Title:

A comparison of the bariatric procedures that are performed in the treatment of super morbid obesity

Authors

Kohei Uno [1)2)]

Yosuke Seki [1)]

Kazunori Kasama [1)]

Kotaro Wakamatsu [1)]

Akiko Umezawa [1)]

Katsuhiko Yanaga [2)]

Yoshimochi Kurokawa [1)]

Weight Loss and Metabolic Surgery Center, Yotsuya Medical Cube [1)]

7-7 Nibancho, Chiyoda-ku, Tokyo 102-0084, Japan

Department of Surgery, Jikei University School of Medicine [2)]

3-19-18 Nishishinbashi, Minato-ku, Tokyo 105-8471, Japan

Abstract

Purpose

We have experienced numerous cases of super morbid obesity (SMO), defined by a BMI of ≥50 kg/m^2, in which laparoscopic sleeve gastrectomy (LSG) was not able to achieve a sufficient weight loss effect. However, the most appropriate procedure for the treatment of SMO has not yet been established.

Materials and Methods

The subjects included 248 successive patients who underwent surgery at our hospital from June 2006 to December 2012. We divided the subjects into an SMO group (BMI, 50 to <70 kg/m^2) and a morbid obesity (MO) group (BMI, 35 to <50 kg/m^2). The subjects underwent LSG, LSG with duodenojejunal bypass (LSG/DJB), or laparoscopic Roux-en-Y gastric bypass (LRYGB). The weight loss effects, safety of surgery, and metabolic profile changes were compared.

Results

Sixty-two subjects were classified into the SMO group (25%). The percent excess weight loss (%EWL) after LSG among the patients in the SMO group was not significantly different from that of patients who underwent other procedures. LSG was associated with a significantly lower success rate in terms of weight loss (%EWL≥50%),

in comparison to the weight loss at one year after LRYGB, and at two years after LSG/DJB and LRYGB. Among the patients in the MO group, the %EWL and the rate of successful weight loss did not differ to a statistically significant extent.

Conclusion

This study demonstrated that in patients with SMO, LSG/DJB, LRYGB can achieve superior weight loss effects in comparison to LSG.

Introduction

Obesity, which has the potential to lead to a decreased QOL and obesity-associated diseases such as hypertension (HT), diabetes mellitus (DM) and dyslipidemia (DL), has become a worldwide issue. The performance of bariatric surgery, which is the sole method of treatment that achieves a good long-term weight loss effect in obese individuals, is rapidly increasing throughout the world [1]. The procedures that are applied in bariatric surgery fall under the general classifications of restrictive and malabsorptive procedures. Common procedures include laparoscopic sleeve gastrectomy (LSG), laparoscopic adjustable gastric banding, laparoscopic Roux-en-Y gastric bypass (LRYGB), and laparoscopic biliopancreatic diversion with duodenal switch (BPD/DS). Although LRYGB remains the most common procedure in the world, the implementation of LSG has rapidly increased in recent years and it is now performed at a similar rate to LRYGB in the U.S. [1]. In Japan, LSG—which is the only procedure covered by health insurance—accounts for 60% of all procedures [2]. However, no criteria have yet been established for the selection of procedures. Currently, each institution chooses its own procedure.

In the case of patients with super-morbid obesity (SMO; defined by a body mass index [BMI] of ≥50 kg/m^2) it is particularly difficult to select an appropriate procedure. We have experienced numerous cases in which surgery was difficult to perform in patients with SMO due to the patient's physical characteristics and many cases in which the weight loss after surgery was considered to be insufficient.

In order to find a procedure that achieves better weight loss effects in patients with SMO, we retrospectively compared the weight loss effects and metabolic profile changes after the above-mentioned procedures (LSG, LSG/DJB, LRYGB) in patients with SMO and morbid obesity (MO; defined by a BMI 35 to < 50 kg/m^2) who underwent surgery in our hospital.

Methods

Patients

The subjects included 248 successive patients who underwent bariatric surgery at our hospital from June 2006 to December 2012. The procedures included LSG, LRYGB, and laparoscopic sleeve gastrectomy with duodenojejunal bypass (LSG/DJB). The LSG/DJB procedure is a modification of BPD/DS, which came to be carried out relatively often in Japan following a report by Kasama [3]. The indications for surgery are determined in accordance with the SAGES guidelines. In brief, the subjects included patients ranging from 18 to 65 years of age, with a BMI of ≥40 kg/m^2 (or ≥35 kg/m^2 in patients without serious mental illness who were suffering from obesity-associated diseases that made medical therapy difficult). Furthermore, we discussed all of the cases in team conferences at our hospital in order to decide whether to perform surgery.

