associated with fewer nutritional complications, while RYGB requires more rigorous follow-up and supplementation strategies. A multidisciplinary approach involving dietitians, surgeons, and primary care providers is essential for optimizing outcomes and minimizing long-term complications.

CONCLUSION

This study demonstrates the grave issue of micronutrient deficiencies after bariatric surgeries and the need to tackle them accordingly with appropriate supplements. The high incidence of preoperative deficiencies augments the need to screen bariatric surgery candidates for micronutrient deficiencies. Furthermore, SG may be associated with improved B12 levels and a decreased incidence of anemia postoperatively, whereas RYGB may have better weight loss outcomes.

Informed Consent: Written informed consent was obtained from all individual participants included in the study after fully explaining the objectives, benefits, and potential risks.

Author Contributions: All authors contributed equally to the conception, design, data collection, analysis, and interpretation of the study. They also participated in drafting, revising, and approving the final manuscript.

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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