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RESEARCH

# Ten-Year Outcomes of Laparoscopic Sleeve Gastrectomy with Roux-en-Y Duodenojejunal Bypass on Weight Loss, Metabolic Syndrome, and Nutrition: A Retrospective Cohort Study

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## Abstract

**Objective** To report the 10-year outcomes of laparoscopic sleeve gastrectomy with Roux-en-Y duodenojejunal bypass (LSG-DJB) on weight loss, resolution of associated medical problems, and nutritional status.

**Background** LSG-DJB is an established metabolic procedure as an alternative to laparoscopic Roux-en-Y gastric bypass (LRYGB), especially in Asia, where the incidence of gastric cancer is relatively high, but long-term data are limited.

**Methods** A retrospective study conducted at a single center involving 177 patients who underwent LSG-DJB, with follow-up data available for up to 10 years. Outcomes measured included weight loss, remission rates of T2DM, hypertension, dyslipidemia, and nutritional markers.

**Results** Durable weight loss was maintained over 8–10 years, with %TWL of 28.9% and %EWL of 93.1%. The remission rates at 8–10 years were 35.5% for T2DM, 39.1% for hypertension, and 48.1% for dyslipidemia. Liver enzyme and uric acid levels also showed significant, sustained improvements. The rate of conversion surgery was low (4%), with no cases of severe malnutrition. The prevalence of anemia increased to 25%, although the mean hemoglobin and iron levels remained stable.

**Conclusions** This is the first report on the long-term outcomes of LSG-DJB. It shows sustained weight loss and control of associated medical problems at 8–10 years, aligning with published data on RYGB. It effectively prevents severe malnutrition but requires monitoring for anemia. These findings confirm the long-term effectiveness and nutritional safety of LSG-DJB and provide strong support for future RCTs that directly compare it to other procedures over more extended follow-up periods.

**Keywords** Sleeve gastrectomy · Duodenojejunal bypass · DJB · Long term · Sleeve plus

Key Points• LSG-DJB provides durable weight loss and metabolic improvement, and significant remission of diabetes, hypertension, and dyslipidemia sustained at 8-10 years.

• The procedure demonstrates a favorable long-term nutritional safety profile with no severe protein malnutrition and manageable anemia, though micronutrient surveillance remains essential.

• With a low overall conversion rate and no conversions for weight regain, LSG-DJB presents a technically durable and effective alternative to Roux-en-Y Gastric Bypass.

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## Introduction

Obesity and type 2 diabetes mellitus (T2DM) remain major global public health issues, with rising prevalence and increasing healthcare costs—even in Japan [1, 2]. Bariatric and metabolic surgeries have become effective interventions for maintaining weight loss and improving glycemic control in patients with obesity and T2DM [3]. Among the different surgical options, laparoscopic sleeve gastrectomy (LSG) has become widely popular because of its technical simplicity and positive outcomes. However, its effectiveness in patients with poorly controlled diabetes and metabolic syndrome has led to modifications aimed at enhancing its metabolic benefits [4].

One such modification is the laparoscopic sleeve gastrectomy with Roux-en-Y duodenojejunal bypass (LSG-DJB). It was first introduced in Japan by Kasama et al. in 2007 as an alternative to the laparoscopic Roux-en-Y gastric bypass (LRYGB) [5]. This approach is believed to reduce the risks of dumping syndrome, reactive hypoglycemia, marginal ulcers, bile reflux, anastomotic stenosis, and nutritional deficiencies [6]. In 2016, Seki et al. reported five-year outcomes of LSG-DJB, highlighting significant improvements in weight loss, glycemic control, and insulin independence in patients with obesity and T2DM [7].

Over the past decade, LSG-DJB has become the second most commonly performed laparoscopic bariatric/metabolic procedure in Japan, accounting for 9.2%, after LSG at 78.1%, according to a nationwide survey conducted in 2020 [8]. However, long-term data beyond the five-year mark remain limited. In recent years, literature has increasingly examined the loop configuration of LSG-DJB due to its technical simplicity; however, concerns still exist regarding bile reflux and its long-term metabolic efficacy [9–11]. The lack of robust long-term comparative data on LSG-DJB highlights a gap in understanding the optimal anatomical configuration for sustained metabolic outcomes.

This study aims to provide updated evidence on the long-term effectiveness, durability of weight loss, resolution of associated medical problems, and nutritional status associated with LSG-DJB. These findings aim to inform the ongoing development of metabolic surgery practices and support evidence-based surgical decisions.