Procedure selection

With respect to cases in which Type 2 diabetes was poorly controlled by medical therapy, LSG/DJB is the first choice as it is a bypass procedure and is associated with a better improvement of diabetes. However, LSG could be selected based on the operative risks posed by comorbidities or the will of the patient. LRYGB is selected for subjects with serious GERD prior to surgery and who are negative for *Helicobacter pylori* (which indicates a low risk of stomach cancer).

The operative procedures

All surgeries were conducted by two surgeons who were familiar with the operative procedures of bariatric surgery at a single facility.

LSG: The greater curvature was resected five times using a 60-mm linear stapler, along a bougie (36- or 45-Fr) that was placed approximately 4 cm proximal from the pyloric ring. The volume of the remaining stomach was approximately 100 cc.

LSG/DJB: After LSG, we performed jejunojejunostomy and duodenojejunostomy. The alimentary limb was set to 150 cm, while the biliopancreatic limb was set to 100 cm. For jejunojejunostomy, we carried out side-to-side anastomosis using a 60-mm auto suture stapler. The entry hole was closed by hand-sewn sutures. For duodenojejunostomy, hand-sewn end-to-side anastomosis (approximately 2 cm in length with ante-colic positioning) was performed. Fig1 shows a schematic illustration of the procedure.

LRYGB: Using a 60-mm auto suture stapler, we created a stomach pouch of approximately 30 cc. The alimentary limb was set to 150 cm, while the biliopancreatic limb was set to 50 cm. For jejunojejunostomy, we carried out side-to-side anastomosis using a 60 mm linear stapler. The entry hole was closed by hand-sewn sutures. For duodenojejunostomy, hand-sewn end-to-side anastomosis (with ante-colic and ante-gastric positioning) was performed. A 12-mm nelaton tube was used to ensure the anastomotic dimensions.

Evaluation methods

The primary endpoints included the percent excess weight loss (%EWL) at two years following surgery and the success rate of weight loss ("success" was defined as a %EWL of ≥50%). The subjects were classified into an SMO group (BMI, 50 to <70) and an MO group (BMI, 35 to <50), after which we compared the weight loss effects of the procedures (LSG vs. LSG/DJB, LSG vs. LRYGB, and LSG/DJB vs. LRYGB) were compared. The ideal weight was calculated based on a BMI of 25.

To investigate the safety of surgery, we divided the subjects into the SMO group and MO group and compared the incidence of intraoperative and postoperative (within 30 days of surgery) complications with each procedure.

In addition, we investigated the metabolic profile changes after each procedure in the SMO group.

Statistical analysis

The results were compared using Student's *t*-test or Fisher exact test, as appropriate. P values of <0.05 were considered to indicate statistical significance. All of the statistical analyses were performed using the EZR software program.

Results

Patient characteristics

Sixty-two (25%) and 186 (75%) of the 248 patients were classified into the SMO and MO groups, respectively. The procedures performed in the SMO group were as follows: LSG, n=28, LSG/DJB, n=14, and LRYGB, n=20. The procedures performed in the MO group were as follows: LSG, n=89; LSG/DJB, n=50; and LRYGB, n=47. The characteristics of the patients in each group are shown in Table 1.

Weight loss

●The SMO group

In the SMO group, at one year following surgery, LRYGB was associated with significantly higher success rates in terms of weight loss than LSG. At two year following surgery, LSG/DJB and LRYGB were significantly higher success rates. On the other hand, there was no significant differences between LSG and LSG/DJB or LSG and LRYGB regarding %EWL. There was no significant difference between LSG/DJB and LRYGB with respect to the %EWL and the rate of successful weight loss at one and two years after surgery.

●The MO group

In the MO group, there was no significant differences were observed between LSG and LSG/DJB or LSG and LRYGB with respect to the % EWL or the rate of successful weight loss at one and two years after surgery.

