Original Article

The remission rate, metabolic changes, and quality of life assessment among patients with type 2 diabetes post-bariatric surgery in Riyadh, Saudi Arabia

A cross-sectional study

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ABSTRACT

الأهداف: تقييم معدل الشفاء والتغيرات الأيضية ونوعية الحياة بعد جراحة السمنة بين المرضى السعوديين المصابين بداء السكري من النوع 2 (T2DM)

المنهجية: أجريت هذه الدراسة المقطعية في مركزين رئيسيين في منطقة الرياض بالمملكة العربية السعودية. شملت الدراسة مرضى T2DM الذين خضعوا إما لجراحة تكميم المعدة بالمنظار (LSG) أو جراحة المجازة المعدية (RYGB) من 2014م إلى 2018م. تم تحديد معدل الشفاء بناءً على معايير جمعية السكري الأمريكية (ADA) ومعايير منظمة السكري الدولية (IDF). تم تقييم جودة الحياة باستخدام منظمة الصحة العالمية لجودة الحياة (WHOQOL – BREF).

النتائج: تضمنت الدراسة 232 مريضا بمتوسط عمر 44.3±10.3 سنة. 93.4% من المرضى خضعوا لجراحة LSG ، بينما 6.6% فقط خضعوا لجراحة RYGB. من بين المرضى الذين خضعوا لجراحة LSG أو RYGB ، كان هناك تحسن كبير في علامات التمثيل الغذائي ونسبة السكر في الدم مقارنة بمجموعة التحكم الأساسية. وفقًا لمعايير ADA ، كان 48.5% من المرضى قد تعافوا تمامًا، بينما كان 18.9% لديهم تعافي جزئي. بشكل عام ، استوفى 7% من المرضى معايير IDF ، بينما استوفى 5.7% معايير تحسين IDF. تجاوز متوسط الدرجة لجميع مجالات QOL 63 ± 13 ، مع حصول مجالات الصحة البيئية والمادية على أعلى الدرجات.

الخلاصة: بين المرضى السعوديين، ارتبطت جراحة السمنة بمعدلات شفاء عالية ونوعية حياة أفضل.

Objectives: To assess the remission rate, metabolic changes, and quality of life after bariatric surgery among Saudi patients with type 2 diabetes (T2DM).

Methods: This cross-sectional study was conducted in 2 main centers in the Riyadh, Saudi Arabia. The study included patients with T2DM who underwent either laparoscopic sleeve gastrectomy (LSG) or Roux-en-Y gastric bypass (RYGB) surgery from 2014 to 2018. The remission rate was defined based on the American Diabetes Association (ADA) and the International Diabetes Federation (IDF) criteria. Quality of life was assessed using the World Health Organization Quality of Life (WHOQOL)-BREF.

Results: A total of 232 patients were included with a mean age of 44.3 ± 10.3 years. 93.4% of the patients had LSG, while only 6.6% had RYGB surgery. Among patients who underwent either LSG or RYGB surgery, there was a significant improvement in metabolic and glycemic markers compared to the baseline. According to the ADA criteria, 48.5% of the patients had complete remission, while 18.9% had partial remission. Overall, 7% of the patients met the IDF optimization criteria, while 5.7% met the IDF improvement criteria. The mean score for all the QOL domains exceeded 63 ± 13, with the environmental and physical health domains having the highest scores.

Conclusion: Among Saudi patients, bariatric surgery was associated with high remission rates and a better quality of life.

Keywords: bariatric surgery, type 2 diabetes, diabetes remission, glycemic control, quality of life

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Obesity is associated with elevated risk factors for cardiovascular diseases, as well as increased morbidity and mortality.[1] Studies have indicated that an increase in body weight is related to increased mortality.[2] Treatment options for obesity include lifestyle modifications, medications, and bariatric surgery, with the last one being the most effective treatment.[3] Furthermore, obese patients have a higher risk for type 2 diabetes (T2DM) and bariatric surgery has been shown to have favorable effects on glycemic control in obese patients with T2DM.[2,4]

Retrospective cohort study proved that 50% of the included T2DM patients had a remission from diabetes after bariatric surgery within 2 to 4 months with low prevalence of relapse.[5] Owing to the advantages of the metabolic surgery such as the efficacy, safety, and cost-effectiveness, surgery was placed within the diabetes treatment algorithm, recommending surgery approach for patients with inadequately controlled diabetes and body mass index (BMI) ≥30 kg/m.[6] Therefore, a total of 53 leading diabetes and surgery societies worldwide have been officially ratified these new guidelines.[7] Thus, metabolic surgery should be recognized as an appropriate approach for T2DM in people with obesity.[8]