## Methods

This is a single-center, retrospective study conducted at a high-volume bariatric center in Japan. From April 2007 to February 2024, a total of 304 patients underwent LSG-DJB at our institution. For this analysis, we included the first 177 consecutive patients who were followed for over 10 years (long-term) by our multidisciplinary team. Data were collected retrospectively from prospectively maintained electronic medical records and follow-up clinic visits. Variables collected included demographic data, weight, body mass index (BMI), associated medical problems (T2DM, hypertension, dyslipidemia), medication use, and laboratory results (e.g., HbA1c, FBS, C-peptide, liver enzymes, lipid profile). All patients underwent LSG-DJB based on indications, and using a standardized Roux-en-Y configuration [5, 7]. It involves a vertical sleeve gastrectomy sized with a 37.5-Fr bougie and a proximal intestinal bypass (the limb lengths were 100 cm for the biliopancreatic tract and 150 cm for the alimentary tract). Outcomes were evaluated at baseline, 1 year, 5 years, and 8–10 years postoperatively. To ensure an adequate sample for the long-term analysis, data from patients seen at their 8-year, 9-year, or 10-year follow-up were combined into a single '8–10 year' time point. Definitions of T2DM, hypertension, and dyslipidemia complete remission were based on ASMBS standardized criteria [12]. Routine monitoring of specific micronutrients was not consistently performed in asymptomatic patients. Therefore, key indicators of nutritional status in our cohort primarily focused on hemoglobin, iron, albumin, and total protein.

### Statistical Analysis

Continuous variables were expressed as means ± standard deviations (SD), while categorical variables were shown as frequencies with percentages. Paired-samples t-tests were used to compare the baseline with each follow-up time point for continuous variables. The McNemar test was employed to assess changes in prevalence rates for categorical variables. For parameters measured across all three follow-up time points, repeated measures ANOVA (for continuous variables, such as %TWL) and Cochran's Q test (for categorical variables, such as remission rates) were used to evaluate changes over time. All statistical tests were two-sided, and a p-value of $< 0.05$ was considered statistically significant. Analyses were performed using SPSS version 30.0 (IBM Corp., Armonk, NY, USA) and JASP version 0.19.3 (JASP Team, Netherlands).

## Results

A total of 177 patients were included in the study. The mean age was 44.0 ± 8.5 years, with a slight female predominance (52.5%). The follow-up rates were 92.1%, 43.5%, and 27.1% at 1, 5, and 8–10 years, respectively.

### Weight Loss

Significant reductions in body weight and BMI were observed at all follow-up points compared to baseline (Fig. 1). Mean

