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NEW CONCEPT

Single-Anastomosis Sleeve Jejunal Bypass, a Novel Bariatric Surgery, Versus Other Familiar Methods: Results of a 6-Month Follow-up—a Comparative Study

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Abstract

Background Obesity and its associated morbidities have become a significant concern all over the world. Bariatric surgery, regardless of its type, is the most effective approach for treating morbid obesity. Single-anastomosis sleeve jejunal (SASJ) bypass is a novel bariatric surgery technique and can be considered for patients with former background of severe gastroesophageal symptoms. The purpose of this research was to compare SASJ bypass outcomes with other techniques during a 6-month follow-up.

Methods This is a non-randomized clinical trial conducted on 100 patients, who underwent four types of bariatric surgery (classic Roux-en-Y bypass, SASJ bypass, omega gastric bypass, and sleeve gastrectomy), and each one of these types contained 25 cases, during the time period of 2 years from 2016 to 2018. Patients' information including age, gender, height, basal weight, body mass index (BMI), serum albumin, and hemoglobin A1C were recorded, within 1, 3, and 6 months after their surgery, and also were compared with each other.

Results Members of the four groups were similar due to their age, gender distribution, height, baseline BMI, hemoglobin A1C, albumin, and also excess weight (P value > 0.05); however, the sleeve gastrectomy group baseline weight was significantly higher compared with the other three groups (P value = 0.013). All of the groups significantly lost weight during this 6-month period, but the comparison between them indicated no statistical difference regarding excess weight loss, BMI, hemoglobin A1C, and albumin (P value > 0.05). The excess weight loss mean during 6 months in SASJ bypass was 34.2 ± 5.4%, which was comparable with other groups.

Conclusions The weight loss trend after the SASJ bypass was similar to that of older techniques; consequently this technique can be considered for cases with particular indications due to the reversibility and also more accessible gastric follow-up studies in the SASJ approach. Further researches with longer follow-ups are strongly recommended.

Keywords Bariatric surgery · Metabolic surgery · Jejunal bypass · Body mass index

Introduction

Nowadays, obesity and metabolic disorders have been turned to a major concern all over the world. Technology progression, urbanization, and lifestyle change have resulted in people's tendency for fast food consumption, less physical activity, and also a sedentary lifestyle; therefore, obesity frequency is progressing dramatically, and age of metabolic disorder onset has decreased in both developing and developed countries [1]. Obesity leads to metabolic disorders like hyperlipidemia, type 2 diabetes mellitus, hypertension, cardiovascular disease–increased risk, musculoskeletal disorders, and various types of malignancies [2].

Nowadays, bariatric surgery is the best approach in order to treat morbid obesity. Bariatric surgery, regardless of its type, leads to dramatic weight loss and metabolic improvement in comparison with those medical treatments used for weight loss management [3, 4].

Bariatric surgery techniques are developing, and factors like surgeons' expectancy, surgical technique complications,

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and clinical findings made physicians improve less complicated and novel approaches [5]. Different techniques of this surgical procedure have been raised due to its pure restrictive, pure malabsorptive, and combined approaches. These methods have also some complications besides their benefits and require long-term monitoring in general [6]. For instance, in techniques that lead to absorption reduction, long-term dependence to supplemental prescription, due to micronutrient malabsorption from the first parts of the small intestine, is inevitable [7].

Single-anastomosis sleeve jejunal (SASJ) bypass that has been developed since 2004 is another bariatric technique. This technique has the advantage of presenting stomach and intestine anatomy with more similarity to normal anatomy compared with other bariatric techniques. Additionally, primary investigations presented acceptable excess weight loss and also comorbidity rehabilitation [8]. Due to ulcer presentation at the site of anastomosis, the technique was modified in order to completely remove the bypassed stomach in 2006 [9]. Additionally, stating the similarity to the original gastrointestinal anatomy helps adequate micronutrient resorption, and consequently fewer long-term supplement requirements were used. Also, early food exposure to the ileum in this technique accompanied with increased secretion of GLP-1 and peptide YY leads to more beta cell stimulation for insulin secretion, less glucagon response, and reduced stomach emptying time [10]. Another considerable advantage of this technique is its reversibility, which can be accomplished in cases with threatening complications [11].

