OBES SURG (2017) 27:795–801
DOI 10.1007/s11695-016-2372-0

ORIGINAL CONTRIBUTIONS

Five-Year-Results of Laparoscopic Sleeve Gastrectomy with Duodenojejunal Bypass for Weight Loss and Type 2 Diabetes Mellitus

Yosuke Seki[1] · Kazunori Kasama[1] · Hidenori Haruta[1] · Atsushi Watanabe[1] · Renzo Yokoyama[2] · Jose Paolo Cabreira Porciuncula[3] · Akiko Umezawa[4] · Yoshimochi Kurokawa[4]

Published online: 19 September 2016

Abstract
Background Laparoscopic sleeve gastrectomy with duodenojejunal bypass (LSG-DJB) has been designated as a novel bariatric surgery procedure. This combination of sleeve gastrectomy and proximal intestinal bypass theoretically offers an effective and prolonged anti-diabetes effect. This is a follow-up of our institution's previous report on the short-term effects of LSG-DJB on type 2 diabetes mellitus (T2DM), which a 68.7 % remission (HbA1c <6 % without diabetes medication) rate 1 year after surgery. The aforementioned result was comparable to the reported remission rates of laparoscopic Roux-en-Y gastric bypass. However, the durability of remission remains unknown.
Objective The objective of this study is to investigate the medium-term (up to 5 years) effects of LSG-DJB on weight loss and T2DM.
Methods In this analysis, consecutive 120 patients (female to male ratio = 61:59, mean age = 44.8 years) with T2DM who underwent LSG-DJB from April 2007 to November 2013 and were followed up beyond 1 year were included. The preoperative mean body weight and BMI were 105.7 kg and 38.5 kg/m^2, respectively. The mean HbA1c and fasting blood glucose values were 8.9 % and 194 mg/dL, respectively. The mean duration of T2DM was 7.3 years. Fifty-five patients (46 %) were being treated with insulin prior to surgery.
Results The follow-up rate was 97.5 % at 1 year, 73.3 % at 3 years, and 50.0 % at 5 years. The mean body weight was 74.9 kg at 1 year, 76.8 kg at 3 years, and 72.8 kg at 5 years ($p < 0.001$, compared to the baseline). The mean percent of total body weight loss (%TWL) was 28.9, 28.6, and 30.7 % at 1, 3, and 5 years, respectively. Remission of T2DM was achieved at 63.6, 55.3, and 63.6 % at 1, 3, and 5 years, respectively. Among those who achieved diabetes remission at 1 year, 10.8 % of them experienced recurrence during the subsequent follow-up period.
Conclusion Although recurrence of T2DM is observed in some patients over time, LSG-DJB is an effective procedure for achieving significant weight loss and improvement of glycemic control, and the effects seem to be durable up to 5 years.

Keywords Sleeve gastrectomy · Duodenojejunal bypass · Diabetes · Medium-term · Asian · Japanese

Introduction

In 2007, our institution has started performing sleeve gastrectomy with duodenojejunal bypass (LSG-DJB) as an alternative to laparoscopic Roux-en-Y gastric bypass (LRYGB). This solution was offered due to the concern that gastric cancer has a high prevalence in Japan, and the inherent difficulty of performing gastric screening by upper gastrointestinal endoscopy has been categorized as a non-negligible problem in the said country [1, 2]. LSG-DJB is a modification of the duodenal switch ("short-limb" DS) and has the following theoretical advantages:

✉ Yosuke Seki
yosuke_seki@hotmail.com

1 Weight Loss and Metabolic Surgery Center, Yotsuya Medical Cube, 7-7 Nibancho, Chiyoda-ku, Tokyo 102-0084, Japan

2 Center for Clinical Research, Okinawa Prefectural Chubu Hospital, Okinawa, Japan

3 Weight Management and Bariatric-Metabolic Surgery Center, St. Luke's Medical Center, Quezon, City, Philippines

4 Department of Surgery, Yotsuya Medical Cube, Tokyo, Japan

1. The pylorus is preserved, leading to lesser occurrence of dumping syndrome and reactive hypoglycemia as compared to LRYGB.
2. A duodenojejunostomy is located at 1–2 cm distal to the pylorus, which allows for a wider anastomotic stoma, leading to less occurrence of anastomotic stenosis as compared to LRYGB.
3. The risks of nutritional deficiencies are expected to be lower in LSG-DJB than that after DS.
4. The combination of a sleeve gastrectomy and DJB (proximal intestinal bypass) is expected to have an effective and prolonged anti-diabetes effect.