The perioperative outcomes (Table 3)

The operative times for each of the procedures in the SMO group were as follows: LSG, 142 ± 31.8 minutes; LSG/DJB, 229 ± 25.7 minutes; and LRYGB, 160 ± 38.3 minutes. The operative time of LSG/DJB was significantly longer than that of LSG, while the operative time of LRYGB was not. In the MO group, the operative times were as follows: LSG, 140 ± 37.8 minutes; LSG/DJB, 220 ± 36.6 minutes; and LRYGB, 160 ± 42.6 minutes. There were no significant differences between the SMO and MO groups (LSG p=0.78, LSG/DJB p=0.38, LRYGB p=0.99). With regard to surgical complications, 3 of 28 subjects with SMO who underwent LSG developed surgical complications (10.7%); the frequency of complications in patients with SMO was higher than that in patients with MO (2/89 subjects, 2.3%, p=0.088). However, in the SMO group, there were no significant differences in the incidence of complications between LSG and LSG/DJB, or LSG and LRYGB. No subjects died and no procedures were converted to laparotomy.

The changes in the metabolic profiles

Table 4 shows the changes in the metabolic profiles among the patients with SMO following each of the procedure. DM, HT, and DL were improved after each procedure.

In particular, LSG/DJB achieved better glycemic control, even though this sub-group included patients with severe DM.

Discussion

This study demonstrated that LSG/DJB and LRYGB can achieve better weight loss effects in patients with SMO in comparison to treatment by LSG alone. In addition, in the SMO group there were no significant differences between the procedures in terms of the incidence of surgical complications.

This study demonstrated that LSG/DJB and LRYGB can achieve better weight loss effects in patients with SMO in comparison to treatment by LSG alone. No significant difference in the %EWL was indicated after surgery in comparison to LSG/DJB and LRYGB. The comparison of the rates of successful weight loss allows us to more clearly see the insufficiency of the weight loss effects in patients with SMO who underwent LSG. In the SMO group, the success rate after LSG/DJB or LRYGB was up to 80%, while the success rate after LSG was less than 60%. In contrast, each procedure achieved up to a 90% success rate in the MO group. According to a report by Tagaya et al. [4], although good weight loss effects can be achieved in patients with MO—even after LSG—the weight loss effects are insufficient in patients with SMO, indicating the need for second-step procedures such as BPD/DS and LRYGB.

LSG and LRYGB are the most common procedures in the world. Some studies have compared the outcomes of these procedures in SMO cases. Thereaux [5] compared LSG and LRYGB in patients with a BMI of ≥50 kg/m^2 and reported that LRYGB was associated with greater weight loss in patients with SMO; the %EWL values at one year after LSG and LRYGB were 40.2 ± 15.2% and 55.0 ± 14.6%, respectively ($P<0.0001$). Furthermore, in the same article, Thereaux reported that the results of a multivariate analysis suggested that—regardless of age, gender, or the incidence of diabetes—LSG was an independent factor of weight loss failure in patients with SMO. Zerrweck [6] compared LSG and LRYGB in patients with a BMI of ≥50 kg/m^2 and reported the LRYGB was associated with better weight loss effects at one year after surgery (%EWL: LRYGB vs. LSG: 63.9 ± 13.3% vs. 43.9 ± 10.4%). The results of RCTs comparing the weight loss effects between LSG and LRYGB, which were reported in the past, indicated that the two procedures were associated with similar weight loss effects. These RCTs included subjects with a BMI of ≤50 kg/m^2 [7][8][9]. Kehagias [10] performed an RCT to compare LSG to LRYGB in patients with a BMI of ≤50 kg/m^2 and reported that the weight loss effects of LSG at one year after surgery were higher but the effects at three years after surgery were similar. These reports also suggest that while there were no significant differences in the weight loss effects achieved by the procedures in the MO group, bypass procedures were associated with better weight loss effects in the SMO group. No reports have compared the weight loss effects of LSG and BPD/DS in patients with SMO.