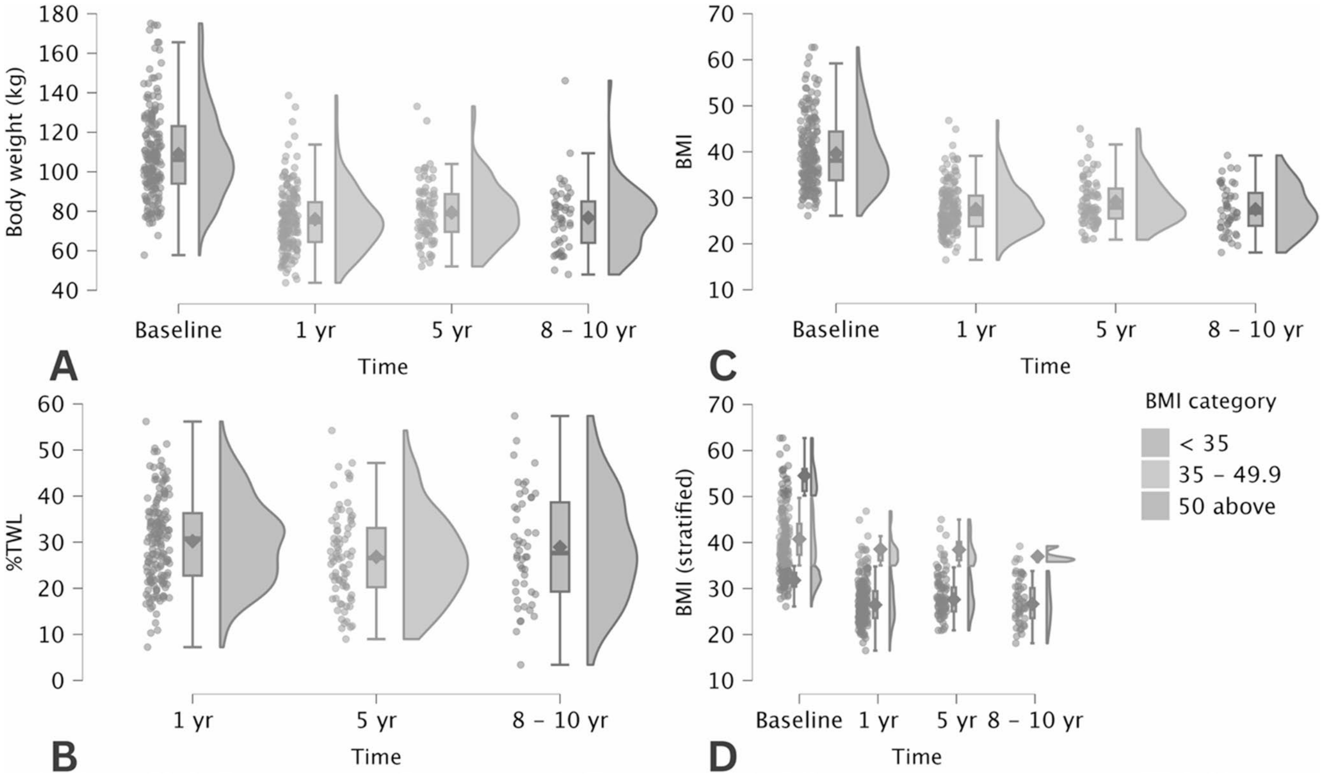


**Fig. 1** Long-term trends in weight loss outcomes following laparoscopic sleeve gastrectomy with Roux-en-Y duodenojejunal bypass (LSG-DJB). (**A**) Mean body weight (kg), (**B**) Percentage of total weight loss (%TWL), (**C**) Body mass index (BMI, kg/m²), and (**D**) Distribution of BMI categories over the study period

body weight decreased from 109.0 ± 23.0 kg to 76.0 ± 16.3 kg at 1 year ($p < 0.001$), with maintained results at 5 years (79.4 ± 15.3 kg) and 8–10 years (76.7 ± 16.9 kg). Similarly, BMI decreased from 39.6 ± 7.7 kg/m² to 27.6 ± 5.2 kg/m² at 1 year ($p < 0.001$), with slight increases afterward but remaining significantly below baseline (Table 1). The percentage of total weight loss (%TWL) was 30.2 ± 9.5% at 1 year and stayed above 25% at subsequent follow-ups ($p = 0.044$). The percentage excess weight loss (%EWL) followed a similar pattern, with 95.6 ± 49.5% at 1 year, 83.8 ± 53.8% at 5 years, and 93.1 ± 67.5% at 8–10 years ($p = 0.049$).

## Diabetes Mellitus and Glycemic Parameters

The prevalence of T2DM decreased from 85.9% at baseline to 18.4% at 1 year ($p < 0.001$), with partial recurrence at 5 years (35.7%) and 8–10 years (62.5%). Usage of oral hypoglycemic agents and insulin both decreased significantly. At 1 year, insulin use declined from 40.1% to 2.9% ($p < 0.001$), with minimal rebound at later follow-ups. Diabetes remission was observed in 78.6% at 1 year, 59.2% at 5 years, and 35.5% at 8–10 years ($p = 0.005$) (Table 2). GLP-1 use was reported in only 26.7% of cases at 8–10 years. HbA1c improved from 7.6 ± 1.3% to 5.9 ± 0.9% at 1 year ($p < 0.001$), and remained lower than baseline at 8–10 years (6.5 ± 1.0%). Fasting blood sugar and C-peptide levels also decreased significantly across all follow-ups ($p < 0.001$) (Table 3). In a post-hoc analysis, we evaluated remission rates by baseline insulin use. At 8–10 years, complete T2DM remission was achieved in 12.5% (2/16) of patients who were insulin-dependent at baseline, compared to 60% (9/15) of those who were not.

