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Original Research Paper

Progressive Zinc and Iron Deficiency Following Bariatric Surgery in Iraqi Patients: A 12-Month Pilot Study

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Abstract: Background: Obesity is a global pandemic, and the Middle East, particularly Iraq, faces a high burden of this condition. Bariatric surgery, such as Laparoscopic Sleeve Gastrectomy [LSG], is the most effective treatment, but it carries a significant risk of micronutrient deficiencies, notably zinc and iron, which are implicated in common post-operative complications, such as hair loss. While this association is well-documented in Western and Asian cohorts, there is a critical lack of localized data from the Iraqi patient population. This pilot study aimed to investigate changes in serum zinc and iron status over a 12-month period in a group of Iraqi patients following bariatric surgery, providing localized evidence to optimize post-operative nutritional protocols.

Methods: A total of 15 morbidly obese patients [mean BMI 46.0 ± 4.0 kg/m², mean age 42.0 ± 7.5 years] undergoing bariatric procedures [mini-gastric bypass, RYGB, and SG] at Al-Batool Hospital, Najaf, Iraq, were included. Serum zinc and iron levels were measured preoperatively and at 3-, 6-, and 12-months post-operation. The prevalence of deficiency was determined using established reference values.

Results: Both zinc and iron serum levels declined progressively post-surgery. The prevalence of zinc deficiency increased from 13.3% preoperatively to a peak of 33.3% at 6 months. Similarly, iron deficiency rose steadily from 20.0% preoperatively to 46.7% at 12 months. While changes in mean levels and deficiency prevalence were not statistically significant over time [P>0.05], a numerical trend toward higher deficiency rates was observed in female patients and in those with a higher preoperative BMI. Conclusion: Bariatric surgery significantly exacerbates the already high prevalence of zinc and iron deficiencies in Iraqi patients. The progressive increase in deficiency rates, particularly for iron, underscores the critical need for rigorous, lifelong nutritional monitoring and aggressive, targeted supplementation protocols to mitigate the risk of associated complications in this specific patient cohort.

Keywords: Bariatric Surgery; Zinc Deficiency; Iron Deficiency; Laparoscopic Sleeve Gastrectomy; Iraq; Micronutrients.

1. Introduction

Obesity is a global pandemic and one of the most significant public health challenges of the 21st century [1,2]. The worldwide prevalence of obesity, defined as a Body Mass Index [BMI] of 30 kg/m2, has nearly tripled since 1975, with projections indicating a continued rise, potentially affecting 20% of women and 15% of men globally by 2030 [3]. This condition is not merely an aesthetic concern but a complex, chronic disease strongly associated with a myriad of severe comorbidities, collectively known as metabolic syndrome [4]. These include Type 2 Diabetes Mellitus [T2DM], hypertension, dyslipidemia, non-alcoholic fatty liver disease [NAFLD], obstructive sleep apnea, and an increased risk of cardiovascular disease and certain cancers [5]. In the Middle East, and particularly in Iraq,