Type 2 diabetes is a growing pandemic.[9] Many diabetic patients fail to achieve glycemic and metabolic treatment goals that aim to reduce diabetes complications, despite increased options for pharmaceutical and non-pharmaceutical interventions. In order to lower cardiovascular morbidity and mortality and to be metabolically healthy as per the most recent recommendations, metabolic health was defined as having ideal blood pressure ≤20/80 mmHg, (<102/88 cm for men and women) circumference of the waist (WC), maintaining hemoglobin A1c (HBA1c) <5.7% and triglycerides (<150 mg/dL), without using any concomitant medications. With the adoption of narrower metabolic levels, only 12.2% of Amercians meet the metabolic health standards.[10]

Currently, Saudi Arabia is facing an epidemic of T2Dand obesity, with the overall diabetes prevalence reported to be 18% as per the International Diabetes Federation (IDF) 2019 report.[11] Moreover, in comparison to other Gulf Cooperation Council (GCC) nations, Saudi Arabia reports the greatest number of diabetes-related deaths.[11] Further, Saudi Arabia is one of the nations with the highest rates of overweight and obesity, ranked the 14th as per the World Health organization most recent data with a prevalence rate of 35.4%.[11] The highest reported prevalence of obesity in Saudi Arabia was 35.6%.[12] Both complications are costly and exhaust the healthcare system financially, Average annual healthcare costs ranged from 2165 to 7558 USD per patient for Saudis with any obesity-related complications. One of the most expensive obesity-related complications was type 2 diabetes, which had annual costs of between $4000 and $5333 per patient.[13] This would mean that the cost of obesity is even higher, since it is associated with other comorbidities other than diabetes, such as hypertension, dyslipidemia, and cardiovascular diseases. By comparison, In the United States, adult obesity-related medical expenses totaled $260.6 billion.[14] A study that estimated the cost in Saudi Arabia to be $19 billion annually also speculated an increase of $78 billion by 2060.[15]

Therefore, adopting more effective strategies to treat obesity and, consequently, prevent, and treat T2Dhas become one of the priorities for medicine in the 21st century. Recently, several studies have shown that those who were subjected to bariatric surgery demonstrated greater improvements in body weight, glycemic control diabetes remission, macrovascular and microvascular complications, and reduced mortality rates compared to patients receiving non-surgical management for obesity and diabetes treatment.[5,16,17] Further, bariatric surgery has been proven to be cost-effective, especially among people with diabetes based on their baseline severity compared to those without it.[18] Additionally, bariatric surgery is correlated with significant improvement in quality of life (QOL) In Saudi Arabia, bariatric surgery was found to be associated with significant reduction in HbA1c, mainly among patients with BMI reduction of ≥10 kg/m.[19,20]

Currently, there is well-established evidence that bariatric surgery can provide substantial weight loss, BMI reduction and Hb1Ac reduction; however, there is limited data on this topic among the Saudi population. Therefore, the main aim of this study was to assess the remission rate and metabolic changes related to weight loss after bariatric surgery among the Saudi population with type 2 diabetes. Additionally, we aimed to assess the quality of life after bariatric surgery among patients with type 2 diabetes.

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Methods. This is a cross-sectional, multicenter chart review study. The data were collected from 2 main centers in Riyadh, Saudi Arabia: Prince Sultan Bin Abdulaziz Humanitarian City (SBAHC) and Prince Sultan Military Medical City (PSMMC). The subjects were enrolled in the study if they: i) were of any gender, ii) were between the age of 18 and 65 years old, iii) had either LSG or RYGB surgical intervention during the period from January 2014 to January 2018, iv) were diagnosed with T2DM and on hypoglycemic agents, v) had a BMI ≥30 kg/m^2, and vi) had at least one year since the surgery. Patients were excluded if they i) had previously undergone bariatric surgery or other complex abdominal surgery, ii) were diagnosed with T1DM or latent adult autoimmune diabetes, iii) had malignancy, and iv) were pregnant. A total of 232 patients met our inclusion criteria, including 122 from SBAHC and 110 from PSMMC. Both institutions' Institutional Review Boards approved the study.

A reviewed and validated data collection form was used to collect the required patient's information. It contains 3 main sections. The first section included the patients' sociodemographic data: age, gender, level of education, and monthly household income, and so on. The second section included the patients' medical history: comorbidities, diabetes duration, diabetes complications, medication list, surgical history, and so on. The third section included anthropometric measurements such as weight, height, and BMI, as well as the metabolic markers (fasting blood glucose, HbA1c, lipid profile, thyroid function, kidney function, and liver enzymes) that were collected from the patients at the baseline before surgery and then 12 months post-surgery. The patients' files were revised by a team member specialized in health informatics to verify if the patients met the research inclusion criteria.