Previously, our institution reported the short-term results of LSG-DJB and showed a total weight loss percentage (%TWL) of 31.6 %. Additionally, 68.7 % of the patients with type 2 diabetes mellitus (T2DM) preoperatively achieved remission of diabetes (HbA1c <6 % without diabetes medication), 1 year following LSG-DJB, with comparable results to patients of LRYGB [3]. Theoretically, the procedure can address some of the shortcomings of LRYGB. However, no long-term data has been published to challenge the gold standard. This will be the first report which shows the medium-term (up to 5 years) effects and outcomes of LSG-DJB. The primary endpoints of the study are weight loss, safety, and remission of diabetes.

Methods

This is a retrospective analysis of a prospectively collected database. From April 2007 to November 2013, 120 consecutive Japanese patients with T2DM underwent LSG-DJB and were followed-up beyond 1 year. Other parameters for inclusion were based on the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) Guidelines for Clinical Application of Laparoscopic Bariatric Surgery, which includes the following: medically uncontrolled, ages between 18 and 65 years with body mass index (BMI) of more than 30 kg/m^2 with obesity related co-morbidities [4], which was approved by the Institutional Review Board. Each patient was preoperatively screened and evaluated by our multidisciplinary team. Prior to making a final decision for surgery, every patient underwent a detailed and up-to-date discussion regarding the various available bariatric surgical options, their pros and cons, the risks and benefits, the potential postoperative complications, including the possibility of reoperations, and the likelihood of requiring postoperative nutritional supplementation.

Diagnosis of Diabetes

The diagnosis of diabetes was based on the following Japan Diabetes Society criteria: FPG ≥126 mg/dL, symptoms of diabetes plus casual plasma glucose ≥200 mg/dL, or 2 h postload glucose ≥200 mg/dL during a 75-g oral glucose tolerance test [5]. Patients with a positive history of diabetes and using diabetic medication before surgery were also classified as having diabetes despite normal values for FPG or HbA1c while on medication.

Surgical Technique

Our surgical technique for LSG-DJB was described in detail previously [1]. The short gastric vessels on the greater curvature of the stomach were divided from a distance 4 cm proximal to the pylorus to the gastroesophageal junction. Complete mobilization of the fundus was obtained. The 37.5 Fr. calibration tube was advanced transorally along the lesser curvature, and the stomach was divided using a linear stapler. The staple line was imbricated while keeping the calibration tube in place. Then, the posterior wall of the duodenum was dissected and divided using a linear stapler 1–2 cm distal to the pylorus. The limb length was 100 cm for the biliopancreatic tract and 150 cm for the alimentary tract. The jejunojejunostomy was created using a linear stapler, and an entry hole was closed by single layer of hand sewing. The omentum was divided to avoid the tension of anastomosis during an antecolic reconstruction. A duodenojejunal end-to-side anastomosis was created by two layers of hand sewing (Fig. 1).

Postoperative Care

A clear-liquid diet was started on postoperative day 1 (POD1) if no complications were detected by physical examination and/or radiographic testing by esophagogram. Patients were discharged from the hospital on POD3 after confirming oral

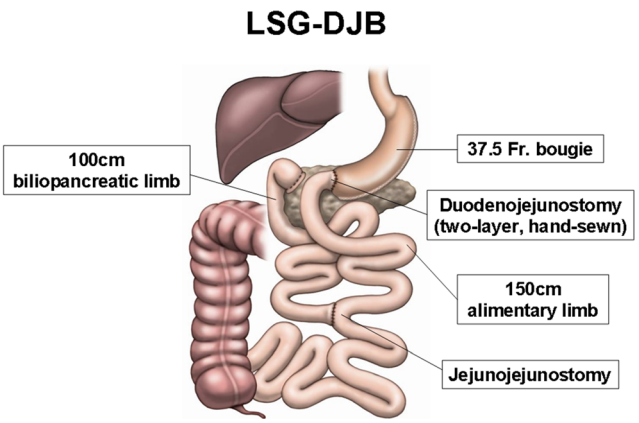

Fig. 1 Illustration of LSG-DJB. Sleeve gastrectomy is achieved after insertion of a 37.5-Fr gastric bougie transorally and orienting it to the lesser curvature of the stomach, then dividing the stomach vertically. The duodenum was transected 1–2 cm from the pylorus by stapler. The biliopancreatic limb is approximately 100 cm long and the alimentary limb, which was anastomosed to the proximal duodenum, was approximately 150 cm in length

liquids were well tolerated. Detailed dietary counseling was given by a bariatric nutrition specialist, and written instructions for optimal health management at home were provided, emphasizing dietary sources of protein, B vitamins, iron, and calcium. Liquid food was started by postoperative week 2, semi-solid foods by week 4, and solid foods thereafter. Standard follow-up included visits to the outpatient clinic at 1; 3; and 6 months; 1 year; and annually thereafter. Also, patients were encouraged to regularly attend the bariatric surgery patient support group meetings.

