J Metab Bariatr Surg. 2024 Dec;13(2):71-77
https://doi.org/10.17476/jmbs.2024.13.2.71
pISSN 2287-2930·eISSN 2508-5956

Journal of Metabolic and Bariatric Surgery JMBS

Original Article

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HbA1c Reductions Following Sleeve Gastrectomy Versus Sleeve Gastrectomy With Proximal Jejunal Bypass: Significant Differences in Diabetic Patients

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Received: Nov 30, 2024
Revised: Dec 16, 2024
Accepted: Dec 17, 2024
Published online: Dec 30, 2024

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Funding
This study was supported by a research grant from the Korean Society for Metabolic and Bariatric Surgery.

Conflict of Interest
None of the authors have any conflict of interest.

ABSTRACT

Sleeve gastrectomy with proximal jejunal bypass (SG with PJB) is often preferred for patients with higher body mass index (BMI) and inadequate glycemic control. This study aimed to compare the outcomes of SG and SG with PJB, focusing on glycemic control and BMI in prediabetic and diabetic patients. Preoperative analysis revealed differences in age and hemoglobin A1c (HbA1c) levels between groups: SG with PJB patients were older (38.72±9.75 vs. 34.93±10.90 years, P=0.002) and had higher HbA1c levels (7.25±1.76 vs. 5.86±0.78%, P<0.001). Patients were stratified into prediabetic and diabetic groups. In the prediabetic group, no preoperative differences were observed between the surgical groups. However, in the diabetic group, patients in the SG with PJB had lower BMI (37.77±5.83 vs. 41.08±8.5 kg/m^2, P=0.034) and higher HbA1c levels (7.88±1.72 vs. 6.51±1.37%, P<0.001) compared to the SG, despite stratification. Postoperatively, SG with PJB led to significantly lower BMI at 3 months compared to SG, but this difference was not sustained at 6 and 12 months in the prediabetic group. In diabetic patients, SG with PJB resulted in significantly greater reductions in HbA1c levels compared to SG, even when adjusted for BMI as a covariate. At the 12-month follow-up, although SG with PJB still showed higher HbA1c levels than SG (5.79±0.78 vs. 5.59±0.44%, P=0.031), the difference was smaller compared to the preoperative period, where SG with PJB had significantly higher levels (7.88±1.72 vs. 6.51±1.37%, P<0.001). These findings suggest that SG with PJB may offer superior glycemic control in morbidly obese diabetic patients.

Keywords: Diabetes mellitus; Hemoglobin A, Glycosylated; Bariatric surgery; Jejunoileal bypass

INTRODUCTION

Morbid obesity is associated with an exponentially increased risk of type 2 diabetes, worsened metabolic dysregulation, and significantly raises the incidence and mortality rates of cardiovascular diseases, dyslipidemia, and nonalcoholic fatty liver disease, necessitating advanced and targeted therapeutic interventions [1,2]. Bariatric surgery is widely recognized for improving glycemic control and achieving significant weight loss in morbidly obese

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Author Contributions
Conceptualization: Seo E, Ryu S; Data curation: Seo E; Formal analysis: Seo E; Methodology: Ryu S; Writing - original draft: Seo E; Writing - review & editing: Ryu S.

patients [3]. Although various bariatric procedures are available, the choice of surgery depends on the patient's clinical profile and expected outcomes [4,5]. Sleeve gastrectomy (SG) with proximal jejunal bypass (SG with PJB) is a modified technique that has gained attention for its potential to offer enhanced safety and effectiveness compared to traditional SG [6-9]. SG with PJB combines the restrictive effects of SG with the metabolic benefits of bypass surgery, providing a promising alternative for improving metabolic health and addressing obesity-related comorbidities [8,10]. Despite these potential benefits, studies evaluating the efficacy and safety of SG with PJB in Korea remain limited, particularly in morbidly obese patients with varying glycemic profiles, such as prediabetes or diabetes.

This study aimed to compare the postoperative outcomes of SG and SG with PJB in patients with prediabetes and diabetes, focusing on changes in hemoglobin A1c (HbA1c) and BMI at 3, 6, and 12 months after surgery. Preoperative and postoperative data were carefully analyzed to assess the effectiveness of both procedures in achieving weight management and improving obesity-related comorbidities. These findings provide evidence for an effective surgical option to improve metabolic health and clinical outcomes in morbidly obese patients and are expected to contribute for the development of more personalized and evidence-based treatment strategies.