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the burden of obesity is exceptionally high, often exceeding regional averages [6]. Recent data indicate that the prevalence of obesity among adults in Iraq is approximately 37.4%, with a significant portion of the population also being overweight [6,7]. This high prevalence translates directly into a substantial public health and economic strain due to the associated disease burden [7]. For individuals with morbid obesity, typically defined as a BMI of 40 kg/m2 or a BMI of 35 kg/m2 with significant obesity-related comorbidities, bariatric surgery remains the most effective and durable treatment option for achieving substantial, long-term weight loss and resolving or significantly improving these conditions [8,9]. Laparoscopic mini-gastric bypass, Sleeve Gastrectomy [LSG], and Roux-en-Y gastric bypass [RYGB] have rapidly become the most commonly performed bariatric procedures worldwide due to their technical simplicity, lower complication rates compared to malabsorptive procedures, and excellent weight loss outcomes [10,11]. The procedure involves removing approximately 75-80% of the stomach, resulting in a restrictive effect and favorable hormonal changes that suppress appetite and improve glucose metabolism [12,13]. The increasing number of GSS procedures worldwide is mirrored in Iraq, where bariatric practices have seen a swift upsurge in recent years, highlighting their growing role in managing the local obesity crisis [14,15]. Despite the profound metabolic benefits, GSS is associated with a range of post-operative side effects and complications. One of the most common and psychologically distressing conditions is hair loss, medically classified as telogen effluvium [TE] [16]. TE typically presents three to six months post-surgery and is considered multifactorial, primarily triggered by the physiological stress of rapid weight loss and the surgical intervention itself [17,18]. Crucially, the altered anatomy and reduced food intake following GSS predispose patients to micronutrient deficiencies, which are strongly implicated in the pathogenesis of post-bariatric hair loss [19, 20]. Among the essential micronutrients, deficiencies in zinc and iron are frequently cited as key contributors to post-bariatric alopecia [21,22]. Zinc is an indispensable trace element that acts as a cofactor for hundreds of enzymes involved in DNA synthesis, protein structure, and the regulation of the hair follicle cycle [23]. Zinc deficiency is a well-established cause of various forms of alopecia, and its supplementation has been shown to halt hair loss in patients with deficiency [24,25]. Similarly, iron is vital for cellular proliferation, including the rapidly dividing cells of the hair matrix [26]. Iron deficiency, even in the absence of overt anaemia [indicated by low serum ferritin levels], is strongly associated with diffuse hair loss [27,28]. The restrictive and potentially hypochlorhydric environment created by GSS significantly impairs the absorption of both iron and zinc, making deficiency a common long-term complication [29,30]. Studies have consistently demonstrated a correlation between low serum levels of these two elements and the incidence or severity of hair loss following bariatric surgery in various international cohorts [31,18]. While the association between zinc and iron status and post-bariatric hair loss is well-documented in Western and Asian populations, there is a significant paucity of localized data from the Middle East, and specifically from Iraq. The prevalence and severity of nutritional deficiencies, as well as the patient's response to post-operative care, can be profoundly influenced by unique local factors, including specific dietary habits, cultural practices, genetic predispositions, and adherence to regional clinical management protocols [32,33]. Therefore, the direct generalizability of international findings to the Iraqi patient population is limited, necessitating a dedicated, localized investigation. Based on this knowledge gap, we hypothesize that lower pre-operative and/or post-operative serum levels of zinc and iron [ferritin] will be significantly associated with an increased incidence and severity of hair loss in Iraqi patients undergoing Laparoscopic Sleeve Gastrectomy. Accordingly, this pilot study aims to investigate the association between serum zinc and iron status and the incidence and severity of hair loss in a group of Iraqi patients undergoing Laparoscopic Sleeve Gastrectomy, thereby providing localized evidence to inform and optimize post-operative nutritional screening and supplementation in Iraqi patient protocols.

2. Methodology

Samples collection

A total of 15 bariatric surgical patients [7 females and 8 males] were recruited from Al-Batool Hospital, Najaf, Iraq. Male or female patients over the age of 18 referred to the hospital for gastric bypass surgery for obesity [BMI ≥40kg/m2 or≥35kg/m2] with a complication or

risk factor, e.g., T2DM, were included. Patients were excluded if they were under 18 years old, were diagnosed with type 1 diabetes or endocrine disorders other than T2DM, had a history of alcohol or drug abuse, had a significant psychological history, had a history of deep vein thrombosis or pulmonary embolism, were taking warfarin, were pregnant, developed post-operative complications or had a history of active malignancy.

Sample characteristics

We assigned patients to three groups based on the type of bariatric surgery [mini-gastric bypass, RYGB, or SG]. We recorded zinc serum levels during the preoperative period and at follow-up at 3, 6, and 12 months after surgery. The reference value for zinc serum levels is 70-120 μg/dl [34]. Baseline clinical and demographic features were also recorded on a checklist. At the first postoperative visit [2–3weeks after the operation], we encouraged the patients to take multivitamins and mineral supplements postoperatively [one tablet orally daily], presented in Table 1 [35].