Diabetes Outcomes Classifications

Diabetes remission was defined as HbA1c <6 % without use of any diabetes medications [6]. The number or prevalence of the patients who achieved HbA1c <6.5 % without diabetes medications, those who achieved diabetes control (HbA1c <7 % with or without diabetes medications), and those with poorly controlled diabetes (HbA1c ≥8 %) were also noted. On the other hand, diabetes was regarded as "recurred" when HbA1c value moved back into the diabetic range (≥6.5 %) or the need for diabetes medication after any period of remission [7].

Statistical Analysis

Continuous data are presented as means ± SD or SE, as indicated. All parametric data were analyzed using Student's *t* test (paired and unpaired) when appropriate. All non-parametric data were analyzed using the Mann-Whitney test. The chi-square test was used to identify significant difference between proportions and categorical variables. A two-sided *p* value of 0.05 was considered statistically significant. The statistical analysis was done using the SPSS version 11.0J for Windows.

Results

There were 120 patients, comprising of 61 females and 59 males with a mean age of 44.8 ± 7.9 years. The mean preoperative body weight was 105.7 ± 21.5 kg, and the mean preoperative BMI was 38.5 ± 7.3 kg/m^2. The follow-up rate during the study period is shown in Table 1.

Table 1 Follow-up rate during the study period

	Pre-OP	1Y	2Y	3Y	4Y	5Y
Actual N	120	117	90	55	21	11
Expected N		120	100	75	32	22
F/U rate (%)		97.5	90.0	73.3	65.6	50.0

Operative Safety

There were no major intraoperative complications or conversions to laparotomy. Mean skin-to-skin operative time was 224 ± 37 min with mean blood loss of 58 ± 89 mL. Mean postoperative hospital stay was 3.4 ± 1.1 days. Postoperative complications were reviewed independently by one of the co-authors (RY) and stratified based on the Clavien-Dindo classification [8]. There were five severe complications (Grade III-a or more) in five patients during the early (within 30 days) postoperative period including one case of leakage from the duodenojejunal anastomosis and four cases of hemorrhages (two intraluminal and two intraabdominal). Also, there were six severe complications that occurred in five patients during late (between 30 days to 2 years) postoperative period including two internal hernias, three sleeve stenoses, and one bowel obstruction. There were no mortalities in all cases done.

Weight Loss

Following surgery, the mean body weight declined to 74.9 ± 15.7 kg at 1 year, 75.0 ± 15.6 kg at 2 years, 76.8 ± 15.9 kg at 3 years, 73.8 ± 15.5 kg at 4 years, and 72.8 ± 12.0 kg at 5 years. The mean BMI declined to 27.2 ± 5.0 kg/m^2 at 1 year, 27.1 ± 5.1 kg/m^2 at 2 years, 28.4 ± 5.2 kg/m^2 at 3 years, 27.4 ± 5.2 kg/m^2 at 4 years, and 28.4 ± 4.8 kg/m^2 at 5 years. The %TWL achieved was 28.9 ± 9.4 % at 1 year, 28.7 ± 11.1 % at 2 years, 28.6 ± 11.0 % at 3 years, 31.0 ± 11.1 % at 4 years, and 30.7 ± 11.3 % at 5 years. Both waist and hip circumference decreased significantly at 1, 3, and 5 years. Waist/hip ratio also decreased significantly at 1 and 3 years, but did not reach statistical significance at 5 years. Abdominal CT scan was routinely performed before surgery and 1 year after surgery in all patients, and both visceral fat area (VFA) and subcutaneous fat area (SFA) at umbilical level were measured. At 1 year, VFA, SFA, and V/S ratio were all significantly decreased. The summary of weight loss and other anthropometric data is shown in Table 2.

Effect on Type 2 Diabetes Mellitus

The mean HbA1c and FPG at the first preoperative visit were 8.9 ± 1.7 % and 194 ± 80 mg/dL, respectively. Intensive medical glycemic control was performed, and the mean HbA1c and FPG at the time of surgery dropped to 8.0 ± 1.2 % and 153 ± 47 mg/dL, respectively. Regarding the type of treatment, 58 patients (48.3 %) were treated with oral hypoglycemic agents (OHA), 18 patients (15.0 %) were treated with insulin, 37 patients were treated with both OHA and insulin, and 7 patients (5.8 %) were treated with lifestyle modification. The mean duration of T2DM from diagnosis was 7.3 ± 5.9 years.