Due to inadequate development of the SASJ bypass, researches are limited and controversial in this regard. This study's purpose was to compare this technique's outcomes with those of other bariatric surgeries that are more common.

Methods

This research is a non-randomized clinical trial conducted on 100 patients who underwent four types of bariatric surgery (classic Roux-en-Y bypass, SASJ bypass, omega gastric bypass, and sleeve gastrectomy) in Al-Zahra and Kashani University Hospitals (affiliated at Isfahan University of Medical Sciences) from January 2016 to June 2018.

Inclusion criteria were as follows: (1) body mass index of over 35 plus the comorbidity presence; (2) body mass index of over 40 with/without comorbidity; (3) patients' willingness to participate in the study; (4) patients' cooperation in follow-up researches; and (5) lacking any psychiatric disease.

Unmet criteria included negating to change their lifestyle, drug abuse and/or addiction, and eating disorder background (e.g., bulimia nervosa).

Moreover, this study excluded those patients who did not refer for follow-up researches, and/or their bariatric surgical type was changed because of any reason.

The Isfahan University Ethics Committee approved this study protocol based on the code of IR.MUI.MED.REC.1397089.

After the comprehensive information provision about bariatric surgeries, their complications, and long-term outcomes, patients were reassured about their personal information confidentiality and were requested to sign their participation in the study informed consent form.

SASJ bypass was performed for patients with the following criteria: (1) positive family history of gastric cancer; (2) refractory *Helicobacter pylori* presence; (3) intestinal metaplasia presence in biopsies derived from a gastroesophageal junction; (4) former history of peptic ulcer; and (5) patients referring with the abundant sweet eating or petite eating complaint, and/or inadequate physical activity and/or documented diabetes mellitus diagnosis.

Patients were divided into four groups non-randomly, and each group consisted of 25 participants. Group A underwent classic Roux-en-Y gastric bypass, group B underwent SASJ bypass, group C underwent one anastomosis (mini or omega) gastric bypass, and group D underwent sleeve gastrectomy.

This study population was included by using the convenience sampling until attaining 25 members for each group.

Group A underwent laparoscopic classic Roux-en-Y gastric bypass, as indicated by Wittgrove et al. [12]. The gastric pouch was made with the approximately 30–40 cc volume by using 36-Fr bougie. After that, the gastrointestinal anastomosis was made based on the Roux-en-Y technique with the antecolic biliopancreatic limb with a length of 70 cm and alimentary limb with a length of 110 cm.

The next group underwent laparoscopic SASJ bypass (group B) [13] as the below order; the sleeve gastrectomy was performed using bougie with the size of 36 Fr primarily. After that, the gastrojejunostomy anastomosis was made within 200 cm of the ligament of Treitz, and the selected loop was stapled side to side within 4 to 6 cm away from the pylorus at the incisura angularis level, almost similar to omega gastric bypass. Eventually, the defect was linearly sutured (Fig. 1).

Group C was treated with the omega gastric bypass laparoscopic technique [14]. In this group, the long and thin gastric pouch with the 50 cc volume and the gastrojejunostomy anastomosis with the 180–200 cm approximate were made within the ligament of Treitz.

Finally, group D was treated with the laparoscopic sleeve gastrectomy bypass technique [15]. In this term, from 4 cm away from the pylorus to the left diaphragmatic crus, resection was done by the use of a 36-Fr bougie.