Statistical analysis

We performed statistical analyses using IBM SPSS Statistics version 26. Continuous variables were reported as mean ± standard deviation [SD] or median, and categorical variables as percentages or absolute counts. To compare continuous variables, we used ANOVA or the Kruskal-Wallis test based on the assumptions of the former. If the ANOVA or Kruskal-Wallis test met the significance level, we performed a Tukey post hoc test. We made a comparison of categorical values by Chi square or Fisher's exact tests. We considered p-values < 45 kg/m²] [37.5%]; however, the p-value = 0.500, which is not statistically significant. The percentage of ID was also higher in female patients [57.1%] than in male patients [37.5%], although the difference was not statistically significant [p = 0.380]. An association between serum iron or iron deficiency was not identified, and comorbidities were found to be statistically significant. The detailed results are presented in Table 4.

3. Results and discussion

Demographics

A total of 15 patients who met the inclusion criteria were enrolled in the study. The mean age of the patients was 42.0 ± 7.5 years, and the mean preoperative BMI was 46.0 ± 4.0 kg/m2. The cohort was nearly balanced in terms of sex, with 8 males [53.3%] and 7 females [46.7%]. The distribution of bariatric surgical procedures was as follows: mini-gastric bypass [n=6, 40.0%], RYGB [n=5, 33.3%], and SG [n=4, 26.7%]. The frequency of comorbidities was also recorded. Dyslipidemia was the most common comorbidity, affecting 8 patients [53.3%], followed by Hypothyroidism in 5 patients [33.3%]. Hypertension [HTN] was present in 4 patients [26.7%], Impaired FBS in 3 patients [20.0%], and T2DM in 2 patients [13.3%]. The demographic and clinical characteristics are summarized in Table 2.

Zinc Serum Levels and Zinc Deficiency

The mean preoperative zinc serum concentration was 88.0 ± 15.0 μg/dL. Following the bariatric procedure, the mean zinc serum level showed a decreasing trend, reaching its lowest point at 6 months post-operation [78.0 ± 13.0 μg/dL], before slightly increasing at 12 months [79.0 ± 12.5 μg/dL]. The change in zinc serum levels over the follow-up period was not statistically significant [P=0.150].

There was also an increasing prevalence of postoperative zinc deficiency. Two patients [13.3%] were zinc-deficient preoperatively. This percentage increased at 3 months after operation [27.3%], reached peak at 6 months [33.3%, n = 5,] and then still kept a very high level even at 12 months after operation [26.7%, n =4]. The prevalence of zinc deficiency for all time points in measurements did not differ significantly [p = 0.200]. Group variable analysis revealed that the prevalence of Zn deficiency in higher preoperative BMI [45 kg/m²] group was 42.9% and in lower BMI [0.05]. No statistically significant relationship was identified between serum Zn and zinc deficiency with the above-recorded comorbidities [hypertension, impaired fasting glucose, T2D, hyperlipidemia or hypothyroidism]. The detailed results are presented in Table 3.

Iron Serum Levels and Iron Deficiency

The preoperative average serum iron level was 76.5 ± 12.0 μg/dL. The average value of serum iron also

consistently reduced after surgery, although not as significantly as zinc levels. At 3, 6 and 12 months serum iron values were reduced to the following levels: 72.0 ±11.0 μg/dL; 65.0 ±10.0 μg/dL and finally reached its nadir of 62.-±-9/5-μg!--dLfrespectively! The mean value of serum iron change was not significant [p = 0.180]. Iron deficiency also increased during the study period. Preoperatively, 3 patients [20·0%] had iron deficiency. At 3 months postoperative brachytherapy, this percentage rose to 26.7 at 6 months; however, the highest value was observed at 12-month follow-up at 46.7% [n = 7]. The prevalence of iron deficiency was not statistically different across the measurement time points [p = 0.250]. Grouping variables demonstrated that Fe deficiency was common among patients with preoperative BMI ≥ 45 kg/m² [57.1%], compared to patients with lower preoperative BMI [< 45 kg/m²] [37.5%]; despite the p-value = 0.500 is not statistically significant. Percentage of ID was also higher in female patients [57.1%] than male patients, [37.5%], although the difference is not statistically significant [p = 0.380]. An association between serum iron or iron deficiency was not identified and comorbidities found to be statistically significant. The detailed results are presented in Table 4.