Table 2 Summary of weight loss and other anthropometric data

	Prep-OP	1Y	3Y	5Y
Body weight (kg)	105.7 ± 21.5	74.9 ± 15.7*	76.8 ± 15.9*	72.8 ± 12.0*
BMI (kg/m2)	38.5 ± 7.3	27.2 ± 5.0*	28.4 ± 5.2*	28.4 ± 4.8*
%TWL (%)		28.9 ± 9.4	28.6 ± 11.0	30.7 ± 11.3
Waist (cm)	120.7 ± 16.2	93.7 ± 12.9*	98.9 ± 13.3*	97.1 ± 9.6*
Hip (cm)	122.8 ± 15.8	101.7 ± 10.8*	105.9 ± 11.8*	107.0 ± 11.0*
W/H ratio	0.98 ± 0.07	0.92 ± 0.07*	0.93 ± 0.07**	0.91 ± 0.05 (NS)
VFA (cm2)	208.1 ± 286.6	54.8 ± 36.8*	NA	NA
SFA (cm2)	511.8 ± 607.9	226.9 ± 131.7*	NA	NA
V/S ratio	0.45 ± 0.20	0.28 ± 0.17*	NA	NA

NA not available, *NS* not statistically significant

Versus prep-OP, *$p < 0.001$, **$p < 0.01$, ***$p < 0.05$ (paired t test)

The changes in HbA1c and FPG are shown in Fig. 2. At 1 year, the mean HbA1c and FPG dropped to 6.0 ± 1.0 % and 105 ± 24 mg/dL, respectively ($p < 0.001$), and leveled off thereafter for up to the 5-year follow-up period.

Response rates based on varying HbA1c cutoffs over the 5-year follow-up were shown in Table 3. Remission of T2DM was achieved in 63.6 % at 1 year, 55.3 % at 3 years, and 63.6 % at 5 years. Among those who achieved diabetes remission at 1 year, 10.8 % of them experienced recurrence during the subsequent follow-up period.

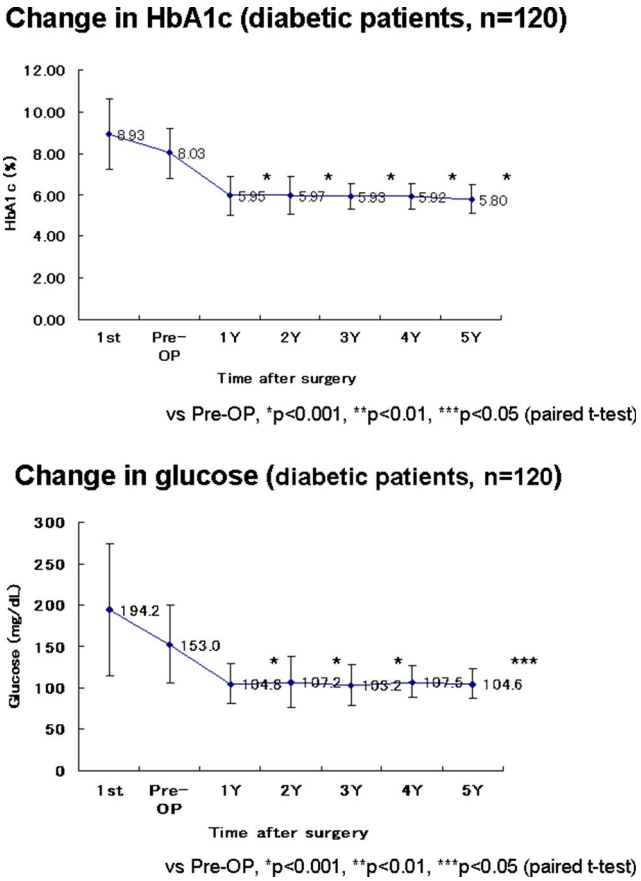

Fig. 2 Change in HbA1c and fasting plasma glucose

Change in the medication usage for T2DM is shown in Fig. 3. Preoperatively, 58 patients (48.3 %) were treated with OHA, 18 patients (15.0 %) were treated with insulin, 37 patients (30.8 %) were treated with both OHA and insulin, and the remaining 7 patients (5.8 %) had no medications (lifestyle modification). By the first-year postoperative period, the number of patients off medications increased to 94 (85.5 %), while those medications have decreased as follows: 11 (10.0 %) on OHA only, 2 (1.8 %) on insulin only, and 3 (2.7 %) on combination of OHA and insulin. This trend was observed throughout the 5-year follow-up period.

