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ORIGINAL CONTRIBUTIONS

Long-Term Outcome of Laparoscopic Sleeve Gastrectomy in Morbidly Obese Japanese Patients

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Abstract
Background Recently, laparoscopic sleeve gastrectomy (LSG) as a standalone bariatric procedure has rapidly gained popularity worldwide mainly because of its technical simplicity and the relatively good short-term outcome. In Japan, according to a domestic survey, 71 % of the bariatric procedures performed were LSG. However, the number of studies reporting long-term results are still not enough; particularly, data for Asian patients are scarce.
Objective The objective of this study was to evaluate the long-term outcomes for LSG in morbidly obese Japanese regarding weight loss and safety.
Methods Between October 2005 and July 2013, 179 morbidly obese Japanese patients (Female 89/Male 90) underwent LSG as a standalone procedure. The mean age was 40.7 years (range, 20–72 years), and the mean preoperative body weight and body mass index (BMI) were 120.4 kg (range, 71.4–231.6 kg) and 43.3 kg/m^2 (range, 30.9–76.5 kg/m^2), respectively. All patients were evaluated and managed under a strict multidisciplinary team approach.
Results The mean BMI declined to 30.0±8.7 kg/m^2 at 1 year, 29.1±8.6 kg/m^2 at 2 years, 28.8±8.7 kg/m^2 at 3 years, 29.3±9.2 kg/m^2 at 4 years, and 32.7±13.6 kg/m^2 at 5 years or more ($p<0.001$). The mean percent total body weight loss (%TWL) achieved was 32.4±12.9 % at 1 year, 34.3±12.9 % at 2 years, 34.4±11.6 % at 3 years, 32.8±10.9 % at 4 years, and 29.5±11.8 % at 5 years or more. Super morbidly obese patients and patients whose gastric tube was created using a thicker (45 Fr.) bougie had a tendency to achieve less weight loss. Early and late complications occurred in 16 patients (8.9 %) and in seven patients (3.9 %), respectively. Revision surgeries were required in six patients (3.4 %). The reasons for revision surgery were insufficient weight loss in five patients and intractable gastroesophageal reflux disease (GERD) in one patient.
Conclusion LSG for Japanese morbidly obese patients is safe, effective, and acceptably durable up to 5 years although some complications unique to the procedure such as leakage from the staple line and intractable GERD occur. For super morbidly obese patients, other surgical options may be required.

Keywords Laparoscopic sleeve gastrectomy · Long-term · Japanese · Asia

Introduction

Recently, LSG as a standalone bariatric procedure has rapidly gained popularity worldwide. According to the latest International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) survey, among 468,609 bariatric procedures performed worldwide in 2013, the most commonly performed procedure was Roux-en-Y gastric bypass (RYGB) (45 %), followed by sleeve gastrectomy (SG) (38 %). Regional differences existed in the types of procedures performed. For example, in the North American chapter, SG was the most common (43 %), on the other hand, in the European chapter, RYGB was still the most common (42 %). In the Asia-Pacific chapter, 52 % was SG, followed by RYGB (24 %) [1]. In Japan, RYGB is not actively performed mainly because the prevalence of gastric cancer is comparatively high and the anatomical difficulty of cancer screening in the remnant stomach by upper GI endoscopy has been perceived as a non-negligible problem [2]. According to the Japan Consortium of Obesity

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and Metabolic Surgery (JCOMS) survey, 71 % of the bariatric procedures performed in Japan in 2013 were LSG [3].

Regarding the short-term weight loss outcome of LSG as a standalone procedure, Brethauer et al. reported in a systematic review (1749 cases in 24 studies) that the mean postoperative BMI and the percent excess weight loss (%EWL) were 32.2 kg/m^2 and 60.4 %, respectively [4]. Also, Diamantis et al. reviewed the published long-term weight loss results after LSG (492 cases in 16 studies) and showed that the mean %EWL was 62.3 % [5]. Among these 16 analyzed studies, only one study was from Asia [6], thus, long-term data from Asia where LSG is a leading procedure is obviously insufficient. The first LSG in our center was performed in 2005 [7]. In this study, we present our long-term outcomes for LSG as a standalone procedure focusing on weight loss and complications.