MATERIALS AND METHODS

1. Patients

This retrospective study utilized data collected between January 2021 and May 2024 at Keimyung University Dongsan Medical Centre, Daegu, Korea. Patients underwent either SG or SG with PJB. All consecutive patients aged 20–65 years with a BMI ≥35 kg/m^2 or a BMI ≥30 kg/m^2 accompanied by obesity-related comorbidities, such as hypertension, glucose intolerance, dyslipidemia, or obstructive sleep apnea, were included in the study. Patients who underwent revision or conversion surgeries following the initial bariatric procedure were excluded from the analysis. Demographic data, obesity-related comorbidities, anthropometric measurements, and laboratory results were reviewed. This retrospective study was approved by the Institutional Review Board of Keimyung University Dongsan Medical Centre (approval number: 2022-06-008), and informed consent was waived.

Eligibility for bariatric surgery in Korea is determined by national insurance reimbursement criteria, including a body mass index (BMI) of ≥35 kg/m^2 or a BMI of ≥30 kg/m^2 with inadequately controlled obesity-related comorbidities such as type 2 diabetes, dyslipidemia, hypertension, obstructive sleep apnea, or non-alcoholic steatohepatitis. The selection of surgical procedure was individualized based on an institution-specific protocol considering the patient's metabolic status, surgical risks, and potential long-term complications.

To account for baseline differences between groups, patients were stratified into prediabetic and diabetic groups taking into account their preoperative HbA1c levels. Prediabetic patients were defined as those with HbA1c levels between 5.7% and 6.4%. Diabetic patients were defined as those with HbA1c levels ≥6.5%, a documented history of diabetes identified through history taking, or the use of glucose-lowering medications. This stratification allowed for subgroup analysis to evaluate the differential impact of SG and SG with PJB on glycemic control and BMI outcomes.

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Data were collected preoperatively and at 3-, 6-, and 12-month postoperatively through outpatient visits. At each visit, anthropometric measurements, laboratory tests, and evaluations of obesity-related comorbidities were conducted.

2. Statistics

All data analyses were performed using R software (version 4.3.0; R Foundation for Statistical Computing, Vienna, Austria). Missing data were addressed by excluding individual data points with missing values rather than excluding entire patients. Continuous variables were compared using the Student's t-test, while categorical variables were analyzed using the Pearson's χ^2 test or Fisher's exact test, as appropriate. For the diabetic group, analysis of covariance (ANCOVA) was utilized to compare postoperative changes in HbA1c levels between SG and SG with PJB, with BMI included as a covariate. For the prediabetic group, differences in HbA1c and BMI at 3-, 6-, and 12-month post-surgery were assessed without adjusting for covariates. The assumptions of linearity, homoscedasticity, and normality in the ANCOVA models were validated through residual analysis. A P value of <0.05 was considered statistically significant.

RESULTS

A total of 298 patients were included in the study, with 179 patients in the SG group and 119 patients in the SG with PJB group. Significant differences were observed in age and preoperative HbA1c levels between the two groups. The SG group had a mean age of 34.93±10.90 years, which was significantly younger than the SG with PJB group, which had a mean age of 38.72±9.75 years (P=0.002). Regarding preoperative HbA1c, the SG with PJB group had significantly higher levels (7.25±1.76%) compared to the SG group (5.86±0.78%) (P<0.001). BMI showed a tendency for a lower mean in the SG with PJB group (38.64±5.76 kg/m^2) compared to the SG group (40.21±8.05 kg/m^2) (P=0.053). Other preoperative variables, including systolic blood pressure, diastolic blood pressure, white blood cell count, blood urea nitrogen, creatinine, total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, and triglycerides, showed no significant differences between the two groups (**Table 1**).