**Table 1** Weight loss outcomes

| Variable | Baseline (Mean ± SD) | 1 Year (Mean ± SD) | *p*-value | 5 Years (Mean ± SD) | *p*-value | 8–10 Years (Mean ± SD) | *p*-value |
|---|---|---|---|---|---|---|---|
| Weight (kg) | 109 ± 23.0 | 76.0 ± 16.3 | < 0.001 | 79.4 ± 15.3 | < 0.001 | 76.7 ± 16.9 | < 0.001 |
| BMI (kg/m²) | 39.6 ± 7.7 | 27.6 ± 5.2 | < 0.001 | 29.2 ± 5.1 | < 0.001 | 27.5 ± 5.1 | < 0.001 |
| %TWL | — | 30.2 ± 9.5% | — | 26.8 ± 9.6% | — | 28.9 ± 11.9% | 0.044 |
| %EWL | — | 95.6 ± 49.5% | — | 83.8 ± 53.8% | — | 93.1 ± 67.5% | 0.049 |

*BMI* body mass index; %*TWL* percentage total weight loss; %*EWL* percentage excess weight loss; *SD* standard deviation

**Table 2** Metabolic profile and remission of associated medical problems

| Variable | Baseline % (*N*) | 1 Year % (*N*) | *p*-value | 5 Years % (*N*) | *p*-value | 8–10 Years % (*N*) | *p*-value |
|---|---|---|---|---|---|---|---|
| Diabetes mellitus prevalence | 85.9% | 18.4% | <0.001 | 35.7% | <0.001 | 62.5% | <0.001 |
| OHA use | 68.4% | 11.8% | <0.001 | 17.1% | <0.001 | 40.6% | <0.001 |
| Insulin use | 40.1% | 2.9% | <0.001 | 0% | -- | 6.3% | <0.001 |
| GLP-1 use | -- | -- | -- | -- | -- | 26.7% | -- |
| Diabetes Remission | -- | 78.6% | -- | 59.2% | -- | 35.5% | 0.005 |
| Systolic BP (mmHg)* | 134.5 ± 20.0 | 124.7 ± 19.6 | <0.001 | 130.4 ± 20.9 | 0.014 | 130.5 ± 16.1 | 0.712 |
| Diastolic BP (mmHg)* | 79.0 ± 14.4 | 73.1 ± 14.4 | <0.001 | 75.9 ± 13.7 | 0.062 | 78.1 ± 11.4 | 0.673 |
| Hypertension prevalence | 68.4% | 31.5% | <0.001 | 49.0% | <0.001 | 53.1% | 0.146 |
| Hypertension meds use | 54.8% | 24.7% | <0.001 | 43.1% | 0.022 | 34.4% | 0.065 |
| Hypertension Remission | -- | 54.9% | -- | 34.2% | -- | 39.1% | 0.028 |
| Dyslipidemia Prevalence | 79.7% | 20.2% | <0.001 | 39.2% | <0.001 | 46.9% | 0.002 |
| Lipid meds use | 48.6% | 6.7% | <0.001 | 17.6% | <0.001 | 21.9% | 0.006 |
| Dyslipidemia Remission | -- | 75.9% | -- | 50.0% | -- | 48.1% | 0.009 |
| Anemia Prevalence[a] | 10.7% | 23.3% | 0.003 | 43.9% | <0.001 | 25% | 0.344 |

*Presented as mean ± standard deviation; [a]Based on World Health Organization definition (hemoglobin levels < 12.0 g/dL in women and < 13.0 g/dL in men)

*OHA* oral hypoglycemic agents; *GLP-1* glucagon-like peptide-1; *BP* blood pressure

**Table 3** Blood indices before and after laparoscopic sleeve gastrectomy with Roux-en-y duodenojejunal bypass (LSG-DJB)