Which bypass procedure is more appropriate? In Japan, LSG/DJB and LRYGB are the most common bypass procedures. Gastric cancer remains a relatively common disease in Japan. Kasama [3] reported that LRYGB is not appropriate for Japanese as it creates a residual stomach following surgery, which cannot be detected by gastroscopy. They reported the performance of LSG/DJB which is a modification of the BPD/DS procedure. With regard to the performance of bypass procedures in Japan since 2007, the LSG/DJB procedure has been more widely performed than the LRYGB procedure. In the present study, there were no significant differences between LSG/DJB and LRYGB in terms of the weight loss effects in patients with SMO. Some studies compared the weight loss effects of LRYGB and BPD/DS in patients with SMO. Topart [11] compared BPD/DS and LRYGB in patients with a BMI of $\geq$50 kg/m^2 and reported that the %EWL of LRYGB at three years after surgery was 63.7 $\pm$ 17.0%, while BPD/DS was 84.0 $\pm$ 14.5%, indicating that BPD/DS was associated with better weight loss effects. Reports by Prachand [12] and Sovic [13] showed similar results and indicated that BPD/DS achieved better weight loss effects than LRYGB. However, in these studies, the common limb length was set to 100 cm, which is different from the common limb length set in the LSG/DJB that we conducted. It is hypothesized that this resulted in the significant difference in weight loss effects that were observed between LRYGB and BPD/DS in these reports. Taken together, it is assumed that the weight loss effects of LSG/DJB and LRYGB (which were conducted at our hospital) do not differ in patients with SMO. The findings suggest that we should choose procedures based on the patient characteristics and familiarity with the procedure.

With regard to the treatment of patients with SMO, we showed that bypass procedures had better weight loss effects than LSG. Bypass procedures are more complicated when they are associated with anastomosis of the GI tract. It is expected that the thick subcutaneous fat and large amounts of intraabdominal fat will make surgery more difficult. Regarding the duration of surgery for patients with SMO in the present study, while there was no significant difference between the LSG and LRYGB sub-groups (145 ± 33.9 min vs 159.7 ± 38.3 min, $p=0.15$), LSG/DJB was associated with a significantly longer operative time than LSG (229 ± 25.7 min, $p<0.001$). However, based on our investigation, the operative times in patients with SMO and MO did not differ to a statistically significant extent. In addition, no significant differences in the incidence of perioperative complications within 30 days after surgery were observed among the procedures in the SMO and MO groups. In brief, there was no extension of the operative time, and the incidence of perioperative complications did not increase in patients with SMO. Even more difficult bypass procedures are believed to be associated with a similar level of risk to MO. Rezvani [14] and Dresel [15] also reported that patients with SMO did not show an increased rate of complications. However, all of the procedures at our hospital were carried out by surgeons who were familiar with the operative procedures. In other words, the operative risks of SMO were similar to those involving patients with a BMI of ≤50, if the operation was conducted by experts familiar with the operative procedures. According to the IFSO guidelines [16], it is more desirable for surgeons to refrain from conducting surgery on patients with a BMI of ≥50 kg/m^2 until they have conducted 50 surgeries on patients with a BMI of ≤50 kg/m^2. According to a report by Benotti [17], the rate of perioperative mortality after LRYGB is significantly higher in patients with SMO. The results of the report did not directly reflect the mortality rate due to the operative procedures that were performed. However, the results suggest that the surgery is more difficult in SMO and that it is associated with severe comorbidities.

Moreover, in the present study, a good weight loss effect of LSG alone was achieved in some of the patients with SMO. An investigation into the factors involved when selecting between bypass procedures and LSG for patients with SMO may play an important role in avoiding unnecessary surgery and surgical revision. Furthermore, the intraoperative findings indicated that a thick intraabdominal fat is a contraindication for bypass among some patients with a high BMI. In such cases, it is not possible to ensure a sufficient surgical field or working space, nor is it possible to ensure that the anastomotic site has been subjected to excessive traction by heavy mesenteric fat. For such patients, LSG is also believed to be effective as the first step of a two-step procedure.

With regard to the metabolic profile changes after surgery in patients with SMO, each procedure improved DM, HT, and DL. In particular, LSG/DJB could achieve significantly better glycemic control, despite the selection of this procedure for patients with more severe DM. Furthermore, although the rate of weight loss was insufficient, LSG improved the metabolic profile of patients with SMO. We hypothesize that this result was reflected by the subjects who achieved better weight loss. We did not compare the metabolic profile changes between each procedure consciously because the decision to select a procedure was usually made based on the level of glycemic control at base line.

The present study is associated with some limitations, including the sample size, the retrospective nature of the study; and the possibility of selection bias. To overcome these limitations, we need to accumulate more subjects, conduct long-term follow-up examinations, and validate our study via a prospective study.