Table 1. Comparison of baseline characteristics of patients who underwent SG and SG with PJB

Variables	SG (n=179)	SG with PJB (n=119)	P value
Age (years)	34.93±10.90	38.72±9.75	0.002**
BMI (kg/m^2)	40.21±8.05	38.64±5.76	0.053
SBP (mmHg)	133.36±13.88	132.65±13.77	0.664
DBP (mmHg)	80.40±11.99	80.44±9.96	0.975
HbA1c (%)	5.86±0.78	7.25±1.76	<0.001***
WBC (μL)	8,134.97±2,023.96	8,588.40±1,919.04	0.052
BUN (mg/dL)	12.72±3.60	12.87±4.00	0.748
Creatinine (mg/dL)	0.76±0.77	0.72±0.19	0.464
Total cholesterol (mg/dL)	180.13±37.49	184.15±61.50	0.524
LDL-C (mg/dL)	119.19±32.94	115.21±40.37	0.372
HDL-C (mg/dL)	45.01±10.33	42.85±11.94	0.107
Triglyceride (mg/dL)	145.11±65.46	219.53±403.63	0.058

SG = sleeve gastrectomy, SG with PJB = sleeve gastrectomy with Proximal Jejunal Bypass, BMI = body mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure, HbA1c = hemoglobin A1c, WBC = white blood cell count, BUN = blood urea nitrogen, LDL-C = low-density lipoprotein cholesterol, HDL-C = high-density lipoprotein cholesterol.
**P<0.01, ***P<0.001.

Based on these results, we focused on HbA1c levels and excluded patients with normal HbA1c levels from the analysis. The remaining patients were stratified into two subgroups: prediabetic and diabetic, and further analyses were conducted to evaluate outcomes within these subgroups. A total of 24 patients in the SG group and 39 patients in the SG with PJB group were categorized as prediabetic, while 38 patients in the SG group and 80 patients in the SG with PJB group were classified as diabetic. For the prediabetic group, no significant differences were observed between the SG and SG with PJB groups in any of the preoperative variables. In the diabetic group, BMI was significantly lower in the SG with PJB group (37.77±5.83 kg/m^2) compared to the SG group (41.08±8.5 kg/m^2) (P=0.034). Additionally, HbA1c levels were significantly higher in the SG with PJB group (7.88 ± 1.72%) compared to the SG group (6.51±1.37%) (P<0.001). The duration of diabetes was also significantly longer in the SG with PJB group (5.16±5.28 years) compared to the SG group (3.21±4.05 years) (P=0.004) (**Fig. 1**, **Table 2**).

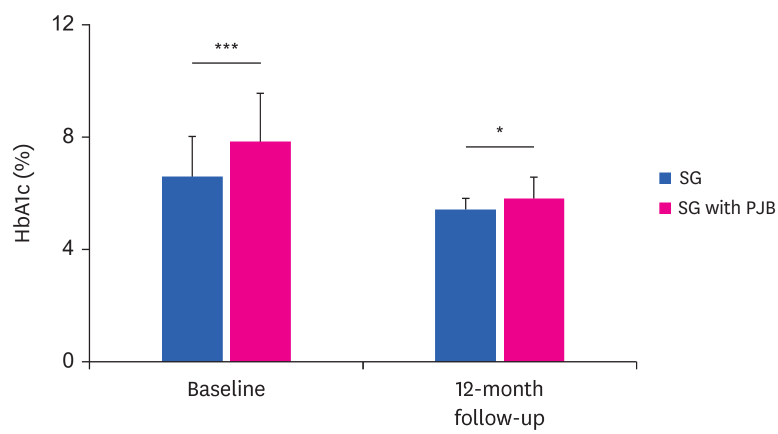

Fig. 1. Comparison of baseline and 12-month postoperative HbA1c results in diabetic patients. At baseline, HbA1c levels were higher in the SG with PJB group compared to the SG group. By the 12-month follow-up, both groups showed a reduction in HbA1c levels, with the SG with PJB group demonstrating a greater improvement. The difference observed at baseline showed a tendency to decrease compared to the preoperative period. Values are presented as mean ± standard deviation.
HbA1c = hemoglobin A1c, SG = sleeve gastrectomy, SG with PJB = sleeve gastrectomy with Proximal Jejunal Bypass.
*P<0.05, ***P<0.001.