All of the patients were treated with proton pump inhibitors for 2 months, right after their surgical procedures. There were

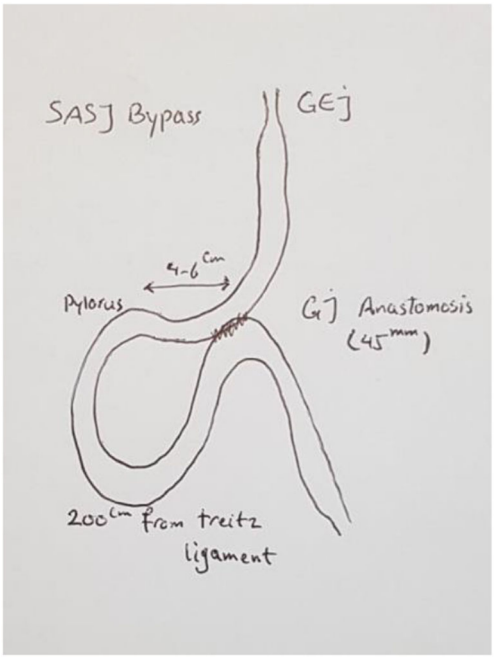

Fig. 1 Diagram of SASJ bypass

limited cases that required anti-acid treatment, elongated duration of 3 months, due to their irritating symptoms.

Then, patients' demographic information like their age, gender, height, basal weight, and body mass index (BMI) were recorded in a checklist.

After that, some indices including weight, serum albumin, and serum hemoglobin AIC were recorded before the surgery and during 1-month, 3-month, and 6-month intervals after the patients' surgical procedure.

All laboratory tests were sent to Al-Zahra Hospital, and HbA1C is presented in millimoles per liter and albumin serum level is presented in grams per deciliter, in order to minimize the bias.

The excess weight loss has been measured throughout the following formula, and also presented in percentages [16]:

$$\text{Percentage of excess weight loss} = [(\text{operative weight} - \text{follow-up weight})/\text{operative excess weight}] \times 100$$

Basic laboratory tests including fasting blood sugar (FBS), ferritin, hemoglobin, zinc, folic acid, and vitamin B_{12} were assessed in each patient. Also, FBS was rechecked in the 6-month follow-up survey.

The attained data were entered into the SPSS 20 (IBM, USA). Descriptive data were displayed in means and percentages, and ANOVA and *T* test were used for analytic data. The *P* value with the amount of less than 0.05 was considered as a significant level.

Results

In this research, 100 patients, who underwent bariatric surgeries, were assessed with different methods. A total number of 14 males (14%) and 86 females (86%) were included. Each of the groups consisted of 25 members.

Based on Table 1 results, patients' basal weight before bariatric surgery (*P* value = 0.035) and height (*P* value = 0.016) were significantly different; however, the comparison between their basal excess weight revealed no statistical difference (*P* value = 0.07). Two-by-two comparison between the groups, due to their patients' weight, indicated significant higher weight status in all of the assessment intervals, statistically between the sleeve group with the SASJ group (*P* value = 0.003) and the RYGB group (*P* value = 0.01).

Further assessments showed statistical difference among four groups, during a month, 3 months, and 6 months after the bariatric surgery, and presented that all of the patients performed significant weight loss during the 6-month follow-up. The RYGB group members had 58.50-kg excess weight before the study initiation; this excess weight was 64.50 kg, 64.96 kg, and 68.73 kg for SASJ bypass, omega bypass, and sleeve gastrectomy, respectively. Comparison between these four groups revealed no significant difference before the surgical procedure among groups (*P* value = 0.070). The trend of excess weight loss was assessed during 1 month, 3 months, and 6 months after the surgical procedure as well. Based on the information in Table 2, the SASJ group's excess weight loss was significantly higher in a 3-month follow-up study (*P* value = 0.011); therefore, other evaluations

Table 1 Comparison of height, basal weight, and basal excess weight among the study population

Variable	Height		Basal weight		Basal excess weight	
	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation
RYGB	165.08	7.59	116.12	15.40	58.50	11.48
SASJ	162.32	5.30	119.04	12.58	64.50	12.28
Omega	163.72	9.84	121.90	16.60	64.96	14.78
Sleeve	168.72	8.36	130.28	17.92	68.73	15.30
P value	0.035		0.016		0.07	

Table 2 Weight, albumin, hemoglobin AIC, body mass index, and excess weight indices among four assessed groups and their comparison during the 6-month assessment