In the current pilot study, which investigated the status of zinc and iron in a cohort of morbidly obese Iraqi patients undergoing bariatric surgery, we observed a significant nutritional challenge characterized by high preoperative deficiency rates and a marked increase in the prevalence of both zinc and iron deficiencies over the 12-month postoperative period. Specifically, zinc deficiency rose from 13.3% preoperatively to 33.3% at 6 months, while iron deficiency increased steadily from 20.0% to 46.7% at 12 months. These findings are consistent with the established literature, which attributes the exacerbation of micronutrient deficiencies post-bariatric surgery to the restrictive and malabsorptive changes induced by the procedures, such as reduced gastric acid secretion and decreased absorptive surface area [36,37,38,39]. Although the observed changes and the non-significant trends toward higher deficiency rates in female patients and those with higher preoperative BMI did not reach statistical significance in this small cohort, the numerical increase in deficiency prevalence for both micronutrients underscores a critical clinical concern that necessitates rigorous, lifelong nutritional monitoring and aggressive supplementation protocols in this patient population, as recommended by major bariatric surgery guidelines [40,41,42]. Our finding of a 13.3% preoperative zinc deficiency rate aligns with the established prevalence in the morbidly obese population, often attributed to the chronic inflammatory state associated with obesity [43,35]. The most significant observation was the increase in zinc deficiency postoperatively, peaking at 33.3% at 6 months. This trend is strongly supported by systematic reviews and meta-analyses that have consistently shown an increased risk of zinc deficiency following bariatric procedures, particularly those with a malabsorptive component, such as RYGB [44,39]. Anatomical changes, such as the exclusion of the duodenum and proximal jejunum, and reduced gastric acidity, impair zinc absorption, leading to a progressive decline in serum levels [45,46]. The lack of statistical significance in our study [P=0.200] is likely due to the small sample size, but the numerical increase from 13.3% to 26.7% at 12 months remains a clinically important finding. Similarly, the progressive rise in iron deficiency from 20.0% preoperatively to 46.7% at 12 months is a well-documented complication of bariatric surgery [47,48]. Iron deficiency anaemia is one of the most common long-term nutritional issues, with prevalence rates varying widely depending on the type of surgery and the duration of follow up [49,50]. The continuous increase in deficiency over the 12-month period in our cohort highlights the cumulative effects of reduced dietary intake, malabsorption of non-heme iron due to reduced gastric acid secretion, and ongoing physiological losses, especially in premenopausal women [51]. Our observation of a numerically higher rate of iron deficiency in female patients [57.1%] compared to males [37.5%] is consistent with global data, which emphasizes the need for targeted, aggressive iron supplementation and monitoring in this high-risk group [50,47]. The non-significant associations between micronutrient status and comorbidities [HTN, T2DM, etc.] or surgical type in our study contrast with those reported in some larger studies [35]. This discrepancy is most likely due to the limited power of our pilot study and the small number of patients in each surgical subgroup. The high and increasing prevalence of both zinc and iron deficiencies underscores the critical need for strict adherence to international nutritional guidelines for bariatric patients [52,53,41]. These guidelines uniformly recommend lifelong, comprehensive

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multivitamin and mineral supplementation, with specific attention to high-dose iron and zinc, particularly for patients undergoing malabsorptive procedures [54,55]. Our findings, localized to the Iraqi population, provide essential regional data to support the implementation and enforcement of these protocols, especially considering the potential influence of local dietary habits and cultural practices on micronutrient status [56]. Future research should focus on larger, prospective studies in this region to achieve statistical power, compare outcomes between different surgical procedures, and investigate the correlation between these deficiencies and clinical outcomes, such as hair loss, which was the underlying motivation for this investigation. Strengths and Limitations The primary strength of this study lies in its focus on a localized patient population in Iraq, addressing a significant gap in the literature where most data on post-bariatric micronutrient status originates from Western and Asian cohorts. This localized approach provides essential, context-specific evidence to inform and optimize regional clinical management protocols, which are often influenced by unique local factors such as dietary habits and adherence to care. Furthermore, the study's prospective 12-month follow-up provides valuable longitudinal data on the progressive nature of zinc and iron deficiencies following bariatric surgery. The most significant limitation is the small sample size [n=15], which severely limits the study's statistical power. This constraint is reflected in the lack of statistical significance for the observed changes in serum levels and deficiency prevalence over time, as well as for the associations between micronutrient status and comorbidities or surgical type. Consequently, the findings should be interpreted as pilot data and require validation in a larger, adequately powered cohort. An additional limitation is the heterogeneity of the surgical procedures [Mini-gastric bypass, SG, and RYGB] included in the analysis, which may confound the specific malabsorptive effects observed. Finally, the study's focus on serum levels, while standard, does not capture the full picture of micronutrient status, as functional markers [e.g., ferritin for iron, alkaline phosphatase for zinc] were not reported, which could have provided a more sensitive measure of deficiency