Table 2. Comparison of baseline characteristics of patients with pre-diabetes and diabetes who underwent SG and SG with PJB

Variables	Prediabetic			Diabetic		
	SG (n=24)	SG with PJB (n=39)	P value	SG (n=38)	SG with PJB (n=80)	P value
Duration of diabetes	-	-	-	3.21±4.05	5.16±5.28	0.004**
HbA1c (%)	5.96±0.39	6.15±1.09	0.400	6.51±1.37	7.88±1.72	<0.001***
Age (years)	33.79±9.88	33.67±6.44	0.950	38.05±12.06	40.62±10.18	0.057
BMI (kg/m^2)	44.3±9.65	40.83±6.09	0.084	41.08±8.5	37.77±5.83	0.034*
SBP (mmHg)	135±14.92	136.62±14.86	0.675	131.45±14.25	132.35±13.36	0.743
DBP (mmHg)	81.74±17.84	80.46±11.15	0.726	78.82±9.42	81.01±9.92	0.248
WBC (μL)	9,017.18±2,045.87	8,881.25±1,753.27	0.780	8,096.05±1,819.38	8,539.12±1,954.57	0.231
BUN (mg/dL)	13.31±3.23	12.42±3.13	0.065	12.76±5.06	13.29±4.28	0.582
Creatinine (mg/dL)	0.66±0.16	0.72±0.15	0.161	0.71±0.26	0.73±0.21	0.650
Total cholesterol (mg/dL)	177.41±36.98	189.54±37.97	0.219	171.53±41.47	179.5±70.51	0.443
LDL-C (mg/dL)	114.91±30.99	128.64±33.53	0.111	110.84±33.01	107.45±42.23	0.636
HDL-C (mg/dL)	42.99±9.02	42.76±12.22	0.935	44.5±9	41.58±11.33	0.134
Triglyceride (mg/dL)	154.65±88.9	171.89±90.44	0.463	137.21±35.14	243.32±488.16	0.056

SG = sleeve gastrectomy, SG with PJB = sleeve gastrectomy with Proximal Jejunal Bypass, HbA1c = hemoglobin A1c, BMI = body mass index, SBP = systolic blood pressure, DBP = diastolic blood pressure, WBC = white blood cell count, BUN = blood urea nitrogen, LDL-C = low-density lipoprotein cholesterol, HDL-C = high-density lipoprotein cholesterol.
*P<0.05, **P<0.01, ***P<0.001.

Table 3. Comparison of changes in BMI and HbA1c between SG and SG with PJB in prediabetic patients

Variables	Follow-up period	SG	SG with PJB	P value
BMI	3-month	38.02±8.07	33.17±5.07	0.025*
	6-month	32.79±6.12	31.68±5.69	0.591
	12-month	29.79±5.53	27.96±3.82	0.300
HbA1c	3-month	5.45±0.35	5.60±0.31	0.197
	6-month	5.30±0.33	5.44±0.31	0.245
	12-month	5.30±0.36	5.25±0.31	0.675

BMI = body mass index, HbA1c = hemoglobin A1c, SG = sleeve gastrectomy, SG with PJB = sleeve gastrectomy with Proximal Jejunal Bypass.
*P<0.05.

In prediabetic patients, the analysis revealed a significant difference in BMI at 3 months post-surgery, with the SG with PJB group showing a lower BMI (33.17±5.07 kg/m^2) compared to the SG group (38.02±8.07 kg/m^2) (P=0.025). However, the difference was no longer observed at 6 and 12 months. Regarding HbA1c levels, there were no significant differences between the SG and SG with PJB groups throughout the follow-up period (**Table 3**).

In diabetic patients, SG with PJB showed higher HbA1c levels compared to SG both preoperatively (7.88±1.72% vs. 6.51±1.37%, P<0.001) and postoperatively at 12 months (5.79±0.78% vs. 5.59±0.44%, P=0.031). However, the difference between the two groups demonstrated a clear tendency to decrease at the 12-month follow-up (**Fig. 1**). In the additional analysis, despite the subgroup analysis, preoperative differences in HbA1c levels and BMI between surgical methods persisted, prompting an analysis of the effect of the surgical method on HbA1c levels with BMI as a covariate. At 3 months post-surgery, BMI had no significant effect on HbA1c changes, while the type of surgical procedure demonstrated a marginal trend toward significance (P=0.052), suggesting that SG with PJB might result in greater HbA1c reduction compared to SG. At 6 and 12 months post-surgery, the type of surgical procedure was significantly associated with a greater reduction in HbA1c levels (P=0.004 and P=0.002, respectively), favoring SG with PJB. In contrast, BMI showed no significant influence at both 6 and 12 months (**Table 4**).