Methods

This study included the initial 179 patients who underwent LSG as a standalone procedure in our center between October 2005 and July 2013. The inclusion criteria for laparoscopic bariatric surgery were based on the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) Guidelines for Clinical Application of Laparoscopic Bariatric Surgery (medically uncontrolled, with ages between 18 and 65 years and BMI more than 30 kg/m^2 with obesity-related comorbidities) [8] 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, risks and benefits, and the potential postoperative complications, including the possibility of reoperations and the likelihood of requiring postoperative nutritional supplementation.

Our surgical technique for LSG was described in detail previously [9]. After establishing pneumoperitoneum at 15 mmHg, five laparoscopic trocars were placed in the upper abdomen. After measuring the appropriate distance (ranging from 4 to 8 cm, varied at different periods) from the pyloric ring, the omentum along the greater curvature of the stomach was progressively freed up to the gastroesophageal junction by dividing all the branches of the gastroepiploic vessels using an ultrasonic energy device. Complete mobilization of the fundus with exposure of the left crus and dissection of the posterior wall of the stomach from the pancreas were routinely obtained. A 36 to 45 Fr. bougie (also, varied at different periods) was advanced transorally along the lesser curvature. We proceeded with dividing the stomach using a 60 mm endoscopic linear stapler. The staple line was routinely imbricated with a 2–0 non-absorbable suture while keeping the bougie in place. The integrity of the staple line was tested intraoperatively by endoscope.

Sips of clear liquids were allowed on the immediate postoperative day, if tolerated. The patients were usually discharged on postoperative day (POD) 3. Detailed dietary counseling by a specialist bariatric dietician and written instructions for optimal health management at home were provided. Patients were started postoperatively on a pureed and soft diet within 2 weeks, progressing to a normal diet by 4 weeks. Patients were encouraged to regularly attend the bariatric surgery patient support group meetings. Standard follow-up included visits to the outpatient clinic at 1 month, 3 months, 6 months, 1 year, and annually thereafter. These patients' data were retrospectively reviewed from a prospectively maintained database. Descriptive results regarding continuous variables were reported as the mean±standard deviation. Differences were analyzed using the unpaired *t* test or a paired *t* test when appropriate. A p value of <0.05 indicated a statistically significant difference. The statistical analysis was done using the SPSS version 11.0 J for Windows.

Results

There were 179 patients, comprising 89 females and 90 males with a mean age of 40.7±11.2 years (range, 20–72 years). The mean preoperative body weight was 120.4±33.9 kg (range, 71–232 kg) and the mean preoperative BMI was 43.3± 10.0 kg/m^2 (range, 31–77 kg/m^2). Thirty patients whose BMI was less than 35 kg/m^2 and 33 patients whose BMI was more than 50 kg/m^2 (super morbid obesity) were included in the series. Also, 16 patients who were older than 60 years at the time of surgery were included. All the procedures were completed laparoscopically without conversion to open surgery. The mean skin-to-skin operative time was 140±37 min (range, 78–235 min). The mean postoperative hospital stay was 3.3±1.1 days (range, 2–12 days). The follow-up rate during the study period is shown in Tables 1 and 2.

Weight Loss

Change in weight in all cases is shown in Fig. 1. Following surgery, the mean weight declined to 83.4±26.5 kg at 1 year, 79.3±25.1 kg at 2 years, 78.8±25.8 kg at 3 years, 82.2± 31.1 kg at 4 years, and 92.0±42.0 kg at 5 years or more ($p<0.001$). The mean BMI declined to 30.0±8.7 kg/m^2 at 1 year, 29.1±8.6 kg/m^2 at 2 years, 28.8±8.7 kg/m^2 at 3 years, 29.3±9.2 kg/m^2 at 4 years, and 32.7±13.6 kg/m^2 at 5 years or more ($p<0.001$). The %TWL achieved was 32.4±12.9 % at 1 year, 34.3±12.9 % at 2 years, 34.4±11.6 % at 3 years, 32.8± 10.9 % at 4 years, and 29.5±11.8 % at 5 years or more. In Japan, the Japan Society for the Study of Obesity (JASO) set the ideal body weight (IBW) in Japanese patients as BMI