| Variable | Baseline (Mean ± SD) | 1 Year (Mean ± SD) | *p*-value | 5 Years (Mean ± SD) | *p*-value | 8–10 Years (Mean ± SD) | *p*-value |
|---|---|---|---|---|---|---|---|
| HbA1c (%) | 7.6 ± 1.3 | 5.9 ± 0.9 | <0.001 | 6.1 ± 0.9 | <0.001 | 6.5 ± 1.0 | <0.001 |
| FBS (mg/dL) | 178.8 ± 77.4 | 103.3 ± 23.0 | <0.001 | 105.8 ± 20.1 | <0.001 | 108.8 ± 25.1 | <0.001 |
| C-Peptide (ng/mL) | 3.6 ± 2.6 | 2.2 ± 0.8 | <0.001 | 2.3 ± 1.0 | <0.001 | 2.0 ± 0.8 | <0.001 |
| Hemoglobin (g/dL) | 13.9 ± 1.6 | 13.3 ± 1.7 | <0.001 | 13.0 ± 2.1 | <0.001 | 13.5 ± 1.8 | 0.134 |
| Iron (µg/dL) | 91.9 ± 31.5 | 92.4 ± 37.4 | 0.963 | 92.5 ± 48.0 | 0.523 | 100.8 ± 57.9 | 0.525 |
| Total Protein (g/dL) | 7.1 ± 0.4 | 7.4 ± 5.0 | 0.381 | 7.2 ± 0.4 | 0.160 | 7.0 ± 0.4 | 0.200 |
| Albumin (g/dL) | 4.1 ± 0.4 | 4.3 ± 0.3 | <0.001 | 4.3 ± 0.3 | <0.001 | 4.3 ± 0.3 | 0.096 |
| Total cholesterol (mg/dL) | 193.1 ± 41.4 | 183 ± 33.8 | 0.001 | 189 ± 45.8 | 0.720 | 176.7 ± 28 | 0.772 |
| Triglyceride (mg/dL) | 150.9 ± 112.4 | 84.6 ± 45.8 | <0.001 | 98.4 ± 60.2 | <0.001 | 92.1 ± 43.3 | <0.001 |
| HDL (mg/dL) | 45.4 ± 9.7 | 57.1 ± 13.7 | <0.001 | 56.1 ± 13.1 | <0.001 | 58.1 ± 14.9 | <0.001 |
| LDL (mg/dL) | 120.2 ± 35.6 | 104.5 ± 29.8 | <0.001 | 107.5 ± 30 | 0.109 | 101.4 ± 26.8 | 0.057 |
| Total Bilirubin (mg/dL) | 0.7 ± 0.2 | 0.7 ± 0.4 | 0.008 | 0.7 ± 0.4 | 0.181 | 0.6 ± 0.3 | 0.828 |
| ALT (U/L) | 49.3 ± 39.9 | 24.1 ± 14.3 | <0.001 | 27.0 ± 42.1 | 0.001 | 25.8 ± 11.6 | 0.002 |
| AST (U/L) | 37.9 ± 29.3 | 22.9 ± 9.1 | <0.001 | 29.6 ± 35.4 | 0.088 | 27.2 ± 9.3 | 0.035 |
| GGT (U/L) | 49.8 ± 44.5 | 20.5 ± 16.0 | <0.001 | 32.2 ± 60.0 | 0.080 | 21.6 ± 14.2 | 0.002 |
| Uric acid (mg/dL) | 6.3 ± 1.6 | 5.5 ± 1.4 | <0.001 | 5.7 ± 1.4 | <0.001 | 5.3 ± 1.2 | <0.001 |
| eGFR (mL/min/1.73 m²) | 112.8 ± 16.3 | 113.6 ± 15.3 | 0.150 | 108.8 ± 15.3 | <0.001 | 78.8 ± 22.2 | <0.001 |

*FBS* fasting blood sugar; *HDL* high-density lipoprotein; *LDL* Low-density lipoprotein; *ALT* alanine aminotransferase; *AST* aspartate aminotransferase; *GGT* gamma-glutamyl transferase; *eGFR* estimated glomerular filtration rate

## Blood Pressure and Hypertension

Systolic and diastolic blood pressures significantly improved at 1 year ($p < 0.001$ for both). Systolic BP decreased from 134.5 ± 20.0 mmHg to 124.7 ± 19.6 mmHg; diastolic BP dropped from 79.0 ± 14.4 mmHg to 73.1 ± 14.4 mmHg. However, by 8–10 years, these values were no longer significantly different from baseline. Hypertension prevalence declined from 68.4% to 31.5% at 1 year ($p < 0.001$), but gradually increased at 5 years (49.0%) and 8–10 years (53.1%). Medication use followed a similar pattern. Hypertension remission occurred in 54.9% at 1 year and remained significant at 8–10 years (39.1%, $p = 0.028$) (Table 2).

## Dyslipidemia, Lipid and Liver Profile

The prevalence of dyslipidemia decreased from 79.7% to 20.2% after one year ($p < 0.001$), with some recurrence by 8–10 years (46.9%, $p = 0.002$). Remission was observed in 75.9% of patients at one year and persisted in nearly half at long-term follow-up (48.1%, $p = 0.009$). The use of lipid-lowering medications significantly decreased at all time points (Table 2). Total cholesterol dropped from 193.1 ± 41.4 to 183.0 ± 33.8 mg/dL after one year ($p = 0.001$), while triglycerides decreased notably from 150.9 ± 112.4 to 84.6 ± 45.8 mg/dL ($p < 0.001$). High-density lipoprotein (HDL) increased from 45.4 ± 9.7 to 57.1 ± 13.7 mg/dL ($p < 0.001$) and remained elevated. In contrast, low-density lipoprotein (LDL) significantly declined at one year but showed no significant difference by 8–10 years (Table 3). Levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transferase (GGT) all decreased at one year and remained lower at 5 and 8–10 years.