DISCUSSION

In this study, we compared the postoperative outcomes of SG and SG with PJB, focusing on glycemic control and BMI changes in patients with prediabetes and diabetes. While both surgical procedures demonstrated efficacy in reducing HbA1c and BMI, SG with PJB consistently exhibited superior metabolic outcomes in diabetic patients. This aligns with findings from previous studies that highlight the additional benefits of including a bypass component in bariatric procedures [11]. Particularly the proximal jejunal bypass, which not only simplifies the technical aspects of gastric bypass but also reduces the risk of malnutrition commonly associated with duodenal exclusion [8-10]. Studies have demonstrated that

Table 4. Comparison of changes in HbA1c between SG and SG with PJB in diabetes patients, adjusted for BMI

Variables	BMI			Operation type		
	F value	P value	Std. error	F value	P value	Std. error
3-month follow-up	0.55	0.831	0.07	8.02	0.052	0.22
6-month follow-up	0.43	0.517	0.03	8.88	0.004**	0.38
12-month follow-up	3.80	0.062	0.03	9.90	0.002**	0.42

HbA1c = hemoglobin A1c, SG = sleeve gastrectomy, SG with PJB, sleeve gastrectomy with Proximal Jejunal Bypass, BMI = body mass index.
**P<0.01.

https://doi.org/10.17476/jmbs.2024.13.2.71

bypassing the proximal jejunum enhances metabolic improvements by altering gut hormone profiles, promoting insulin sensitivity, and inducing changes in bile acid signaling [12-14].

In diabetic patients, the significant reduction in HbA1c levels achieved with SG with PJB is likely attributable to mechanisms extending beyond mere caloric restriction and weight loss. The bypass element in SG with PJB is known to augment incretin hormone secretion, particularly glucagon-like peptide-1, which improves β-cell function and insulin secretion [13,15]. These physiological changes are likely responsible for the superior glycemic outcomes seen in SG with PJB compared to SG alone, as supported by our findings at 6 and 12 months post-surgery. The absence of a significant influence of BMI on HbA1c changes further underscores the metabolic impact of the bypass component, independent of weight loss [16]. In prediabetic patients, the lack of significant differences in HbA1c between SG and SG with PJB throughout the follow-up period suggests that baseline glycemic status plays a crucial role in determining the metabolic benefits of surgical interventions [17]. The relatively normal β-cell function and less severe insulin resistance in prediabetic patients might limit the incremental metabolic benefits of the bypass component, making the outcomes more comparable between the two surgical methods [18]. This is consistent with research showing that patients with more advanced metabolic dysfunction derive greater glycemic benefits from procedures incorporating bypass elements [4,19]. A significant reduction in BMI at 3 months post-surgery was observed in prediabetic patients undergoing SG with PJB compared to SG, suggesting that SG with PJB may offer superior initial weight loss benefits in this subgroup. However, the diminishing difference at 6 and 12 months indicates a convergence of weight outcomes over time, which aligns with previous reports suggesting that the initial advantages of more complex procedures may attenuate as patients reach a weight plateau [20,21].

Based on the findings of this study, SG with PJB appears to provide metabolic benefits beyond weight loss, making it a promising surgical option for diabetic patients by potentially reducing dependence on antidiabetic medications and mitigating long-term complications. In contrast, for prediabetic patients, the comparable glycemic outcomes between the procedures suggest that the choice of surgery may be better guided by weight-related goals and personal preferences. For prediabetic patients, however, the choice of procedure might be better guided by weight-related goals and personal preferences, given the comparable glycemic outcomes. Despite its strengths, this study has several limitations. The retrospective design introduces inherent risks of selection bias, and the relatively short follow-up period limits our ability to evaluate the long-term sustainability of the observed benefits. Future prospective studies with longer follow-up durations are needed to validate our findings and assess the durability of SG with PJB's metabolic benefits. Additionally, studies investigating the impact of SG with PJB on other obesity-related comorbidities, such as dyslipidemia and hypertension, could provide a more comprehensive understanding of its efficacy.

CONCLUSION

Our findings indicate that SG with PJB offers significant advantages over SG, particularly in achieving superior glycemic control among diabetic patients in the Korean population. The metabolic benefits of SG with PJB, which appear to function independently of weight loss, support its potential as an effective surgical intervention for managing diabetes and related comorbidities in morbidly obese individuals. Further research is needed to clarify its role in personalized surgical strategies and to assess its long-term outcomes across diverse patient populations.

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