Quality of life assessment. The quality of life after the surgery was assessed using the World Health Organization Quality of Life (WHOQOL)-BREF questionnaire that was filled out by the patients through a telephone interview using the interview-administered form following the standardized instructions.[21] The 4 domains on which the WHOQOL-BREF is built. These points are included in the first domain's discussion of physical health (daily living activities, energy and exhaustion, mobility, sleep and rest, work capability, and so on). The second area of importance is psychological health, including thinking, learning, memory, and focus as well as body image, appearance, self-esteem, and spirituality. The third domain focuses on interpersonal interactions, including sexual activity and social support. The final domain is concerned with the environment (which includes material resources, liberty, physical safety and security, health and social care, involvement in recreational activities, physical environment, and so on).

Diabetes remission. Remission was defined by both the American Diabetes Association (ADA)and the International Diabetes Federation (IDF) criteria.[22,23] Partial or complete remission of T2DM was defined as per ADA criteria, which defines complete remission as HbA1c of <6% with fasting blood glucose (FBG) of <5.6 mmol/L, 100 mg/L and at least one year of absence of active pharmacological therapy, while the partial remission was defined as HBA1c of <6.5 and fasting blood glucose in the pre-diabetic stage 5.9–6.9 mmol/l (100–125 mg/dL).[22] The IDF criteria defined remission by either optimization or improvement, in which optimization is considered if following values hold: HbA1c <6%, total cholesterol <4 mmol/L, LDL <2.0 mmol/l, triglycerides <2.2 mmol/l, blood pressure <135/85 mmHg, >15% weight loss with reduced medications from pe-operated state with or without other medications. Improvement was considered if the following criteria were met: lowering HbA1c by 20%, LD of <2.3 mol/l, and blood pressure of <135/85 mmHg with reduced medications from the pre-operated state.[23]

Statistical analysis. The SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, N.Y., USA) was used for the statistical analysis. The means and standard deviations of continuous variables are displayed. Numbers and percentages are used to represent categorical variables. Continuous variables were compared between research groups using the t-test, while categorical variables were compared between study groups using the Chi-square test. The paired sample t-test was used to assess changes in clinical measures for patients at different follow-ups. Therefore, a paired sample t-test was used to compare patients before and after one-year sleeve or bypass surgery. A p-value of ≤0.005 was considered statistically significant.

Results. A total of 232 patients were screened, and all patients completed the study. The baseline characteristics of the studied population are presented in Table 1. The mean age was 44.3 ± 10.3 years, with females being significantly older than males with p=0.045. The vast majority of the patients underwent LSG (93.4%), while 6.6% underwent RYGB. Patients who underwent LSG sleeve surgery were significantly younger than patients who underwent RYGB surgery (p=0.002). More than 75% of the study sample had an educational level of high school or above, with this percentage being higher

Table 1 - Baseline characteristics for the studied cohort according to gender and type of surgery.