Discussion

In 2007, our institution introduced LSG-DJB as an alternative to LRYGB in 2007 [1, 2]. Through years of experience, we have observed LSG-DJB compensates for the shortcomings of LRYGB, which was considered the gold standard surgical intervention for obesity and metabolic syndrome. We observed an efficient and sustained anti-diabetic effect in LSG-DJB comparable to LRYGB. We now offer this procedure, after a strict selection process with a multidisciplinary team, to obese patients with associated metabolic syndrome, specifically severe diabetes. We previously reported our initial first-year experience, and this study would be a follow-up focusing on the medium-term (up to 5 years) effects of LSG-DJB on weight loss and improvement of diabetes. The mean preoperative BMI of the patients included in the study was 38.5 kg/m^2, comparatively lower than in typical Caucasian patients. This could be read as a feature that Asians are prone to central obesity-induced diabetes and show susceptibility to diabetes at a lower BMI.

Short-term weight loss studies on humans comparing LSG-DJB with other procedures are sparse. Raj and his colleagues, in 2012, reported the preliminary results of a randomized trial

Table 3 Glycemic control during 5 years of follow-up

	Pre-OP	1Y	2Y	3Y	4Y	5Y
HbA1c < 6 without meds (%)	0	63.6	59.2	55.3	53.8	63.6
6 ≤ HbA1c < 6.5 without meds (%)	1.7	11.8	15.5	15.8	15.4	9.1
HbA1c < 7 (%)	20	87.2	87.3	89.5	92.3	100
7 ≤ HbA1c < 8 (%)	32.5	9.1	7	10.5	7.7	0
8 ≤ HbA1c (%)	47.5	3.6	5.6	0	0	0

comparing LSG-DJB and LRYGB for 57 morbidly obese Indian patients (mean preoperative BMI, 48.28 kg/m^2 in the LSG-DJB group and 49.29 kg/m^2 in the LRYGB group). In their study, the limb lengths were similar in both groups (biliopancreatic limb length of 50 cm and alimentary limb length of 75 cm for <50 kg/m^2 BMI and 150 cm for >50 kg/m^2 BMI), both of which were shorter than those in our technique. The calibration tube (bougie) used in their technique in LSG was 36 Fr. When follow-up was done 1 year after surgery, percent excess weight loss (%EWL) in LSG-DJB and LRYGB were 81.94 ± 9.51 and 79.98 ± 4.77 %, respectively (p = 0.326) [9].

There has been no literature comparing LSG-DJB and other procedures in terms of long-term outcomes. We recently published our 5-year results of LSG as a primary procedure under the same follow-up protocol by the same multidisciplinary team. Among 179 patients with mean preoperative BMI of 43.3 kg/m^2, the %TWL at 1, 3, and 5 years were 32.4, 34.4, and 29.5 %, respectively [10]. Of important note was that adding a proximal intestinal bypass to sleeve did not show any "increased effect" in terms of weight loss. One possibility for this phenomenon is in LSG-DJB, weight loss might be influenced primarily by the restrictive component of the "vertical sleeve," not the malabsorptive "proximal intestinal bypass." On the other hand, multiple systematic reviews have shown that distal intestinal bypass (e.g., DS) had a significant influence on weight loss and nutritional sequela [11, 12].

Results on the anti-diabetic effect appear to vary; Raj and his group observed in a randomized controlled trial comparing LRYGB and LSG-DJB that the remission rate of diabetes (defined by achieving A1c <7 % without diabetes medication at 1 year) was similar (LSG-DJB: 80 %, LRYGB: 81 %) [9]. Lee et al. reported a retrospective matched case-control study comparing LSG with single-anastomosis duodenal-jejunal bypass and LSG alone (mean preoperative BMI, 35.1 kg/m^2 in the LSG-DJB group, and 36.2 kg/m^2 in the LSG group). In their study, a 36-Fr bougie was used when they performed sleeve gastrectomy, and the length of the (loop) biliary limb was 150 to 250 cm according to the BMI value. At 1 year, the %EWL in the LSG-DJB group was superior to that in the LSG alone group (87.2 versus 67.5 %, p = 0.023). The mean reduction in the HbA1c level in the LSG-DJB group was also higher than that found for the LSG group (2.8 versus 2.1 %, p = 0.045) [13].

A recent prospective study by Adams et al. reported 6-year outcomes for 418 patients who underwent RYGB. Between 2 and 6 years after surgery, the rate of partial remission of diabetes (A1c <6.5 % without medication) changed from 75 to 62 % [14]. Arterburn et al. reported a retrospective multicenter study including 4434 adults with T2DM who had gastric bypass. They reported that 47.2, 72.5, and 76.9 % achieved