Table 1 Follow-up rate during the study period

Follow-up rate (n=179)			
Time after OP	Eligible patients	Patients who presented	F/U rate (%)
1 month	178	177	99
3 months	167	162	97
6 months	161	154	96
12 months	146	132	90
24 months	94	63	67
36 months	63	32	51
48 months	43	22	51
60 months+	32	19	59

22 kg/m^2 [10]. Under this definition, the %EWL achieved was 68.5±24.3 % at 1 year, 72.9±23.8 % at 2 years, 74.6±25.4 % at 3 years, 72.9±26.5 % at 4 years, and 64.2±28.5 % at 5 years or more. Given that IBW is set as BMI 25 kg/m^2, in order to meaningfully compare data from studies abroad, "adjusted" figures are that the %EWL achieved was 83.5±32.9 % at 1 year, 87.6±31.0 % at 2 years, 91.2±34.6 % at 3 years, 89.7±36.9 % at 4 years, and 77.3±36.0 % at 5 years or more.

There were 18 patients who completed the 5-year follow-up. Change in weight in these 18 patients is also shown in Figs. 2 and 3. Following surgery, mean weight declined to 90.6±34.5 kg at 1 year, 83.8±31.5 kg at 2 years, 77.3±25.2 kg at 3 years, 81.6±33.8 kg at 4 years, and 92.0±42.0 kg at 5 years or more. The mean BMI declined to 31.5 ±10.2 kg/m^2 at 1 year, 30.5±9.1 kg/m^2 at 2 years, 28.5±7.1 kg/m^2 at 3 years, 29.5±10.1 kg/m^2 at 4 years, and 32.7±13.6 kg/m^2 at 5 years or more. The mean %TWL achieved was 31.1±9.3 % at 1 year, 31.6±10.1 % at 2 years, 35.4±10.2 % at 3 years, 30.9±12.1 % at 4 years, and 29.5±11.8 % at 5 years or more. The %EWL (IBW as BMI 22) achieved was 66.5±25.8 % at 1 year, 67.0±24.8 % at 2 years, 74.2±26.5 % at 3 years, 68.8±28.3 % at 4 years, and 64.2±28.5 % at 5 years or more. Also, the %EWL (IBW as BMI 25) achieved was 79.7±33.6 % at 1 year, 79.9±31.2 % at 2 years, 87.7±33.9 % at 3 years, 83.6±35.4 % at 4 years, and 77.3±36.0 % at 5 years or more.

Preoperative BMI

There were 30 patients whose BMI was less than 35 kg/m^2 (mild obesity) and 33 patients whose BMI was higher than 50 kg/m^2 (super morbid obesity) at the time of surgery. There was no statistical difference in terms of %EWL between the mild obesity group and reference (BMI 35–50 kg/m^2) group. The %EWL in the super morbid obesity group was significantly lower than that in the mild obesity group and reference group, respectively.

Bougie Size

A 45 Fr. bougie was used for calibration in 27 patients and a 36 Fr. bougie was used in 146 patients (status of the remaining six patients is unknown). The preoperative BMI in the 45 Fr. group was 45.9±14.0 kg/m^2 and that in the 36 Fr. group was 42.7±8.8 kg/m^2 (N.S.). At 1, 2, and 5 years, the %EWL in the 36 Fr. group was significantly higher than that in the 45 Fr. group (p<0.05) (Fig. 4).