Time		Before the surgery		Within a month after surgery		Within 3 months after surgery		Within 6 months after surgery		Repeated measures ANOVA	
Variable		Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	Mean	Std. deviation	*P* value (within-subject)	*P* value (between-subject)
Weight* (kg)	RYGB	116.12	15.40	104.56	15.48	97.36	14.82	87.24	13.05	< 0.001	0.017
	SASJ	119.04	12.59	105.64	13.27	93.20	13.83	84.84	14.05	< 0.001	
	Omega	121.90	16.60	109.84	16.07	100.76	16.87	88.80	14.96	< 0.001	
	Sleeve	130.28	17.92	117.32	16.90	107.52	15.94	96.44	14.88	< 0.001	
P value*		*0.013*		*0.019*		*0.012*		*0.013*			
Albumin (g/dl)	RYGB	4.20	0.20	4.14	0.18	4.14	0.27	4.14	0.24	0.026	< 0.001
	SASJ	4.23	0.15	4.13	0.17	4.11	0.19	4.10	0.16	< 0.001	
	Omega	4.10	0.31	4.16	0.36	4.29	0.45	4.52	0.45	< 0.001	
	Sleeve	4.16	0.38	4.27	0.41	4.56	0.45	4.86	0.39	< 0.001	
P value**		*0.58*		*0.87*		*0.63*		*0.48*			
Hemoglobin AIC (mmol/mol %)	RYGB	6.31	0.50	6.20	0.49	6.17	0.49	6.07	0.51	< 0.001	0.55
	SASJ	6.25	0.42	6.19	0.41	6.03	0.24	6.00	0.21	< 0.001	
	Omega	-	-	-	-	-	-	-	-	-	
	Sleeve	-	-	-	-	-	-	-	-	-	
P value**		*0.64*		*0.95*		*0.20*		*0.54*			
BMI (kg/m^2)	RYGB	42.51	4.07	38.24	4.11	35.61	4.08	32.00	4.33	< 0.001	0.25
	SASJ	45.26	5.22	40.16	5.29	35.41	5.40	32.27	5.63	< 0.001	
	Omega	45.63	6.12	41.07	5.61	37.63	5.87	33.21	5.38	< 0.001	
	Sleeve	45.81	5.77	41.25	5.47	37.79	4.99	33.92	4.95	< 0.001	
P value*		*0.108*		*0.15*		*0.28*		*0.52*			
Excess weight loss (%)	RYGB	-	-	20.40	6.57	33.01	7.89	50.54	11.93	< 0.001	0.16
	SASJ	-	-	21.46	6.28	41.24	11.05	54.54	14.59	< 0.001	
	Omega	-	-	18.91	6.23	33.50	10.30	52.48	11.36	< 0.001	
	Sleeve	-	-	19.35	5.91	33.92	9.81	50.70	11.78	< 0.001	
P value*				*0.48*		*0.011*		*0.64*			

*ANOVA

***T* test

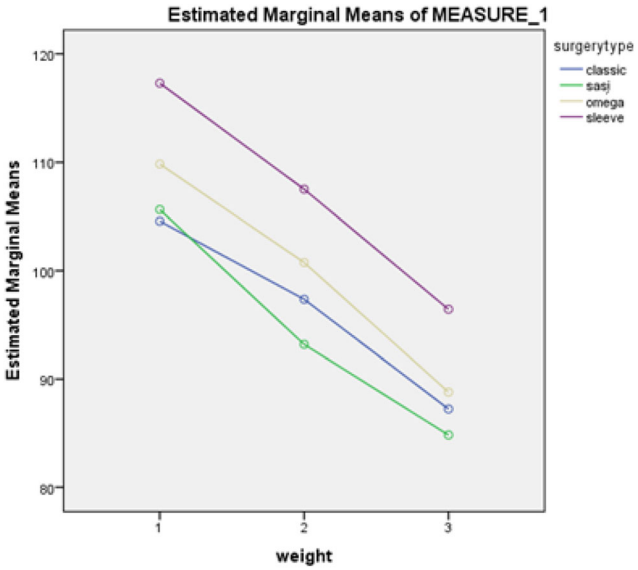

Fig. 2 Comparison of body weight change within 6-month follow-up in the four assessed groups (*X*-axis: time (months) and *Y*-axis: weight (*10 kg))