Variables	Total (232)	Gender		*P*-value*	Surgery		*P*-value†
		Male (44%)	Female (56%)		LSG sleeve (93.4%)	RYGB bypass (6.6%)	
Age (years), n (%)							
mean (± standard deviation [SD])	44.3 ± 10.3	42.8 ± 10.5	45.5 ± 9.9	0.045	43.8 ± 10.1	52.1 ± 12.0	0.002
< 34 years,	38(16.4)	24 (23.5)	14 (10.8)		37 (17.5)	1 (6.7)	
34- 44 years	93(40.1)	40 (39.2)	53 (40.8)	0.054	87 (41.0)	2 (13.3)	0.002
45- 54 years	59(25.4)	21 (20.6)	38 (29.2)		54(25.5)	4 (26.7)	
>54 years	42(18.1)	17 (16.7)	25 (19.2)		34 (16.0)	8 (53.3)	
Education level, n (%)							
Post graduate	10 (4.58)	6 (6.31)	4 (3.25)		6 (3.0)	4 (22.22)	
University	84 (38.53)	51 (53.68)	33 (26.82)		80 (40.0)	4 (22.22)	
High school	72 (33.02)	30 (31.57)	42 (34.14)	0.000	66 (33.0)	6 (33.33)	0.379
<High school	38 (17.43)	8 (8.42)	30 (24.39)		36 (18.0)	2 (11.11)	
Illiterate	14 (6.42)	0 (0.0)	14 (11.38)		12 (6.0)	2 (11.11)	
Income (Saudi Riyals), n (%)							
<5,000 SR, --	31(14.2)	9 (9.5)	22 (17.9)		30 (15.0)	1 (7.1)	
5,000-10,000 SR	86(39.4)	30 (31.6)	56 (45.5)	0.004	80 (40.0)	6 (42.9)	0.513
>10,000 SR	101(46.3)	56 (58.9)	45 (36.6)		90 (45.0)	7 (50.0)	
Smoking status, n (%)							
Current	28 (12.8)	24 (25.0)	4 (3.3)		27 (13.4)	0 (0.0)	
Ex-smoker	21 (9.6)	20 (20.8)	1 (0.8)	0.000	21 (10.4)	0 (0.0)	0.051
None	170 (77.6)	52 (54.2)	118 (95.9)		153 (76.1)	14 (100)	
Physical activity, n (%)							
≥150 min/ week	99 (45.4)	50 (50.5)	49 (49.5)	0.172	93 (95.9)	4 (4.1)	0.193
Body mass index, n (%)							
mean (± SD)	45±6.75	44.90±6.70	45.51 ± 6.82	0.495	45.31 ± 6.70	44.4 ± 7.65	0.616
< 35 kg/m^2	7 (3.0)	4 (3.9)	3 (2.3)		6 (2.8)	1 (6.7)	
36-40 kg/m^2	42 (18.2)	16 (15.7)	26 (20.2)	0.000	35 (16.6)	5 (33.3)	0.615
> 40 kg/m^2	182 (78.8)	82 (80.4)	100 (77.5)		170 (80.6)	9 (60.0)	
Diabetes mellitus duration							
mean (± SD)	8 ± 7	8 ± 8	9 ± 7	0.501	8 ± 7	15 ± 11	0.001
<5 years	99 (48.1)	50 (55.9)	49 (42.2)		93 (49.5)	4 (28.6)	
6 -10 years	53 (25.7)	20 (22.2)	33 (28.4)	0.307	50 (26.6)	2 (14.3)	0.024
>10 years	54 (26.2)	20 (22.2)	34 (29.3)		45 (23.9)	8 (57.1)	
Diabetes mellitus complication							
Neuropathy	50 (49.01)	20 (51.28)	30 (47.61)	0.326	46 (51.11)	4 (36.36)	0.46
Retinopathy	47 (46.07)	17 (43.58)	30 (47.61)	0.267	40 (44.44)	6 (54.54)	0.068
Vasculopathy	3 (2.94)	1 (2.56)	2 (3.17)	0.603	3 (3.33)	0 (0.0)	0.807
Nephropathy	2 (1.96)	1 (2.56)	1 (1.58)	0.852	1 (1.11)	1 (9.09)	0.826
Comorbidity							
Hypertension	111 (48.3)	50 (45.0)	61 (55.0)	0.459	100 (90.1)	11 (9.9)	0.046
Hyperlipidemia	104 (45.2)	42 (40.4)	62 (59.6)	0.152	89 (87.3)	13 (12.7)	0.001
Hyperthyroidism	34 (15.0)	9 (26.5)	25 (73.5)	0.005	30 (88.2)	4 (11.8)	0.93
Metabolic markers							
Hemoglobin A1c (%)	8.04 ± 1.59	8.42 ± 1.77	8.22 ± 1.67	0.100	8.93 ± 2.04	8.04 ± 1.59	0.121
Fasting blood sugar (mmol/L)	8.25 ± 1.70	8.99 ± 3.67	9.01 ± 3.32	0.962	9.08 ± 3.44	8.47 ± 3.95	0.528
High density lipoprotein (mmol/L)	9.00 ± 3.46	1.27 ± 0.77	1.23 ± 0.40	0.660	1.23 ± 0.52	1.42 ± 0.86	0.228
Low density lipoprotein (mmol/L)	1.24 ± 0.56	2.54 ± 0.76	2.83 ± 0.97	0.064	2.76 ± 0.90	2.42 ± 0.85	0.157
Ttriglycerides (mmol/L)	2.73 ± 0.91	1.68 ± 0.91	1.62 ± 0.90	0.686	1.63 ± 0.93	1.68 ± 0.61	0.850
Total cholesterol (mmol/L)	1.64 ± 0.90	4.04 ± 1.19	4.56 ± 1.28	0.016	4.37 ± 1.29	4.28 ± 1.08	0.784
Renal functions							
Serum creatinine,(µmol/L)	4.36 ± 1.27	71.46 ± 21.74	59.14 ± 26.68	0.00	64.25 ± 26.13	65.36 ± 14.65	0.875
Blood urea nitrogen, (mg/dl)	64.39 ± 25.38	5.73 ± 3.82	4.96 ± 5.28	0.348	5.37 ± 5.00	3.96 ± 1.35	0.316
Thyroid functions							
Thyroid stimulating hormone (mIU/L)	5.25 ± 4.78	2.44 ± 1.75	2.58 ± 1.65	0.610	2.46 ± 1.61	2.97 ± 2.55	0.366
Free thyroxin t4 test (pmol/L)	2.52 ± 1.69	12.62 ± 5.73	14.41 ± 4.71	0.063	14.06 ± 5.01	14.49 ± 2.11	0.780

LSG: laparoscopic sleeve gastrectomy, RYGB: Roux-en-y gastric bypass. **P*-value comparing males to females, †*P*-value comparing LSG to RYGB surgery

among males at 91.4% compared to females at 64.1% (p=0.000). However, the percentage of such a group did not vary much between the 2 types of surgery.