Table 2 Early/late complications and reoperations

Complications	Number	Reoperations/reinterventions
Early complications (<30 days)	16	10
Leaks 5 3	5	3
High (angle of His)	1	1
Low (angularis incisura)	2	2
Unknown (treated conservatively)	2	0
Hemorrhage	9	6
Intraabdominal	6	4
Subcutaneous (wound, port site)	2	1
Intraluminal	1	1 (endoscopic clipping)
Sleeve stenosis	1	1
Acute renal failure	1	0
Late complications (30 days<)	7	6
Intractable GERD	5	5
Bleeding due to severe GERD	1	1 (endoscopic clipping)
Repeated hypoglycemia	1	0
Mortality	0	–

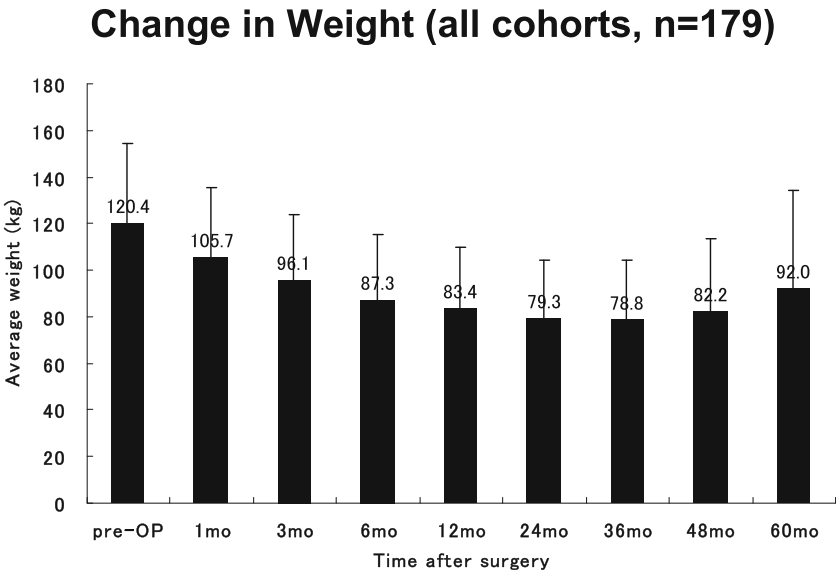

Fig. 1 Change in weight in all cohorts

Distance from Pylorus

The antrum of the stomach was preserved longer than 6 cm from the pyloric ring in 36 patients and shorter than 4 cm in 137 patients (status of the remaining nine patients is unknown). The preoperative BMI in the larger antrum group was 45.8±13.1 kg/m^2 and that in the smaller antrum group was 42.5±8.7 kg/m^2 (N.S.). At 2 years only, the %EWL in the smaller antrum group was significantly higher than that in the larger antrum group ($p<0.05$) (Fig. 5).

Age

There were 16 patients who were older than 60 years at the time of surgery. The preoperative BMI in the older group was 39.3±6.2 kg/m^2 and that in the younger group was 43.4±10.0 kg/m^2 (N.S.). There was no statistical difference in terms of %EWL between the groups.

Complications

There were neither intraoperative complications nor any mortality. Early complications within 30 days of surgery occurred in 16 patients (8.9 %), of which ten patients required reoperations. Leakage occurred in five patients (2.8 %) including leakage from the angle of His in one patient, from the distal part of the staple line in two patients and an unknown locality (treated conservatively) in two patients. The case of His leak was difficult to treat. The patient complained of a high fever 10 days