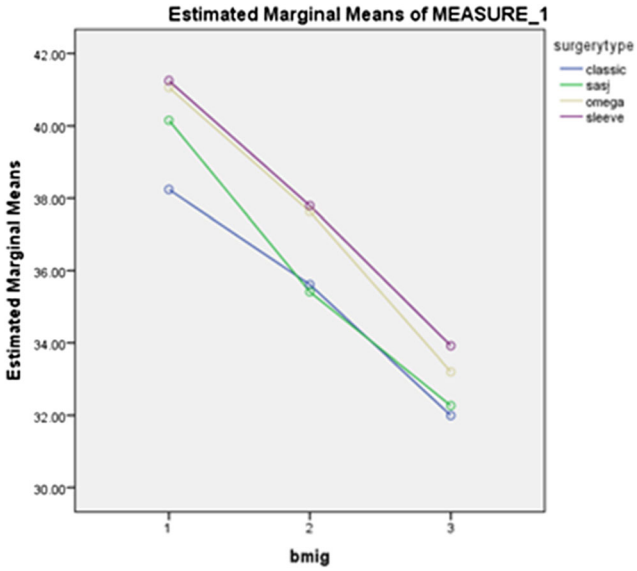

Fig. 3 Comparison of body mass index change within 6-month follow-up among the four assessed groups (*X*-axis: time (months) and *Y*-axis: BMI (*10 kg/m^2))

indicated no significant difference among the groups (*P* value > 0.05). Comparison on the four groups within a particular time revealed no significant difference among these groups due to their excess weight loss during a 6-month follow-up research. Body mass index was this study's next assessment. Based on the Table 1 information, four groups were statistically different either at study initiation before the surgical procedure or in follow-up assessments (*P* value > 0.05). The HbA1C and albumin comparison also presented no statistical difference among groups (*P* value > 0.05). Detailed information is displayed in Table 2.

Figure 2 compares the patients' weight status during their follow-up assessments, which indicated the least weight levels in the SASJ group except for the 1-month follow-up study. The other parameter presented in Fig. 3 is about BMI that has considerable but not statistical reduction in the SASJ group in comparison with the other three groups.

In total, 20 patients had diabetes, and from them, 2 patients underwent SASJ bypass, 12 underwent classic RYGB, and 6 underwent omega bypass. All of the patients indicated improved diabetes mellitus during the 6-month study and ceased medication, and also insulin therapy.

Eighty patients (80%) presented vitamin D deficiency (less than 30 ng/ml). Ten patients (10%) presented zinc deficiency (less than 70 ng/dl). Folic acid (< 6 ng/ml), vitamin B_{12} (< 250 pg/ml), and ferritin (< 40 μg/l) deficiencies were found in 8 (8%), 20 (20%), and 32 (32%) patients, respectively. All of the deficiencies were corrected before the time of surgery, and all of their amounts were in the normal range. No one had iron deficiency anemia, defined as having hemoglobin level of less than 14 mg/dl for males and 12 mg/dl for females (Table 3).

In the 6 months of follow-up, none of the patients presented clinical symptoms of gastroesophageal reflux. Besides, all of them underwent fluoroscopic study after 6 months (Fig. 4).

Furthermore, in the study population with a 6-month follow-up, no complication was observed.

Discussion

Nowadays, bariatric surgery has opened a new window toward both physicians detecting the best way to help their

Table 3 Micronutrient, fasting blood sugar, and ferritin assessment of the studied population in the study basis

	RYGB	SASJ	Omega	Sleeve gastrectomy
Diabetes mellitus (mg/dl)	12 (48%)	2 (8%)	6 (24%)	0 (0%)
Vitamin D deficiency (less than 30 ng/ml)	21 (84%)	17 (68%)	19 (76%)	23 (92%)
Zinc deficiency (less than 10 ng/dl)	5 (20%)	3 (12%)	1 (4%)	1 (4%)
Folic acid deficiency (< 6 ng/ml)	2 (8%)	3 (12%)	1 (4%)	2 (8%)
Vitamin B_{12} (< 250 pg/ml)	6 (30%)	5 (20%)	4 (16%)	5 (20%)
Ferritin (< 40 μg/l)	8 (32%)	6 (24%)	9 (36%)	9 (36%)