### Anemia and Nutritional Markers

Anemia prevalence increased from 10.7% at baseline to 23.3% at 1 year ($p = 0.003$), peaking at 43.9% at 5 years ($p < 0.001$), but then declined to 25.0% at 8–10 years ($p = 0.344$). Hemoglobin levels dropped modestly but remained within normal limits. No patient developed severe protein-calorie malnutrition. Iron, total protein, and albumin levels remained stable over time (Tables 2 and 3).

### Conversion Surgery

Seven patients (4%) required conversion to laparoscopic RYGB during follow-up: one due to gastric sleeve stenosis and six due to intractable gastroesophageal reflux disease (GERD). No patients required conversion for severe malnutrition.

## Discussion

This long-term, single-center study evaluated the outcomes of LSG-DJB in a Japanese population predominantly with obesity and diabetes, with follow-up extending from 8 to 10 years. The results demonstrate durable weight loss, sustained glycemic improvement, and partial remission of metabolic problems, including T2DM, dyslipidemia, and hypertension. Despite physiological regression over time, a substantial proportion of patients maintained clinically meaningful improvements a decade after surgery.

In 2007, Kasama et al. introduced LSG-DJB in Japan as an alternative to LRYGB, eliminating the concern of a retained excluded remnant stomach. This approach holds particular significance in regions with a high incidence of gastric cancer (the third most prevalent malignancy in Japan), where endoscopic surveillance of a bypassed stomach would otherwise be challenging [5, 13]. Furthermore, LSG-DJB offers distinct physiological benefits: (1) preservation of the pylorus mitigates risks of dumping syndrome, marginal ulcers, and anastomotic stenosis, and (2) its design as a modified "short limb" duodenal switch (DS) helps avoid the long-term nutritional complications associated with the classic biliopancreatic diversion with duodenal switch (BPD/DS) [5, 7, 14]. For over a decade, only one randomized controlled trial (RCT) has directly compared LSG-DJB ($n = 28$) to LRYGB ($n = 29$). Both procedures demonstrated comparable outcomes in terms of weight loss and remission of associated medical problems, with no mortality reported in either group at one-year follow-up. The study concluded that LSG-DJB is a safe and effective alternative to LRYGB, though long-term comparative data remain unreported [15].

Long-term follow-up in our cohort demonstrated significant and durable weight loss after LSG-DJB, with a %TWL of 28.9 ± 11.9% and a %EWL of 93.1 ± 67.5% from a baseline weight of 109 kg and a BMI of 39.6 kg/m². When viewed alongside long-term data from RYGB (Swiss national database, SM-BOSS, SLEEVEPASS, SOReg), the weight loss in our LSG-DJB cohort appears comparable in magnitude, as measured by %TWL [16–19]. However, any direct comparison of efficacy must be interpreted with extreme caution due to critical methodological differences. The historical RYGB studies benefited from substantially higher follow-up rates, providing a more representative outcome. Furthermore, the use of GLP-1 receptor agonists in 26.7% of our long-term patients represents a modern therapeutic adjunct that was unavailable during the follow-up periods of the cited RYGB studies and undoubtedly influences the weight outcomes reported here. A definitive comparison would require a prospective, randomized trial with matched follow-up protocols while accounting for adjunct pharmacotherapy.

Our study demonstrated sustained remission of associated medical problems across all follow-up intervals, although rates gradually declined over time. At 8–10 years after LSG-DJB, we observed remission rates of 35.5% for T2DM, 39.1% for hypertension, and 48.1% for dyslipidemia. These outcomes compare favorably with the spectrum of results reported for RYGB, a notable finding given that our cohort presented with a substantially higher baseline disease burden.