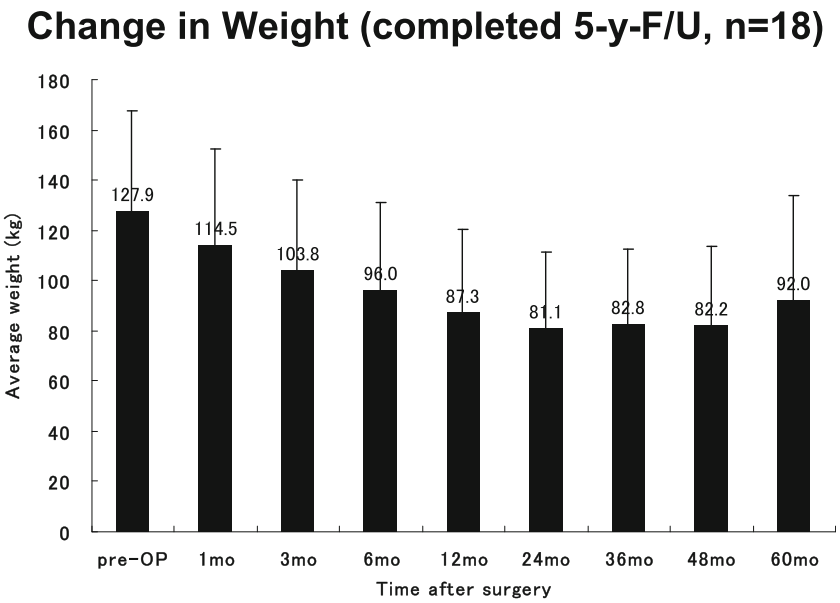

Fig. 2 Change in weight in the 18 patients who completed the 5-year-follow-up

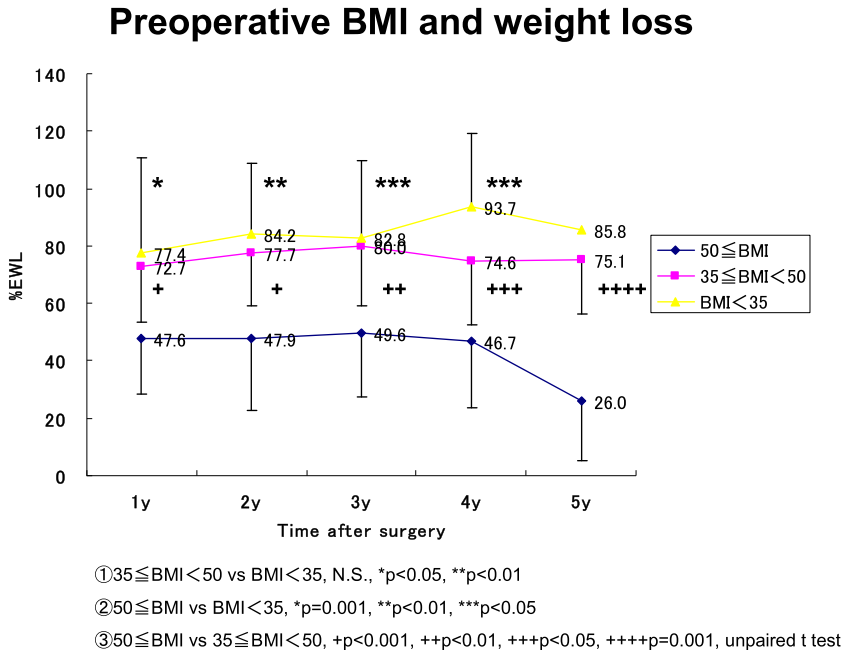

Fig. 3 Preoperative BMI and change in %EWL

after an uneventful LSG and was readmitted. A CT scan revealed a left subphrenic abscess. Laparoscopic drainage with an omental patch was immediately performed, however, failed. Several subsequent trials of endoscopic clipping, argon plasma coagulation, and cyanoacrylate injection all failed. Finally, a covered self-expandable and retrievable esophageal stent (HANAROSTENT, M.I.Tech, Korea) was placed endoscopically and the leakage was thus successfully sealed [11]. The other two patients complained of sudden upper abdominal pain on POD2 and POD4, and CT scans revealed small free air spaces. Intraoperative endoscopy revealed minimal leakages from the distal part of the staple line (around the incisura angularis) and laparoscopic suture repairs with an omental patch were successful in both cases. The remaining two patients complained of mild to moderate upper abdominal pain, and CT scans revealed small free air spaces along the staple line. Both of them were treated conservatively.