Fig. 4 Barium study of a SASJ patient 6 months after surgery

patient lose their weight and people who are resenting from their excess weight as the only significant weight-loss-apparent way among the morbidly obese patients [17]. Complication reports following bariatric surgeries changed this surgical procedure trends in order to make new, reversible, less invasive methods, which require fewer patient supplementary follow-ups and pose more rapid weight loss, accompanied with healthy metabolic state attainments [18].

Varieties of bariatric surgeries have been presented; some were eliminated in their first months of life while others survived, and investigations about more novel techniques with ultimate results and with also less complications are in progress [19].

Based on this research, due to the SASJ technique novelty, most of the studies have been conducted in order to assess the SASJ efficacy. The theory of this novel method was raised, due to the weight loss hypothesis achieved by the use of malabsorption plus patients' earlier hunger satiety as they have the feeling of being full [20, 21].

SASJ bypass is a technique that combines both restrictive and malabsorptive approaches [11], which has not been well established in the literature. In this research, we attempt to compare the findings of this technique with those of the former methods that were more common surgeries all over the world. Eventual findings of this research revealed no statistical difference among groups, due to their excess weight loss, serum albumin level as the body caloric status presentation, and HbA1C as the glycemic metabolic status presentation. In other words, patients under SASJ bypass bariatric surgery indicated significant excess weight loss during the 6 months after their surgical procedure, as they lost 54.54% of their excess weight in this time period. Additionally, a comparison between these four groups presented no significant difference among them (P value = 0.16), which means SASJ was as successful as other procedures that were more common.

As mentioned previously, vertical gastrectomy leads to early exposure of undigested food to the ileum accompanying with incretin hormone secretion increase, especially the GLP-1. This hormone poses early satiety, and higher beta cell secretion activity [22, 23].

Although, those studies that are assessing SASJ outcomes are remarkably limited, we found studies in the literature that assessed other techniques added to sleeve gastrectomy findings with considerable longer follow-up durations, which are displayed as follows.

Kasama et al. reported sleeve gastrectomy with duodenojejunal bypass to assess its efficacy on weight loss and diabetes mellitus. Our procedure is similar to theirs with a different anastomosis site [24].

Fried et al. performed another research, and they presented a 30-year bariatric surgery literature summary in Britain, eventually presenting procedures with the combined malabsorption and restriction mechanisms, which were accompanied with significant superior BMI change, and also with the metabolic improvements [25]. Mahdy et al. conducted their research on 61 patients, who have undergone SASI (single-anastomosis sleeve ileal) bypass approach of bariatric surgery in order to assess its results on diabetic mellitus type 2 patients. Eventually, they presented marvelous short-term outcomes as over 90% to even 100% of improvement in assessed indices were achieved, including weight loss, glycemic state, and lipid profile [26]. Melissas et al. performed another study, which compared the sleeve gastrectomy plus jejunoileal bypass with usual sleeve gastrectomy outcomes. They presented a significant and better trend of weight loss, higher rate of diabetes resolution, and as a result less required time for food passage in sleeve gastrectomy plus jejunoileal bypass in comparison with the standard sleeve gastrectomy. Also, they presented three cases with intestinal obstruction, hypoalbuminemia, and nausea-vomiting complications [27].