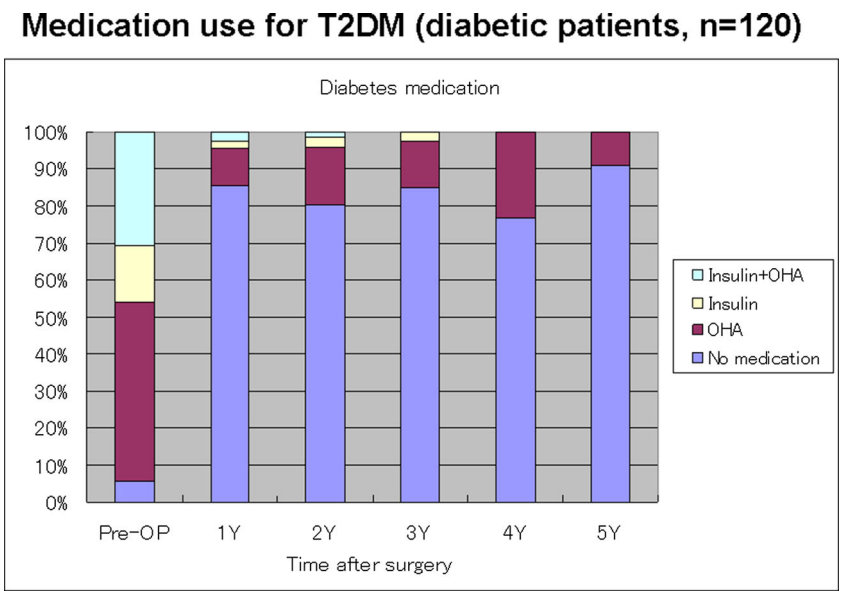

Fig. 3 Medication usage for T2DM among patients. At 1-year postoperative, a majority of the patients were off medication, with the rest reducing consumption as compared to preoperative phase

partial remission within 1, 3, and 5 years after surgery, and 37.1, 63.3, and 68.2 % achieved complete remission (A1c <6 % without medication) within 1, 3, and 5 years after surgery [15]. Cohen et al. reported a prospective study including 66 diabetic patients with BMI 30–35 kg/m^2 who underwent RYGB. For up to 6 years, following durable partial remission of diabetes occurred in 88 % of cases [16]. Lakdawala reported a prospective study including 52 Indian patients with uncontrolled T2DM and a BMI of 30–35 kg/m^2 who underwent LRYGB. In their cohort at 5 years, the rate of those who achieved A1c <7 % without medication was 57.7 % and that of those who achieved A1c <7 % with medication was 38.5 % [17]. In contrast, studies reporting long-term diabetic remission after LSG are scarce. Breathuer et al. reported that the complete/partial remission rates after LSG were 26/9 % in the short-term (first 2 years) and 9/22 % in the long-term [18]. Recently, Golomb et al. reported the long-term metabolic effects of LSG. In their study, 443 patients with initial BMI of 43.9 kg/m^2 were included and the %EWL at 1, 3, and 5 years were 76.8, 69.7, and 56.1 %, respectively. Among those who were associated with T2DM preoperatively, complete remission of diabetes was maintained in 50.7, 38.2, and 20.0 %, respectively. The rates of patients who stopped using medications for T2DM were 64.5, 48.3, and 55.5 %, respectively. In patients with preoperative insulin use, rates of cessation of medication use were 36.8, 9.1, and 0 %, respectively [19]. Although the rates of diabetes remission after bariatric surgery would be highly influenced by various possible confounding factors such as patients' background especially in terms of diabetes severity, surgical technique, surgeon's preference, etc., it still seems to be safe to say that LSG-DJB would be superior to LSG and at least equivalent to RYGB in terms of long-term glycemic control.

Among those who achieved diabetes remission at 1 year, 10.8 % of them experienced recurrence during the subsequent follow-up period, which is lower than a retrospective cohort study utilizing data from three integrated health care systems by Arterburn et al. In that study, the overall complete remission rate was 68 % within 5 years of surgery (68 % follow-up) after which a third of those patients had recurrent diabetes. Predictors of relapse after remission were poor preoperative glycemic control, longer duration of diabetes, and insulin use [15]. Similar to our institutions results in another study by Brethauer et al., the recurrence rate in the RYGB group was 17 %, and predictors of relapse after remission were duration of diabetes, less weight loss, and weight regain [18]. It appears that lifelong follow-up under a multidisciplinary team including an endocrinologist is essential after bariatric surgery to achieve optimal outcomes.