Postoperative hemorrhage occurred in nine patients (5.0 %), of which six patients required reoperations. They included six intraabdominal, two subcutaneous (trocar site),

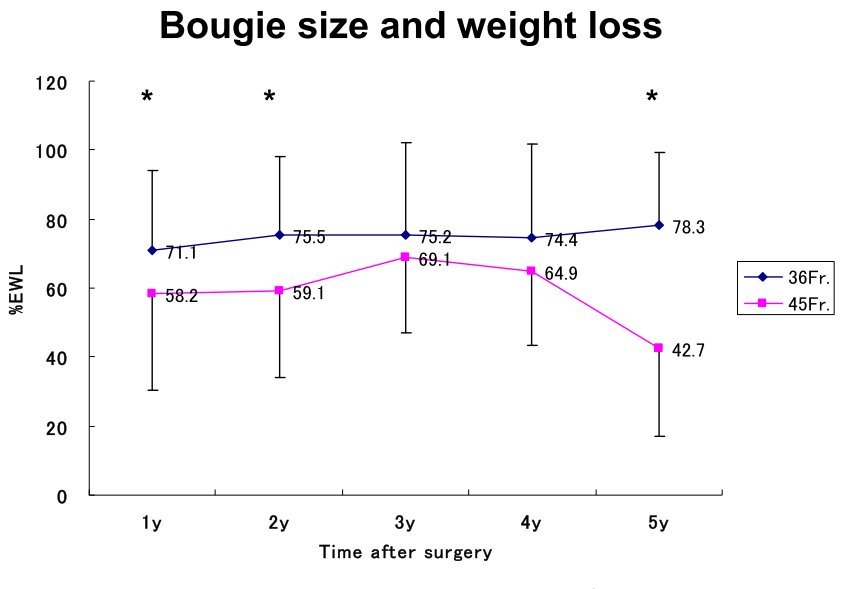

Fig. 4 Bougie size and change in %EWL

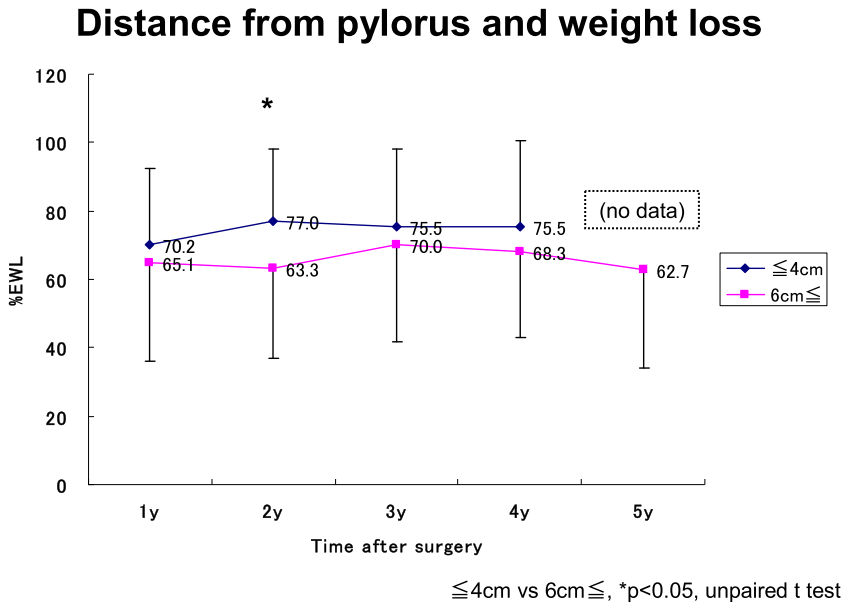

Fig. 5 Distance from the pylorus and change in %EWL

and one intraluminal (from the staple line treated by endoscopic clipping) hemorrhages. Early sleeve stenosis occurred in one patient. On POD19, laparoscopic strictureplasty was performed, however, failed, and laparoscopic revision RYGB was eventually required on POD21.

Late complications more than 30 days after surgery occurred in seven patients (3.9 %), of which six patients required interventions. Intractable GERD which was refractory to proton pump inhibitor administration occurred in five patients all of whom had associated obstruction at the incisura angularis. Four out of the five patients were treated by endoscopic balloon dilation (intervals from the primary LSG were 2, 21, 24, and 39 months) and the remaining one patient required laparoscopic seromyotomy (as described below). Acute bleeding from the lower esophagus due to severe GERD occurred in one patient 13 months after LSG and emergent endoscopic clipping was successful. The overall complication rate was 12.8 %.