Zachariah et al. accomplished a study in order to compare the duodenal-jejunal bypass sleeve gastrectomy with the standard sleeve gastrectomy in 2016. Their 1-year follow-up research was conducted on diabetic type 2 patients and presented 25.7% of weight in duodenal-jejunal bypass with sleeve gastrectomy patients, which were superior to 22% of the other groups. Moreover, over 62% of the duodenal-jejunal bypass sleeve gastrectomy group attained the HbA1C less than 6% in comparison with only 32% of the rater group. They finally concluded that duodenojejunal bypass addition to sleeve gastrectomy accompanied three encouraging findings: (1) higher rate of diabetes remission, (2) less glycemic state fluctuation, and also (3) less C-peptide levels [28]. Lee et al. conducted another similar research on 89 patients and compared the duodenal-jejunal bypass with sleeve gastrectomy to the sleeve

gastrectomy, and investigated similar results with those results mentioned by Zachariah et al. [29].

Sánchez-Pernaute et al. performed a study on 92 diabetic patients who underwent single-anastomosis duodenoileal bypass with sleeve gastrectomy, a more generalized type of single-anastomosis bypass with sleeve gastrectomy, and observed them for 5 years. The excess weight loss rate was 73% during the 6-month study, while this rate reached 98% by passing 5 years. These percentages are considerably higher regarding SASJ bypass, in comparison with this study's findings. Additionally, complications presented for their study were negligible. Therefore, those studies that are conducted on the subject of this technique comparison with SASJ are strongly recommended [30].

Jammu et al. compared the omega bypass, RYGB, and sleeve gastrectomy outcomes, except the SASJ, and declared significant better outcomes of omega-loop gastrectomy than RYGB and sleeve gastrectomy techniques; also they mentioned that RYGB should be considered, due to its reversibility and technical ease in comparison with the rater loop gastric bypass. Furthermore, they reported that sleeve gastrectomy is acceptable only for non-compliant patients, who can tolerate weight regaining [31].

Alamo et al. performed their research assessing efficacy of sleeve gastrectomy with jejunal bypass on type 2 diabetes control during 18 months after surgical procedure. They presented significant weight loss amounts in their assessment as 31.9%, 56.9%, 76.1%, and 81.5%, of weight loss, were achieved during 3, 6, 12, and 18 months after the surgery, respectively. The excess weight loss trend in their study was similar in this study; however, they have observed their patients for a longer duration. Furthermore, all of the patients presented normal glycemic state during 18-month observation after the surgery [11].

In this research, we found a statistically higher rate of excess weight loss during 3 months of observation after the surgery, among those who underwent SASJ, but the trend of weight loss changed to insignificant during the 6-month follow-up. We have hypothesized that the change in the excess weight loss trend may be associated to the double pathway of food transition in SASJ, as transited food through the pyloric sphincter; the normal pathway is accompanied by an excess amount of absorbed food causing less speed of weight loss in further follow-ups, in contrast with the goal of the surgical procedure. Further studies with longer follow-up duration are required in order to achieve a thorough vision.

In conclusion, these study results about added procedures to sleeve gastrectomy were all in favor of more successful findings achieved by the above-mentioned added techniques in comparison with the conventional sleeve gastrectomy. Furthermore, a unique advantage of SASJ compared with more common bariatric surgeries is because of its follow-up study, which can be performed by using upper gastroesophageal endoscopy, and it is more practical, is less invasive, is less operator dependent, and poses fewer complications in comparison with the routine follow-up researches for other bariatric techniques. Although we have not found any study comparing SASJ outcomes with other malabsorptive techniques, only limited papers compared it with the sleeve gastrectomy. Further studies with a larger sample population and longer follow-up duration are required in order to have a comprehensive assessment of SASJ outcomes.

Conclusion

In conclusion, based on these research findings, the trend of weight loss, and also achieving appropriate weight after the SASJ bypass, was as successful as that of the other older procedures during this 6-month follow-up study. Additionally, 1 year and 2 years of follow-up studies on this research investigated population are in progress, which in that the patients are supposed to be followed through barium swallow assay within a year after surgical procedures.

Compliance with Ethical Standards The Isfahan University Ethics Committee approved this study protocol based on the code of IR.MUI.MED.REC.1397089. After the comprehensive information provision about bariatric surgeries, their complications, and long-term outcomes, patients were reassured about their personal information confidentiality and were requested to sign their participation in the study informed consent form.

Conflict of Interest The authors declare that they have no conflict of interest.

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