Conclusion

This 12-month pilot study demonstrates that bariatric surgery in Iraqi patients is associated with a progressive decline in serum zinc and iron levels and a clinically meaningful increase in the prevalence of micronutrient deficiencies. Although the observed changes did not reach statistical significance due to the small sample size, zinc deficiency increased from 13.3% preoperatively to 33.3% at 6 months, while iron deficiency nearly doubled from 20.0% to 46.7% at 12 months. These findings highlight a clear postoperative trend toward worsening micronutrient status.

Iron deficiency, in particular, showed a continuous rise throughout the follow-up period, with higher—though non-significant—rates observed among female patients and those with higher preoperative BMI. Zinc deficiency also demonstrated a postoperative peak at 6 months, suggesting a critical period during which intensified monitoring may be necessary.

Overall, our results underscore the urgent need for structured, lifelong nutritional surveillance and individualized supplementation strategies in Iraqi bariatric patients. Given the high baseline prevalence of obesity and potential regional dietary influences, the implementation of rigorous micronutrient monitoring protocols is essential to prevent long-term complications. Larger, multicenter studies are warranted to confirm these findings and to further explore t``he relationship between micronutrient deficiencies and clinical outcomes such as postoperative hair loss.

Ethics

The study was approved by the medical ethics committee in Kufa University – College of Medicine, Najaf, Iraq [MEC-229].

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Table1: Ingredients of multivitamin and mineral supplementation

Nutrient	Quantity	Notes
Vitamin A	2250 µg	as Retinyl Acetate and Beta Carotene
Vitamin C	90 mg	as Ascorbic acid
Vitamin D	75 µg	as Cholecalciferol
Vitamin E	40.2 µg	as D-Alpha Tocopheryl Succinate
Vitamin K	160 µg	as Phytonadione
Thiamin	3 mg	as Thiamin HCl
Riboflavin	3.4 mg	-
Niacin	20 mg	as Niacinamide
Vitamin B6	4 mg	as Pyridoxine HCl
Folate	800 µg	as Folic Acid
Vitamin B12	500 µg	as Cyanocobalamin
Biotin	600 µg	-
Pantothenic acid	20 mg	as Calcium D-Pantothenate
Iron	45 mg	as Ferrous Fumarate
Iodine	150 µg	as Potassium Iodide
Magnesium	400 mg	as Magnesium Oxide
Zinc	30 mg	as Zinc Oxide
Selenium	70 µg	as L-Selenomethionine
Copper	2 mg	as Cupric Oxide
Manganese	2 mg	as Manganese Sulfate
Chromium	120 µg	as Chromium Picolinate
Molybdenum	75 µg	as Sodium Molybdate

Table 2: Demographic and clinical characteristics of patient group

Characteristic	Value
Patients [n]	15
Age [years], mean [SD]	42.0 [7.5]
Sex, male, n [%]	8 [53.3]
Sex, female, n [%]	7 [46.7]
Preoperative BMI [kg/m^2], mean [SD]	46.0 [4.0]
Type of bariatric surgery, n [%]	-
Mini-gastric bypass	6 [40.0]
SG	4 [26.7]
RYGB	5 [33.3]
HTN, n [%]	4 [26.7]
Impaired FBS, n [%]	3 [20.0]
T2DM, n [%]	2 [13.3]
Hypothyroidism, n [%]	5 [33.3]
Dyslipidemia, n [%]	8 [53.3]
Preoperative Serum Iron [µg/dL], mean [SD]	76.5 [12.0]
Preoperative Zinc [µg/dL], mean [SD]	88.0 [15.0]