Revision Surgery

Revision surgery was performed in six patients (3.4 %). The reasons for revision were insufficient weight loss in five patients and intractable GERD in one patient. The procedures for insufficient weight loss were laparoscopic duodenal switch in three patients (intervals from the primary LSG were 13, 16, and 22 months) and laparoscopic re-sleeve gastrectomy in two patients (intervals from the primary LSG were 13 and 26 months). For one patient with intractable GERD, laparoscopic seromyotomy was successfully performed (interval was 8 months) after two failed endoscopic balloon dilations (intervals were 7 months).

Discussion

According to a review of the published long-term weight loss results after LSG by Diamantis et al., among the patients who underwent LSG as a definitive procedure, the mean preoperative BMI was 43.9 kg/m^2 and the average mean %EWL was 56.3 % (range, 49.5–71.3 %) at 5 years postoperatively [5]. In our series in Japanese morbidly obese patients, the mean preoperative BMI was 43.3 kg/m^2 and the average %EWL at 5 years was 77.3 %. Therefore, it could be said that our results are relatively superior. Our LSG technique is quite a standard one in the global sense [12]. Possible differences between our patients and, for instance, American patients are dietary patterns and body composition (predominantly fat distribution). Japanese generally consume mainly carbohydrates and less protein and fat, compared to for instance, Americans, resulting in Japanese having a higher incidence of central obesity [13]. Our patients' fat intake is higher than in normal weight Japanese individuals, but still lower than the recommendations for healthy Americans [14]. However, precisely how these differences influenced our study's outcome are unclear.

Choosing the ideal surgical procedure for treatment of super morbidly obese patients (BMI more than 50 kg/m^2) is still the subject of intense debate due to the unique and particularly difficult to manage characteristics of this group, and the technical surgical and other challenges they present. The comprehensively reported short-term %EWL from LSG as a primary bariatric procedure in super morbidly obese patients was between 45 and 50 % [15–18]. Our long-term results involving 33 super morbidly obese patients were consistent with these results for the first 4 years but some of the patients regained weight thereafter. Zerrweck et al. reported their retrospective study comparing 77 super morbidly obese patients who

underwent either L(laparoscopic)RYGB (n=32) or LSG (n=45). Although operative time was significantly shorter in the LSG group, the %EWL at 1 year was significantly higher in the LRYGB group than in the LSG group (63.9 and 43.0 %, respectively) while the overall complication rate was similar (9 % for LRYGB, 22 % for LSG, p=0.217) [19]. In our experience as well, intestinal bypass procedures such as LRYGB and LSG-DJB (DJB: duodenojejunal bypass) achieve a better weight loss outcome compared to LSG only for super morbidly obese patients (data not shown). Thus, in the case where a surgeon/surgical team is fully competent and sufficiently experienced to safely perform intestinal bypass procedures for super morbidly obese patients, we believe that performing LRYGB or LSG-DJB would be a good surgical option.

There are many points of controversy regarding the optimal operative technique giving rise to a wide range of surgical options including the size of the bougie, necessity of reinforcing the staple line, routine use of intraoperative seal testing, section size at the gastroesophageal junction, and distance from the pylorus to the beginning of the antral resection. All of these are matters that are debated among the most experienced surgeons [12]. Regarding the antral resection, conservative surgeons may prefer to begin the resection at 6 cm from the pylorus with the aims of improving gastric emptying by preserving its contractile function and of decreasing intraluminal pressure, which allow early closure of any potential gastric leakage, whereas other surgeons perform the resection close to the pylorus and therefore achieve and maintain better weight loss results. Abdallah et al. randomly allocated 159 morbidly obese patients undergoing LSG as a standalone procedure into group I (LSG in which the division begins 2 cm from the pylorus) and group II (LSG in which the division begins 6 cm from the pylorus), and they found the group I patients achieved significantly better weight loss up to 2 years without increasing complication rates [20]. On the other hand, according to a systematic review and meta-analysis (9991 cases in 112 studies) by Parikh M et al., distance from the pylorus did not affect %EWL or leakage when LSG is performed as a primary bariatric procedure [21]. In our cohorts with long-term outcomes, we did not find a statistically significant difference between the short (4 cm in most cases) and long (6 cm in most cases) antrum group in terms of weight loss although, the actual impacts of this small difference of only 2 cm in length might not be discernible among the minor (and thus, probably statistically inadequate) sample size of our small antrum group.