The mean BMI was 45 ± 6.7 kg/m^2 with no significant difference between the 2 genders or the types of surgery (p=0.495). A total of 48.1% of the patients had a diabetes duration of less than 5 years and 48.3% of the patients had hypertension. The mean HbA1c was 8.04 ± 1.5%, and the mean FBG was 8.25 ± 1.70 mmol/L. Neither the glycemic nor the lipid markers varied significantly between the 2 genders or the 2 surgery groups, except for the mean total cholesterol, which was significantly higher among the females (p=0.016).

The preoperative and postoperative data of the studied cohort are displayed in **Table 2**. After surgical intervention, there was a significant reduction in glycemic markers in the total sample (p=0.000). Among patients who underwent either sleeve or bypass surgery, there was a significant reduction in the mean weight, BMI, HbA1c, FBG, and triglycerides, with p=0.000, while there was a significant increase in the mean HDL among patients who underwent sleeve surgery only. According to the ADA criteria, 48.5% of the patients who were subjected to any type of bariatric surgery had complete remission, while 18.9% had partial remission. Regardless of surgery type, 9.7% met the IDF optimization criteria, while 5.7% met the IDF improvement criteria.

The remission rate according to ADA and IDF criteria is shown in **Figure 1**. Among the patients who underwent LSG, 9.9% met the IDF optimization criteria, while only 4.7% met the IDF improvement criteria. However, the situation was the opposite among the patients who underwent RYGB surgery, as 20% met the IDF improvement criteria versus 6.6% who met the IDF optimization criteria. Among the patients who underwent sleeve surgery, 50% and 19.8% met the ADA criteria for complete and partial remission, respectively.

Table 2 - Summary of preoperative and postoperative data of the studied cohort.

Variables	Normal values	Before surgery			After surgery					
		Total	LSG	RYGB	Total	*P*-value*	LSG sleeve	*P*-value§	RYGB bypass	*P*-value†
		Mean±SD	Mean±SD	Mean±SD	Mean±SD		Mean±SD		Mean±SD	
Weight		121.04±21.49	121±21.07	119.46±33.20	76.55±14.43	0.362	100.87±31.46	0.000	80.11±16.04	0.000§
BMI	18.50 - 24.90	45.24±6.76	44.74±5.26	44.41±7.65		-	33.51±17.08	0.000	20.10±15.05	0.000
Percentage of total weight loss		-	-	-	17.4±18.59	-	16.73±18.73	-	27.42±13.34	-
HbA1c (%)	4.00 - 5.60	8.25±1.70	8.26±1.67	8.92±2.03	5.94±1.11	0.000	5.90±1.12	0.000	6.21±1.02	0.000
FBS (mmol/L)	<5.60 mmol/L	9.00±3.46	9.06±3.41	8.06±3.80	5.24±1.14	0.013	5.17±0.95	0.000	5.99±2.39	0.002
HDL (mmol/L)	Female >1.30 Male >1.00	1.24±0.56	1.19±0.46	1.28±0.70	1.37±0.63	0.638	1.39±0.66	0.001	1.30±0.29	0.912
LDL (mmol/L)	<2.60	2.73±0.91	2.77±0.88	2.49±0.81	2.78±0.81	0.633	2.78±0.81	0.795	2.69±0.77	0.795
TG (mmol/L)	<1.70	1.64±0.90	1.68±0.94	1.71±0.61	1.28±0.72	0.817	1.28±0.75	0.000	1.23±0.40	0.003
TC (mmol/L)	<5.18	4.36±1.27	4.38±1.29	4.45±0.86	4.34±1.12	0.959	4.33±1.16	0.566	4.36±0.75	0.566
Creatinine (µmol/L)	Female 52.20-91.90 Male 65.40-119.30	64.39±25.38	62.42±20.81	61.33±9.83	61.47±17.50	0.713	61.34±18.08	0.243	63.25±12.51	0.357
BUN (mg/dl)	7–20	5.25±4.78	5.48±5.17	3.67±1.13	4.49±2.35	0.181	4.56±2.40	0.026	3.53±1.43	0.026
TSH (mIU/L)	0.38–5.33	2.52±1.69	2.26±1.60	2.96±254	2.35±2.92	0.694	2.36±3.14	0.785	2.70±1.86	0.783
Free T4 (pmol/L)	7.86–14.41	13.78±5.14	13.93±5.08	14.49±1.95	13.86±4.44	0.404	13.56±4.72	0.239	14.85±1.95	0.239
ADA criteria										
Partial					18.9%	-	19.8%	-	26.7%	-
Complete					48.5%	-	50%	-	6.7%	-
No remission					32.6%	-	30.2%	-	66.6%	-
IDF										
Optimization					9.7%	-	9.9%	-	6.7%	-
Improvement					5.7%	-	4.7%	-	20.0%	-