Conclusion

In the present study, we demonstrated that malabsorptive procedures (LSG/DJB, LRYGB) were associated with significantly higher rates of successful weight loss than restrictive (LSG) procedures in patients with SMO. When performed by skilled surgeons, these procedures are safe for patients with SMO. With respect to the surgical procedure, the degree of obesity, the type, severity and technical difficulty of the obesity-associated diseases of each patient, and the proficiency of surgeons should be taken into consideration in order to select the most appropriate procedure for each case.

Conflict of Interest

The authors declare that they have no conflict of interests.

Ethical Approval

All procedures performed in our study involving human participants were in accordance with the ethical standards of the institutional and/or Japanese national research committees 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 our study.

References

1. Angrisani L, Santonicola A, Iovino P, Formisano G, Buchwald H, Scopinaro N. Bariatric surgery worldwide 2013. Obes Surg. 2015;25:1822–32.

2. Haruta H, Kasama K, Ohta M, Sasaki A, Yamamoto H, Miyazaki Y, et al. Long-term outcomes of bariatric and metabolic surgery in Japan: results of a multi-institutional survey. Obes Surg. 2017;27:754-62.

3. Kasama K, Tagaya N, Kanehira E, Oshiro T, Seki Y, Kinouchi M, et al. Laparoscopic sleeve gastrectomy with duodenojejunal bypass: technique and preliminary results. Obes Surg. 2009;19:1341–5.

4. Tagaya N, Kasama K, Kikkawa R, Kanahira E, Umezawa A, Oshiro T, et al. Experience with laparoscopic sleeve gastrectomy for morbid versus super morbid obesity. Obes Surg. 2009;19:1371–6.

5. Thereaux J, Corigliano N, Poitou C, Oppert J-M, Czernichow S, Bouillot J-L. Comparison of results after one year between sleeve gastrectomy and gastric bypass in patients with BMI ≥50 kg/m^2. Surg Obes Relat Dis. 2015;11:785-90.

6. Zerrweck C, Sepúlveda EM, Maydón HG, Campos F, Spaventa AG, Pratti V, et al. Laparoscopic gastric bypass vs. sleeve gastrectomy in the super obese patient: Early outcomes of an observational study. Obes Surg. 2014;24:712–7.

7. Peterli R, Borbély Y, Kern B, Gass M, Peters T, Thurnheer M, et al. Early results of the Swiss Multicentre Bypass or Sleeve Study (SM-BOSS): a prospective randomized trial comparing laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass. Ann Surg. 2013;258:690-4.

8. Zhang N, Maffei A, Cerabona T, Pahuja A, Omana J, Kaul A. Reduction in obesity-related comorbidities: is gastric bypass better than sleeve gastrectomy? Surg Endosc Other Interv Tech. 2013;27:1273–80.

9. Keidar A, Hershkop KJ, Marko L, Schweiger C, Hecht L, Bartov N, et al. Roux-en-Y gastric bypass vs sleeve gastrectomy for obese patients with type 2 diabetes: A randomised trial. Diabetologia. 2013;56:1914–8.

10. Kehagias I, Karamanakos SN, Argentou M-I, Kalfarentzos F. Randomized clinical trial of laparoscopic Roux-en-Y gastric bypass versus laparoscopic sleeve gastrectomy for the management of patients with BMI < 50 kg/m^2. Obes Surg. 2011;21:1650–6.

11. Topart P, Becouarn G, Ritz P. Weight loss is more sustained after biliopancreatic diversion with duodenal switch than Roux-en-Y gastric bypass in superobese patients. Surg Obes Relat Dis. 2013;9:526-30.

12. Prachand VN, DaVee RT, Alverdy JC. Duodenal switch provides superior weight loss in the super-obese (BMI ≥50kg/m2) compared with gastric bypass. Ann Surg.

2006;244:611–9.

13. Søvik TT, Taha O, Aasheim ET, Engström M, Kristinsson J, Björkman S, et al. Randomized clinical trial of laparoscopic gastric bypass versus laparoscopic duodenal switch for superobesity. Br J Surg. 2010;97:160–6.

14. Rezvani M, Sucandy I, Klar A, Bonanni F, Antanavicius G. Is laparoscopic single-stage biliopancreatic diversion with duodenal switch safe in super morbidly obese patients? Surg Obes Relat Dis. 2014;10:427-31.

15. Dresel A, Kuhn JA, McCarty TM. Laparoscopic Roux-en-Y gastric bypass in morbidly obese and super morbidly obese patients. Am. J. Surg. 2004;187:230–2.