Regarding the bougie size, Spivak et al. reported their retrospective case-controlled study comparing groups who underwent LSG using a 42 and 32 Fr. bougie. At 1 year, there was no difference in terms of weight loss (mean %EWL was 67 and 65 %, respectively) or complications and resolution of comorbid conditions between the groups [22]. By contrast, Parikh M et al. reported that the risk of leakage decreased with a bougie ≥40 Fr. although there was no difference in %EWL between a bougie <40 Fr. and bougie ≥40 Fr. up to 36 months (mean %EWL, 70.1 %) [21]. Arguments for and against a small-sized bougie can go either way. On the one hand, there is a concern that the greater the amount of preserved stomach tissue, the more susceptible to stretching it will be, and thus long-term sleeve dilation will ultimately cause failure. On the other hand, a smaller-sized bougie may lead to undesirable postoperative patient behavior changes: owing to restricted food intake, some patients "compensate" by turning to excessive consumption of "sweets" in various forms such as liquid (sodas, etc.) or semi-liquid (ice-creams, chocolates, etc.), and they are thus likely to regain weight, as Spivak et al. pointed out. In our cohorts, patients on whom a smaller bougie size of 36 Fr. was used had a tendency to achieve better weight loss at 1, 2, and 5 years after LSG compared to a thicker bougie of 45 Fr. We believe this kind of inconsistency arises from variations of surgeons' techniques, for example, the way the stapler is placed alongside the bougie, distance from the pylorus, etc.

The overall complication rate in our series was 12.8 %. Brethauer et al. reported in their systematic review that the major postoperative complication rates ranged from 0 to 23.8 % in all included studies and that complication rates ranged from 0 to 15.3 % only in the studies with over 100 patients [4]. Another systematic review by Shi et al. reported that the mean complication rate was 11.2 % (range, 0–29 %), with a leakage rate of 1.17 % (range, 0 to 5.5 %), bleeding rate of 3.57 % (range, 0 to 15.8 %), and mortality rates between 0 and 3.3 % [23]. On the other hand, according to *The International Sleeve Gastrectomy Expert Panel Consensus Statement 2011* which was based on the data of 12,799 LSGs performed only by highly experienced surgeons each having performed over 500 bariatric procedures, the leakage rate was 1.06 %, stricture rate 0.35 %, and postoperative GERD rate 12.11 % [12]. Obviously, the complication rate (as a percentage of procedures performed) could differ depending on the criteria used by authors/doctors to determine whether certain clinical problems are to be defined as "major" complications or merely an "adverse" event. At any rate, these numbers suggest that postoperative complications after LSG could be proportionately influenced by the extent of the surgeons' experience. For one surgical centre, Zachariah et al. reported that major complication rates dropped from 8 % for the first 50 surgeries performed to 1.68 % for the remaining 178 surgeries with statistical significance [6]. In our series, all the leakages occurred during our center's early experience (#3, 16, 19, 53, 55) of the subject procedure.

The limitation of our center's study is that the patient follow-up rate fell down to 50–60 % after 3 years or more. One possible reason 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 disincentivize some patients to present 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 weight loss after bariatric surgery, so care should be taken in interpreting the data.

Conclusion

LSG for Japanese morbidly obese patients is safe, effective, and acceptably durable up to 5 years although some complications unique to the procedure such as leakage from the staple line and intractable GERD occur. For super morbidly obese patients, other surgical options such as LRYGB and LSG-DJB may be required.

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Conflict of Interest The authors declare that they have no competing interests.

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 or comparable ethical standards.

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

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