ADA: America Diabetes Association, BMI: body mass index, BUN: blood urea nitrogen, DM: diabetes mellitus, FBS: fasting blood sugar, HDL: high density lipoprotein, IDF: international diabetes federation, LDL: low density lipoprotein, LSG: laparoscopic sleeve gastrectomy, RYGB: Roux-en-y gastric bypass, Scr: serum creatinine, SR: Saudi Riyals, T4: thyroxin t4 test, TC: total cholesterol, TG: triglycerides, TSH: thyroid stimulating hormone. *P-value for total before and after surgery, §P-value comparing the date before and after sleeve surgery†P-value comparing data before and after bypass surgery, SD: standard deviation

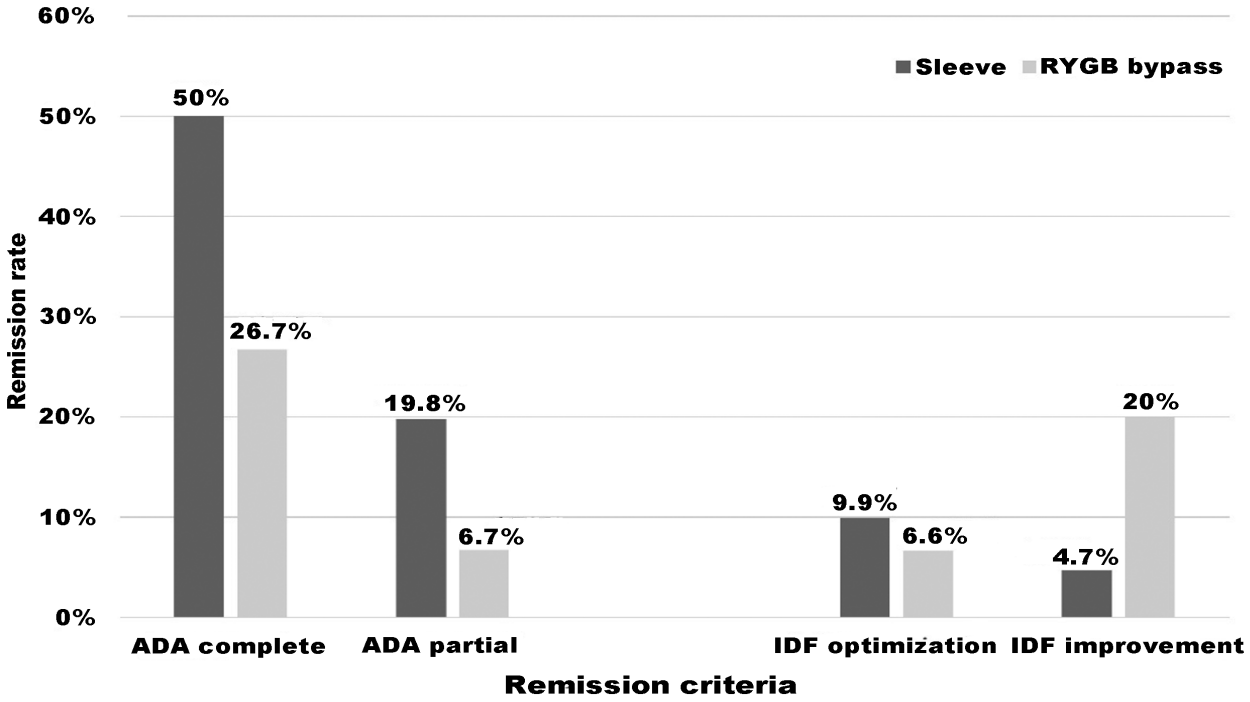

Figure 1 - Remission rate of the studied cohort according to American Diabetes Association criteria and International Diabetes Federation criteria.

A lower percentage of patients who underwent bypass surgery met the ADA criteria for complete (26.7%) and partial (6.7%) remission.