16. Melissas J. IFSO guidelines for safety, quality, and excellence in bariatric surgery. Obes Surg. 2008;18:497–500.

17. Benotti P, Wood GC, Winegar DA, Petrick AT, Still CD, Argyropoulos G, et al. Risk factors associated with mortality after Roux-en-Y gastric bypass surgery. Ann Surg. 2014;259:123-30.

Figure legends

Fig. 1

A schematic illustration of laparoscopic sleevegastrectomy with duodenojejunal bypass.

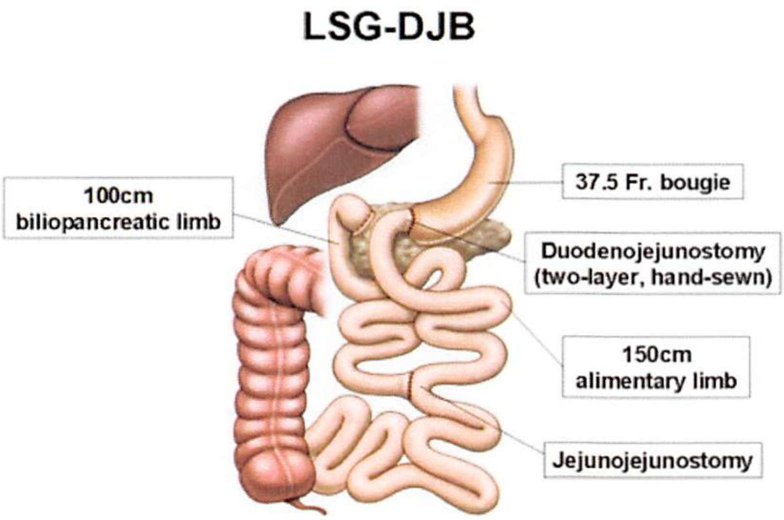

Fig. 2

The %EWL and the rates of successful weight loss. The %EWL and the success rates of LSG and LSG/DJB in the SMO and MO groups are shown. The results were compared using Student's *t*-test. P values of <0.05 were considered to indicate statistical significance.

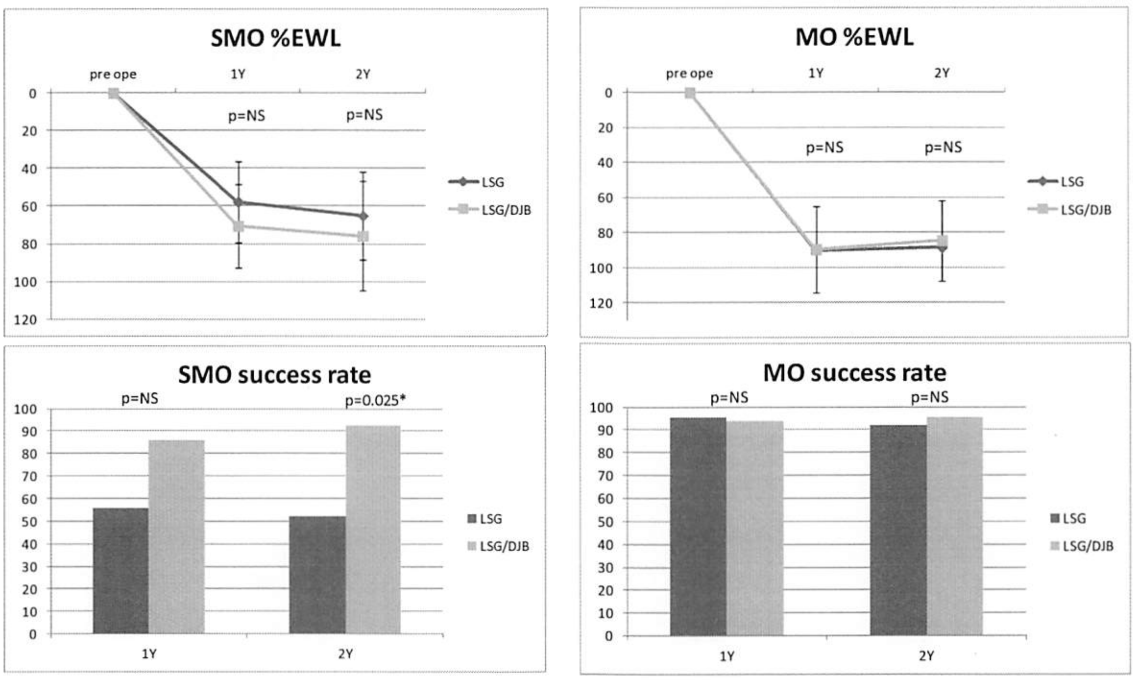

Fig. 3

The %EWL and the rates of successful weight loss. The %EWL and the success rates of LSG and LRYGB in the SMO and MO groups are shown. The results were compared using Student's *t*-test. P values of <0.05 were considered to indicate statistical significance.