The observed decline in T2DM remission, from 78.6% at 1 year to 35.5% at 8–10 years, is a recognized phenomenon consistent with long-term data from RYGB. For instance, an Italian cohort study of morbidly obese T2DM patients who underwent RYGB reported a decline from 74% at 1 year to 53% at 10 years [20]. The more pronounced decline in our cohort is likely attributable to our population's more advanced disease state, characterized by a higher rate of baseline insulin use (40.1% vs. 24%), indicating poorer β-cell reserve. This hypothesis is directly substantiated by our subgroup analysis, which revealed a markedly lower long-term remission rate in baseline insulin-dependent patients (12.5%) compared to their non-insulin-dependent counterparts (60%), thereby confirming the positive influence of preoperative disease severity on durable glycemic outcomes. Furthermore, the use of GLP-1 receptor agonists in 26.7% of our long-term patients highlights the emerging role of adjunctive pharmacotherapy in maintaining metabolic control after the waning effects of surgery. This relapse aligns with the natural history of T2DM and is strongly predicted by factors such as longer preoperative diabetes duration, higher HbA1c, and insulin dependence [20–22].

A similar pattern of durable yet declining efficacy was seen for hypertension. Our long-term remission rate of 39.1% aligns with the 48.8% rate from the SM-BOSS trial but exceeds the 15.1% rate from the large SOReg study [17, 19]. This variation highlights how baseline characteristics influence remission rates; our cohort had a higher baseline hypertension prevalence (68.4%) than the SOReg population (31.3%). The gradual decline in remission rates over time is likely multifactorial, attributable to factors such as aging, weight trajectory, and preoperative factors, including disease duration and medication burden [23].

Most notably, dyslipidemia remission emerged as a particular strength of the LSG-DJB procedure, with a remission rate of 48.1% persisting at 8–10 years. This result suggests a potential superiority over RYGB outcomes from large registries, which report rates of 8.8% (SOReg), 19.4% (SM-BOSS), and 35% (SLEEVEPASS) [17, 19]. This comparison is particularly notable given the significantly higher baseline prevalence of dyslipidemia in our cohort (79.7%) compared to these studies (12.3% – 42.5%). The procedure's robust and sustained impact on the lipid profile underscores a cornerstone metabolic benefit. A recent prospective study confirmed that significant improvements in all lipid parameters after RYGB can be maintained at 10–15 years [24]. Ultimately, the fact that over one-third of patients remained in remission from the obesity-associated medical problems a decade postoperatively constitutes a profound and clinically meaningful intervention.

The long-term nutritional safety of a metabolic procedure is as critical as its efficacy. In this series, LSG-DJB exhibited a strong nutritional safety profile. There were no cases of severe protein-calorie malnutrition requiring conversion surgery, and levels of total protein and albumin remained stable throughout the follow-up. This contrasts sharply with classic BPD/DS, which carries a well-documented risk of hypoalbuminemia (up to 25%) and a considerable conversion surgery rate for malnutrition (exceeding 10%) [25, 26]. The nutritional outcomes of LSG-DJB also compare favorably to those of RYGB, where, despite a low conversion rate for malnutrition (1.7–1.9%), concerns about protein deficiency (0% – 8.9%) and other nutritional sequelae can still occur in the long term [27]. Furthermore, the prevalence of anemia increased from 10.7% at baseline to 25% at 8–10 years, a known sequela of malabsorptive procedures. However, mean hemoglobin and iron levels for the entire cohort remained within normal limits, indicating that the observed anemia was generally mild and clinically manageable. This is consistent with 10-year RYGB outcomes, where anemia prevalence ranges from 18% to 50%, underscoring the critical need for lifelong micronutrient surveillance and supplementation after any procedure with a bypass component [28, 29].

The positive effects of bariatric surgery on non-alcoholic fatty liver disease (NAFLD) are well proven for procedures like LSG and RYGB [30]. In Japan, where NAFLD and non-alcoholic steatohepatitis are particularly common among patients with obesity, our results suggest that LSG-DJB is a highly effective treatment option. This is backed by the consistently maintained reduction in transaminases and gamma-glutamyl transferase levels observed over 8–10 years after surgery [31]. Likewise, uric acid levels showed a significant and lasting decrease from baseline at all follow-up points, dropping from 6.3 mg/dL to 5.3 mg/dL at 10 years. This improvement appears more pronounced than the decrease reported in the Swedish Obese Subjects (SOS) study after RYGB, which showed a decrease from 5.98 mg/dL to 5.34 mg/dL over ten years [32].