Out of the 232 participants, 214 completed a WHOQOL brief assessment via telephone interview, with 43% male and 57% female. The QOL assessment showed that the worst scores were found in the psychological health (mean=63.10; SD ± 13.81) and social relationships (mean=72.55; SD ± 22.48) domains. The highest scores were found in the environmental (mean=79.48; SD ±15.4) and physical health (mean=78.05; SD ±17.25) domains. With respect to gender, males had generally higher scores than females in all QOL domains. Patients aged 34-54 years had higher QOL domains when compared with patients aged less than 34 years or more than 54 years, except for the psychological domain, in which patients aged less than 34 years old had the best score (mean=64.0; SD ± 11.48). The higher the educational level, the higher the domain scores, except for the environmental domain score, which showed an increase as the educational level decreased, with 82.77 ± 14.48 for patients with postgraduate studies and 97.7 ± 14.71 for patients with high school. Patients who underwent LSG had better mean scores for the physical domain compared with patients who underwent RYGB surgery, at 78.25 ± 17.14 versus 75.21 ± 19.13, respectively. By contrast, patients who underwent bypass surgery scored better in both psychological health and social relationship domains. The different domain scores did not change markedly with the remission state.

Discussion. In this study, we demonstrated that bariatric surgery is associated with statistically significant improvements in HbA1c, fasting blood glucose, triglycerides, BMI, and body weight at least one year postoperatively among the Saudi population. These findings are in line with observations of previous studies, that have shown that bariatric surgery improves glycemic control in patients with T2DM.[16,17]

According to the ADA criteria, the rate of complete remission was 2.6 times higher than the rate of partial remission among patients who were subjected to any type of bariatric surgery. This was not the same as the finding by Miras et al,[24] who demonstrated that the partial remission rate exceeded the complete remission rate, which could be explained by the fact that our studied cohort were younger with a mean age of 44.3 ± 10.3 years versus 51 ± 10 years of Miras et al's[24] study. However, our results are consistent with many other studies, as the complete remission dramatically exceeded the partial remission at 46% versus 11% in

Table 3 - Mean domain scores according to demographic data and remission status among patients with type 2 diabetes who underwent bariatric surgery.

Variables	Physical domain mean ± SD	Psychological domain mean ± SD	Social domain mean ± SD	Environmental domain mean ± SD
Total	78.05 ± 17.25	63.10 ± 13.81	72.55 ± 22.48	79.48 ± 15.89
Age				
< 34 years	81.56 ± 13.64	64.0 ± 11.48	62.32 ± 20.91	77.18 ± 13.9
34–44 years	81.06 ± 16.60	62.92 ± 14.19	75.70 ± 23.0	97.80 ± 15.19
P-value*	0.869	0.677	0.0022	<0.0001
45–54 years	73.34 ± 18.4	63.53 ± 14.84	74.71 ± 20.65	80.42 ± 16.64
P-value*	0.020	0.868	0.0045	0.321
>54 years	74.66 ± 18.45	62.02 ± 14.06	72.76 ± 23.13	79.71 ± 18.27
P-value*	0.063	0.495	0.035	0.491
Gender				
Male	83.30 ± 14.15	66.17 ± 12.17	76.52 ± 21.16	81.32 ± 16.50
Female	74.17 ± 18.23	60.88 ± 14.46	69.55 ± 23.06	78.28 ± 15.21
P-value†	<0.0001	<0.003	0.018	0.146
Educational level				
Post graduate	87.77 ± 10.75	70.88 ± 8.16	92.85 ± 10.52	82.77 ± 14.48
P-value‡	0.005	0.037	0.005	0.1302
University	82.77 ± 15.01	66.05 ± 12.29	74.31 ± 21.20	83.15 ± 14.01
P-value‡	0.000	0.017	0.450	0.027
High school	79.50 ± 15.77	64.65 ± 11.58	74.26 ± 20.28	97.75 ± 14.71
P-value‡	0.011	0.039	0.444	<0.0001
<High school	67.07 ± 18.08	54.68 ± 15.29	63.00 ± 26.33	72.68 ± 20.40
P-value***	0.990	0.694	0.406	0.784
Illiterate	67.14 ± 19.25	56.7 ± 18.97	69.64 ± 22.29	74.28 ± 11.95
Type of surgery				
Sleeve	78.25 ± 17.14	62.91 ± 13.91	72.12 ± 22.56	79.46 ± 15.98
Bypass	75.21 ± 19.13	65.71 ± 12.55	78.64 ± 21.08	79.71 ± 15.18
P-value§	0.593	0.449	0.278	0.953
Remission				
Partial	77.09 ± 18.57	61.57 ± 17.19	70.66 ± 25.99	77.23 ± 17.24
P-value**	0.699	0.610	0.368	0.173
Complete	78.17 ± 16.81	63.0 ± 12.36	71.73 ± 21.47	79.01 ± 16.11
P-value**	0.915	0.960	0.352	0.306
No remission	78.45 ± 17.25	63.10 ± 13.81	74.84 ± 21.73	81.48 ± 14.70

SD: standard deviation, **P*-value: compared to the age of <34 years, †*P*-value: compared to males, ‡*P*-value: compared to illiterate, §*P*-value: compared to bypass surgery, ***P*-value: compared to no remission

one study 25 and at 42.2% versus 18.8% in the other study.[26] Our study showed lower remission rates based on IDF criteria, which was the same observation of the research group that first applied the IDF criteria.[25] This could be due to the fact that the IDF criteria have a strict and holistic approach.