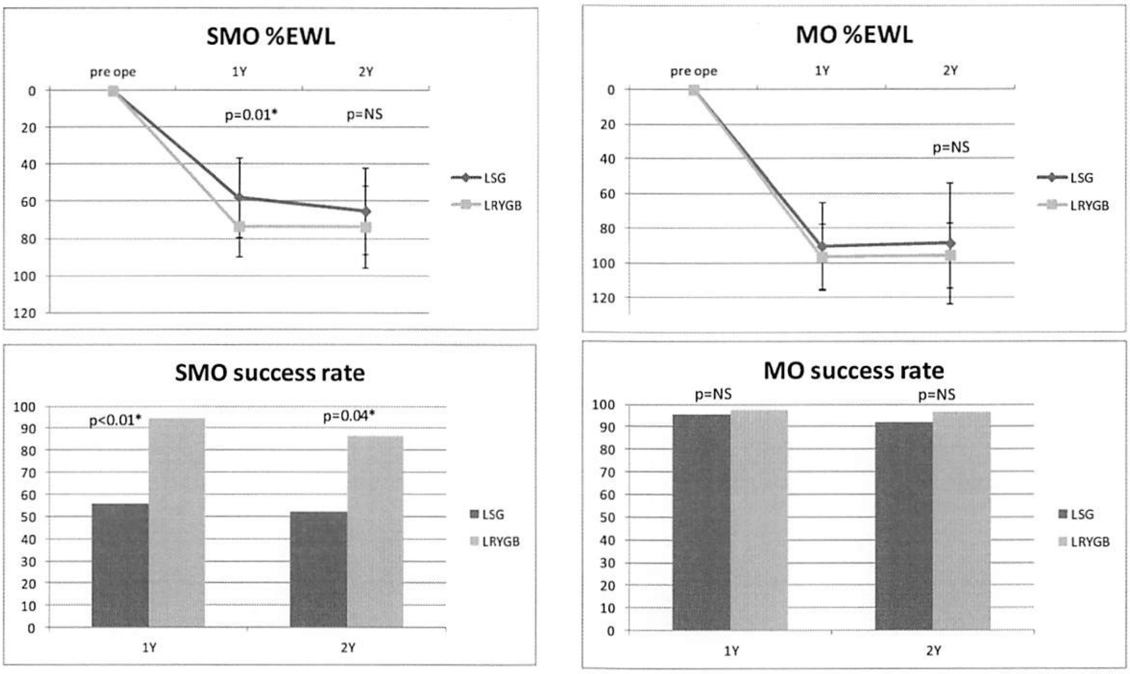

Table1 Preoperative characterstics

50≦BMI<70 kg/m^2 SMO group	LSG n=28	LSG/DJB n=14	LRYGB n=20	*P* value LSG vs. LSG/DJB	LSG vs. LRYGB	LSG/DJB vs. LRYGB
Age (Years)	37.9±9.2	39.9±8.8	32.6±6.6	0.49	0.033*	0.008*
Sex Male(Female)	22 (6)	7 (7)	8 (12)	0.082	0.014*	0.72
Weight (kg)	163.6±22.0	147.5±19.4	155.6±21.2	0.027*	0.22	0.25
BMI (kg/m^2)	57.1±5.1	55.5±4.4	55.7±4.2	0.32	0.34	0.86
35≦BMI<50 kg/m^2 MO group	**LSG** n=89	**LSG/DJB** n=50	**LRYGB** n=47	***P* value** LSG vs. LSG/DJB	LSG vs. LRYGB	LSG/DJB vs. LRYGB
Age (Years)	41.2±10.8	45.9±8.3	35.0±9.9.9	0.01*	0.001*	<0.001*
Sex Male(Female)	39 (50)	23 (27)	13 (34)	0.86	0.094	0.092
Weight (kg)	112.4±15.5	110.0±14.5	111.5±16.9	0.423	0.798	0.642
BMI (kg/m^2)	41.0±3.9	40.0±4.2	41.4±3.7	0.135	0.59	0.075