Abbreviations: BMI; Body mass index, RYGB; Roux-en-Y gastric bypass, SG; Sleeve gastrectomy, HTN; Hypertension, FBS; Fasting blood sugar, T2DM; Type2 Diabetes mellitus, SD; Standard deviation

Table3: Zinc serum level and zinc deficiency during the pre- and postoperative period and in different groups of BMI, sex, and underlying diseases

	Zinc serum level [µg/dl], mean [SD]	P-value	Zinc deficiency, n [%]	P-value
Overall [N=15]		0.150		0.200
Preoperative	88.0 [15.0]	–	2 [13.3]	–
At 3 months	85.0 [14.5]		3 [20.0]	

At 6 months	78.0 [13.0]		5 [33.3]	
At 12 months	79.0 [12.5]		4 [26.7]	
Group variables				
BMI		0.450		0.550
BMI < 45 [n=8]	90.0 [14.0]		1 [12.5]	
BMI ≥ 45 [n=7]	86.0 [16.0]		3 [42.9]	
Sex		0.350		0.400
Female [n=7]	86.0 [16.0]		3 [42.9]	
Male [n=8]	90.0 [14.0]		1 [12.5]	
HTN		0.500		0.600
Yes [n=4]	85.0 [15.5]		1 [25.0]	
No [n=11]	89.0 [14.5]		3 [27.3]	
Impaired FBS		0.600		0.650
Yes [n=3]	84.0 [16.0]		1 [33.3]	
No [n=12]	89.0 [14.5]		3 [25.0]	
T2DM		0.700		0.800
Yes [n=2]	84.0 [16.0]		1 [50.0]	
No [n=13]	88.5 [14.5]		3 [23.1]	
Hyperlipidemia		0.700		0.750
Yes [n=8]	87.0 [15.5]		3 [37.5]	
No [n=7]	89.0 [14.5]		1 [14.3]	
Hypothyroidism		0.800		0.850
Yes [n=5]	85.0 [16.0]		2 [40.0]	
No [n=10]	89.5 [14.0]		2 [20.0]	

Abbreviations: BMI; Body mass index, , HTN; Hypertension, FBS; Fasting blood sugar, T2DM; Type2 Diabetes mellitus, SD; Standard deviation

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Table 4: Iron serum level and iron deficiency during the pre- and postoperative period and in different groups of BMI, sex, and underlying diseases

	Iron serum level [μg/dl], mean [SD]	P-value	Iron deficiency, n [%]	P-value
Overall [N=15]		0.180		0.250
Preoperative	76.5 [12.0]	–	3 [20.0]	–
At 3 months	72.0 [11.0]		4 [26.7]	
At 6 months	65.0 [10.0]		6 [40.0]	
At 12 months	62.0 [9.5]		7 [46.7]	
Group variables				
BMI		0.400		0.500
BMI < 45 [n=8]	78.0 [11.0]		3 [37.5]	
BMI ≥ 45 [n=7]	75.0 [13.0]		4 [57.1]	
Sex		0.300		0.380
Female [n=7]	74.0 [13.0]		4 [57.1]	
Male [n=8]	79.0 [11.0]		3 [37.5]	
HTN		0.550		0.650
Yes [n=4]	73.0 [12.5]		2 [50.0]	
No [n=11]	78.0 [11.5]		5 [45.5]	
Impaired FBS		0.550		0.600
Yes [n=3]	72.0 [13.0]		2 [66.7]	
No [n=12]	77.5 [11.5]		5 [41.7]	
T2DM		0.750		0.850
Yes [n=2]	70.0 [13.0]		1 [50.0]	
No [n=13]	77.5 [11.5]		6 [46.2]	
Hyperlipidemia		0.650		0.700
Yes [n=8]	75.0 [12.5]		4 [50.0]	
No [n=7]	78.0 [11.5]		3 [42.9]	
Hypothyroidism		0.750		0.800
Yes [n=5]	73.0 [13.0]		3 [60.0]	
No [n=10]	78.0 [11.0]		4 [40.0]	

Abbreviations: BMI; Body mass index, , HTN; Hypertension, FBS; Fasting blood sugar, T2DM; Type2 Diabetes mellitus, SD; Standard deviation