Although gastric bypass surgery is considered the gold standard weight loss procedure, and it has been shown to be superior to sleeve gastrectomy for remission of type 2 diabetes, the sleeve surgery is rapidly becoming a more popular procedure worldwide.[27,28] This is mainly due to its better safety profile, such as normal intestinal absorption, lack of intestinal anastomosis, and being a single step procedure, which could explain the predominance of sleeve surgery in our cohort.[29] Another explanation for the higher rate of sleeve surgery is the fact that the Council of Cooperative Health Insurance in Saudi Arabia is authorizing insurance companies to cover only sleeve surgery.

The mean domain scores among patients with T2Dwho underwent bariatric surgery are presented in Table 3. The studied population mean scores for all the quality-of-life domains, except for the psychological domain, were higher compared with the mean domain scores of patients with T2DM in Saudi Arabia.[30] This finding indicates that bariatric surgery is associated with improvement of the quality of life. This is consistent with findings of a recent systematic review by Faria et

al,[19] who reported significant improvement in quality of life among patients who underwent both types of bariatric surgery, with this improvement starting within the first few months after the surgery and lasting up to 10 years.

The current study has shown that there are more females engaged in bariatric surgery than males (56% versus 44%). Similarly, other studies have shown that females are more interested in undergoing bariatric surgery compared to males.[31] This might be justified by the fact that women care more about authentic appearance and the sociocultural pressure that affects the women's self-esteem and body image, forcing them to meet the socially imposed standards of beauty.[32] Middle-aged participants had better mean scores for different domains of quality of life. This is aligned with the fact that younger age is strongly associated with better quality of life after surgery.[33,34] This could be explained by the fact that older patients are more prone to a higher incidence of complications and mortality.[35] LSG was associated with a better mean score of physical domains, whereas bypass surgery was associated with a better social domain mean score. However, in general, there was no meaningful difference between the 2 types of surgeries in terms of QOL, which is aligned with the systematic findings of review.[19] To the best of our knowledge, this is the first study to assess this aspect among patients with T2DM post-bariatric surgery in Saudi Arabia.

Study limitations. This study is limited by its cross-sectional design, which is not the proper setting to assess causality; however, our study is descriptive in nature. The second limitation of this study was the lack of a quality-of-life assessment before surgery. The third limitation was being conducted only in the Riyadh region, which could affect the external validity of the study results; however, the 2 study centers are referral centers, and most of the bariatric surgeries in Saudi Arabia are conducted in them. The fourth limitation was the small number of patients who underwent RYGP surgery compared to those who underwent LSG sleeve surgery, which hindered us from conducting a proper comparison between the 2 groups. Despite these limitations, the current study is the first to report the diabetes remission rate among the Saudi population with T2DM after bariatric surgery.

In conclusion, both types of bariatric surgery were associated with high remission rates and improved metabolic outcomes. The surgery was associated with improved quality of life compared with the social norm among patients with type 2 diabetes. Such findings shed light on the efficacy of this intervention among the Saudi population that faces an epidemic of diabetes mellitus. Although the current study did not assess the cost-effectiveness of bariatric surgery, further investigation could assess the cost-effectiveness of bariatric surgery compared with medications/lifestyle interventions. Therefore, the Ministry of Health should increase investments in health to establish more bariatric surgery units in different healthcare sectors, especially when it is expected that the need for such services will increase during the next 10 years in the Kingdom.[36] Additionally, since shorter diabetes duration was associated with better surgery outcomes, considering early intervention whenever the patient is eligible for surgical procedure is highly recommended. Policymakers and health insurance companies should consider revising the eligibility criteria, mainly the baseline BMI, for covering patients for bariatric surgery to be less than 45 kg/m^2 especially when the outcomes among patients with baseline BMI ≥35 kg/m^2 were comparable to patients with BMI <35kg/m^2 in terms of diabetes remission.[37] Larger multi-center studies should be conducted to asses the remission rate, metabolic changes, and quality of life assessment pre/post-bariatric surgery in patients with type 2 diabetes

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