Regarding procedural safety, Seki et al. have previously shown that LSG-DJB has a favorable safety profile, with a 4.2% rate of Clavien-Dindo grade ≥ III complications in both early and late postoperative periods. There were no instances of intraoperative major complications, conversion to laparotomy, or mortality [7]. In our long-term cohort, the conversion surgery rate was low (4%), with all cases due to foregut complications (six intractable GERD and one gastric sleeve stenosis). This pattern of indications differs from the complication profile of RYGB. While RYGB is linked to specific issues such as dumping syndrome (incidence of 2.5%) and gastrojejunostomy ulcer/stricture (6.7%), these do not always require reoperation [18]. Additionally, although our conversion surgery targeted symptomatic problems, many RYGB conversions reported in the literature are performed for weight recidivism, with rates from 5.5% to 9% [17, 33]. In the Swiss national database, despite a high overall conversion rate (28.5%) following primary RYGB in the long term, specific conversion rates for gastrojejunostomy stricture and marginal ulcer were low (5.8% and 1.4%, respectively), suggesting that most conversions were for other reasons, such as recurrent weight gain [16]. This suggests that while LSG-DJB may be more prone to certain foregut issues, it demonstrates durable effectiveness in maintaining weight loss, as evidenced by the lack of conversions for recurrent weight gain or suboptimal weight loss. Therefore, LSG-DJB and RYGB can be seen as complementary procedures, each with a distinct risk-benefit profile, and the choice between them may be guided by patient-specific factors, including the primary risk of recurrent weight gain versus foregut complications.

In 2011, Lee et al. introduced the laparoscopic single-anastomosis duodenal-jejunal bypass with sleeve gastrectomy (SADJB-SG), a loop-configuration variant of LSG-DJB. Based on the principles of the "short" DS and one anastomosis gastric bypass (OAGB), its design aims to provide technical simplicity (one anastomosis) and a lower risk of malnutrition while achieving comparable metabolic results to RYGB. Initial one-year outcomes confirmed that SADJB-SG/loop LSG-DJB offers weight loss and metabolic improvements similar to those of RYGB/OAGB, with comparable nutritional outcomes [34, 35]. Additionally, Huang et al. reported a 3% conversion rate ($n$ = 10/337) in their 9-year experience with loop LSG-DJB [36]. To date, only one RCT ($n$ = 88) has directly compared Roux-en-Y to loop LSG-DJB configurations, reporting that the loop modification provided several benefits, including technical simplicity, shorter operative time, lower costs, and better %TWL [11]. However, while the loop configuration simplifies the procedure, our Roux-en-Y data demonstrate lasting metabolic effectiveness with a similarly low conversion rate, supporting its use where long-term biliary reflux and anastomotic stability are primary concerns. The lack of solid long-term comparative data precludes definitive conclusions about the optimal configuration.

Several limitations should be considered. The retrospective and single-center design may limit the generalizability of the findings. The decreasing patient follow-up rate over 10 years introduces potential attrition bias, which could lead to an overestimation of the procedure's long-term optimal clinical response. Aggregating 8- to 10-year follow-up data, although necessary to address attrition, may obscure subtle temporal trends within this period. The generalizability of our findings may be limited by the homogenous nature of our cohort (Japanese patients with a characteristic high metabolic burden at a lower BMI). While the presented comparative data with RYGB provides context, validation in more diverse populations is needed. The absence of a control group also prevents definitive comparative conclusions. Lastly, the absence of systematic data on specific micronutrients (e.g., Vitamins B12, D, thiamine) limits our ability to fully characterize the nutritional profile of LSG-DJB.

## Conclusions

This study represents the first and longest follow-up investigation of LSG-DJB, addressing a critical evidence gap in the field of bariatric surgery. The findings confirm the procedure's long-term efficacy in weight loss and control of associated medical problems, along with a low conversion rate that compares favorably with published long-term outcomes for RYGB. These results provide a robust foundation for future RCTs with extended follow-up to directly compare LSG-DJB with LRYGB and loop-configuration variants, thereby advancing beyond the short-term data currently available.

**Author Contributions** Substantial contributions to conception, design, and acquisition of data - R.V.Y., Y.S., K.K., E.K., A.T., and R.Y.; Analysis and interpretation of data - Y.S., R.V.Y., and R.Y.; Drafting the main manuscript text - R.V.Y., Y.S., and K.K.; All authors reviewed the manuscript; Y.S. and K.K. gave final approval of the version to be submitted.

**Data Availability** No datasets were generated or analysed during the current study.

## Declarations

**Ethical Approval** The Institutional Review Board (IRB) approved this study. Since this was a retrospective study utilizing anonymized clinical data, the IRB waived the requirement for informed consent in accordance with institutional and national guidelines. All methods were performed in accordance with relevant policies and regulations, including the Declaration of Helsinki.

**Human and Animal Rights** No human or animal rights were violated in this study.

**Competing Interests** The authors declare no competing interests.

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