We believe that LSG-DJB has several advantages over LRYGB. First, in LSG-DJB, the pylorus, a physiological valve, is preserved leading to less occurrence of dumping syndrome which is often problematic after RYGB. The reported incidence of dumping syndrome after RYGB varies significantly between 15.7 and 76 % [20–23]. Dumping syndrome is known to debilitate gastric bypass patients and occurs at a higher incidence in diabetics than in non-diabetics [24, 25]. The second advantage of LSG-DJB is less occurrence of anastomotic stenosis. In LRYGB, creating a small-diameter gastrojejunal anastomosis is believed to be one of the keys to the long-term success, which occasionally involves an increased incidence of stenosis. The incidence of stenosis developing after gastrojejunostomy has been reported to range from 2.9 to 23 % [26, 27]. In LSG-DJB, the duodenojejunostomy is located 1–2 cm distal to the pylorus; thus, the anastomotic stoma can be formed at a larger diameter as compared to that of LRYGB. Actually, in all our cases of LSG-DJB, we have not experienced any stenosis at the duodenojejunal anastomosis. And lastly, marginal ulceration is also a potentially serious complication of LRYGB where the reported incidence ranges from 1 to 16 % [28, 29]. In contrast, the incidence of marginal ulcer after DS is known to be extremely low. Anthone et al. reviewed their prospectively collected data from 701 patients undergoing duodenal switch during the 10-year period and showed that marginal ulcers were not seen [30]. In our experience of LSG-DJB, the incidence of marginal ulcers at the duodenojejunal anastomosis was minimal at 0.49 %.

The major drawbacks of LSG-DJB are that the operation is relatively technically challenging and time consuming compared to LRYGB. Recently, Lee et al. reported the short-term results of laparoscopic single-anastomosis duodenal-jejunal bypass with sleeve gastrectomy (SADJB-SG) [31]. They used 45 Fr gastric bougie, left antrum 6 cm proximal to the pylorus, and set 150–250 cm biliopancreatic limb according to the initial BMI. The mean %TWL at 1 year was 32.7 %, and complete remission rate of T2DM (80 % of the 30 patients were diabetic and the preoperative HbA1c was 9.2 %) was 60 %, which seem to be similar to our results. The potential advantages of SADJB-SG over LSG-DJB may be to alleviate technical difficulty of RY reconstruction, to shorten the operation time, and to reduce the complication from entero-entero anastomosis. A well-designed randomized controlled trial is needed to actively delineate such variables.

The limitation of the study includes its retrospective design, single-center experience, and the loss to follow-up rate of over 30 % after 4 years or more. One possible reason of the follow-up loss is that our center accepts patients seeking bariatric surgery from all over Japan (from Hokkaido (northernmost end) to Okinawa (southernmost end)) and such distant physical proximity to our center might discourage some patients to return to our center for follow-up. It can be assumed that patients who do not present for follow-up are less likely to achieve good outcome after bariatric surgery, so care should be taken in interpreting the data.

Conclusion

In summary, LSG-DJB achieves excellent weight loss and improvement of glycemic control in both the short and medium term (up to 5 years). Its clinical effects seem to be at least equivalent to those of LRYGB, and it also compensates for some shortcomings of LRYGB. Although well-designed randomized controlled trial directly comparing LSG-DJB and LRYGB to draw a definitive conclusion, LSG-DJB could replace LRYGB, a gold standard, as an effective procedure for the treatment of obese patients with T2DM.

Compliance with Ethical Standards

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

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments of comparable ethical standards.

Informed Consent Informed consent was obtained from all individuals participants included in the study.

References

1. Kasama K, Tagaya N, Seki Y, et al. Laparoscopic sleeve gastrectomy with duodenojejunal bypass: technique and preliminary results. Obes Surg. 2009;19(10):1341–5.
2. Tagaya N, Kasama K, Inamine S, et al. Evaluation of the excluded stomach by double-balloon endoscopy after laparoscopic Roux-en-Y gastric bypass. Obes Surg. 2007;17(9):1165–70.
3. Seki Y, Kasama K, Umezawa A, et al. Laparoscopic sleeve gastrectomy with duodenojejunal bypass for type 2 diabetes mellitus. Obes Surg. 2016; [Epub ahead of print].
4. Guidelines for clinical application of laparoscopic bariatric surgery. Society of American Gastrointestinal and Endoscopic Surgeons. http://www.sages.org/publications/guidelines/guidelines-for-clinical-application-of-laparoscopic-bariatricsurgery/
5. Evidence-based practice guideline for the treatment for diabetes in Japan 2013. The Japan Diabetes Society. http://www.jds.or.jp/modules/en/index.php?content_id=44
6. Buse JB, Caprio S, Cefalu WT, et al. How do we define cure of diabetes? Diabetes Care. 2009;32(11):2133–5.
7. Brethauer SA, Kim J, el Chaar M, et al. ASMBS clinical issues committee. Standardized outcomes reporting in metabolic and bariatric surgery. Surg Obes Relat Dis. 2015;11(3):489–506.
8. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240(2):205–13.
9. Praveen Raj P, Kumaravel R, Chandramaliteeswaran C, et al. Is laparoscopic duodenojejunal bypass with sleeve an effective alternative to Roux en Y gastric bypass in morbidly obese patients: preliminary results of a randomized trial. Obes Surg. 2012;22(3):422–6.
10. Seki Y, Kasama K, Hashimoto K. Long-term outcome of laparoscopic sleeve gastrectomy in morbidly obese Japanese patients. Obes Surg. 2016;26(1):138–45.
11. Buchwald H, Estok R, Fahrbach K, et al. Weight and type 2 diabetes after bariatric surgery: systematic review and meta-analysis. Am J Med. 2009;122(3):248–56.
12. Buchwald H, Avidor Y, Braunwald E, et al. Bariatric surgery: a systematic review and meta-analysis. JAMA. 2004;292(14):1724–37.
13. Lee WJ, Almulaifi AM, Tsou JJ, et al. Duodenal-jejunal bypass with sleeve gastrectomy versus the sleeve gastrectomy procedure alone: the role of duodenal exclusion. Surg Obes Relat Dis. 2015;11(4):765–70.
14. Adams TD, Davidson LE, Litwin SE, et al. Health benefits of gastric bypass surgery after 6 years. JAMA. 2012;308(11):1122–31.
15. Arterburn DE, Bogart A, Sherwood NE, et al. A multisite study of long-term remission and relapse of type 2 diabetes mellitus following gastric bypass. Obes Surg. 2013;23(1):93–102.
16. Cohen RV, Pinheiro JC, Schiavon CA, et al. Effects of gastric bypass surgery in patients with type 2 diabetes and only mild obesity. Diabetes Care. 2012;35(7):1420–8.
17. Lakdawala M, Shaikh S, Bandukwala S, et al. Roux-en-Y gastric bypass stands the test of time: 5-year results in low body mass index (30–35 kg/m2) Indian patients with type 2 diabetes mellitus. Surg Obes Relat Dis. 2013;9(3):370–8.
18. Brethauer SA, Aminian A, Romero-Talamás H, et al. Can diabetes be surgically cured? Long-term metabolic effects of bariatric surgery in obese patients with type 2 diabetes mellitus. Ann Surg. 2013;258(4):628–36.
19. Golomb I, Ben David M, Glass A, et al. Long-term metabolic effects of laparoscopic sleeve gastrectomy. JAMA Surg. 2015;150(11):1051–7.
20. Sugerman HJ, Starkey JV, Birkenhauer R. A randomized prospective trial of gastric bypass versus vertical banded gastroplasty for morbid obesity and their effects on sweets versus 15 non-sweets eaters. Ann Surg. 1987;205:613–24.
21. Mallory GN, Macgregor AM, Rand CS. The influence of dumping on weight loss after gastric restrictive surgery for morbid obesity. Obes Surg. 1996;6:474–8.
22. Cawley J, Sweeney MJ, Kurian M, et al. Predicting complications after bariatric surgery using obesity-related co-morbidities. Obes Surg. 2007;17:1451–6.
23. Banerjee A, Ding Y, Mikami DJ, et al. The role of dumping syndrome in weight loss after gastric bypass surgery. Surg Endosc. 2013;27(5):1573–8.
24. Loss AB, de Souza AA, Pitombo CA, et al. Analysis of the dumping syndrome on morbid obese patients submitted to Roux en Y gastric bypass. Rev Col Bras Cir. 2009;36(5):413–9.
25. Padoin AV, Galvão Neto M, Moretto M, et al. Obese patients with type 2 diabetes submitted to banded gastric bypass: greater incidence of dumping syndrome. Obes Surg. 2009;19(11):1481–4.
26. Alasfar F, Sabnis AA, Liu RC, et al. Stricture rate after laparoscopic Roux-en-Y gastric bypass with a 21-mm circular stapler: the Cleveland Clinic experience. Med Princ Pract. 2009;18:364–7.
27. Mathew A, Veliuona MA, DePalma FJ, et al. Gastrojejunal stricture after gastric bypass and efficacy of endoscopic intervention. Dig Dis Sci. 2009;54:1971–8.
28. Sapala JA, Wood MH, Sapala MA, et al. Marginal ulcer after gastric bypass: a prospective 3-year study of 173 patients. Obes Surg. 1998;8:505–16.
29. Csendes A, Burgos AM, Altuve J, et al. Incidence of marginal ulcer 1 month and 1 to 2 years after gastric bypass: a prospective consecutive endoscopic evaluation of 442 patients with morbid obesity. Obes Surg. 2009;19:135–8.
30. Anthone GJ, Lord RVN, DeMeester TR, et al. The duodenal switch operation for the treatment of morbid obesity. Ann Surg. 2003;238(4):618–28.
31. Lee WJ, Lee KT, Kasama K, et al. Laparoscopic single-anastomosis duodenal-jejunal bypass with sleeve gastrectomy (SADJB-SG): short-term result and comparison with gastric bypass. Obes Surg. 2014;24:109–13.