The baseline characteristics of the patients. The characteristics were compared between procedures and using Student's t-test.
P values of <0.05 were considered to indicate statistical significance(*).
BMI: body mass index, SMO: super morbid obesity, MO: morbid obesity

Table2 Postoperative outcome

50≦BMI<70 kg/m² SMO group	LSG	LSG/DJB	LRYGB	P value LSG vs LSG/DJB	LSG vs LRYGB	LSG/DJB vs LRYGB
1year after surgery	n=27	n=14	n=19			
follow-up rate (%)	96.4	100	95			
BMI (kg/m²)	39.1±8.5	33.9±6.27	33.1±4.9	0.048*	0.01*	0.72
Weight (kg)	113.0±26.1	91.0±21.5	93.9±19.0	0.01*	0.01*	0.68
%EWL 1Y	57.7±21.4	70.6±21.8	73.4±16.1	0.078	0.01*	0.67
2year after surgery	n=23	n=13	n=15			
follow-up rate (%)	82.1	92.9	75			
BMI (kg/m²)	36.0±7.8	32.0±8.1	32.8±6.8	0.172	0.217	0.78
Weight (kg)	113.0±26.1	91.0±21.5	93.9±19.0	0.01*	0.01*	0.5
%EWL 2Y	65.1±23.4	75.9±29.0	73.7±22.0	0.25	0.284	0.82
success rate						
1year success number	15	12	18	0.08	<0.01*	0.56
1year rate (%)	55.6	85.7	94.7			
2year success number	12	12	13	0.025*	0.04*	1
2year rate (%)	52.2	92.3	86.7			

35≦BMI<50 kg/m² MO group	LSG	LSG/DJB	LRYGB	P value LSG vs. LSG/DJB	LSG vs. LRYGB	LSG/DJB vs. LRYGB
1year after surgery	n=89	n=50	n=41			
follow-up rate (%)	100	100	87.2			
BMI (kg/m²)	27.0±4.1	27.0±4.1	25.7±3.0	0.98	0.08	0.103
Weight (kg)	74.0±14.2	74.4±12.9	70.7±11.7	0.85	0.2	0.158
%EWL 1Y	90.1±25.0	89.5±24.7	96.3±19.0	0.89	0.16	0.153
2year after surgery	n=77	n=45	n=28			
follow-up rate (%)	86.5	90	59.6			
BMI (kg/m²)	27.5±4.4	27.6±3.7	25.8±3.0	0.93	0.06	0.037*
Weight (kg)	74.7±14.0	76.3±12.1	70.8±11.4	0.53	0.19	0.058
%EWL 2Y	88.4±34.7	84.5±22.8	95.4±18.7	0.5	0.31	0.037*
success rate						
1year success number	85	47	40	0.75	1	0.62
1year rate (%)	95.5	94	97.6			
2year success number	71	43	27	0.71	0.67	1
2year rate (%)	92.2	95.6	96.4			

The weight-loss after surgery. We compared the weight-loss achieved by each procedure Student's t-test was used to compare the parametric values. Fisher's exact test was used to compare the categorical values. P values of <0.05 were considered to indicate statistical significance(*).
BMI; body mass index, %EWL: percent excess weight loss,

Table3 Perioperative outcomes

	LSG		p value	LSG/DJB		p value	LRYGB		p value	LSG vs. LSG/DJB		LSG vs. LRYGB	
	SMO	MO		SMO	MO		SMO	MO		SMO	MO	SMO	MO
Perioperative complications	3 (10.7%)	2 (2.3%)	0.088	1 (7.1%)	4 (8.0%)	1	4 (20%)	10 (21.3%)	1	1	0.188	0.429	<0.01*
bleeding	3				2		4						
leakage		2			1			4					
sleeve obstruction					1								
anastomotic stenosis								5					
intestinal injury								1					
wound infection				1									
Conversion to open surgery	0	0		0	0		0	0					
Mean operative time	142.3±31.8	140.1±37.8	0.78	228.8±25.7	219.6±36.6	0.38	159.7±38.3	159.5±42.6	0.99	<0.01*	<0.01*	0.094	<0.01*

The occurrence of intraoperative and postoperative (within 30 days after surgery) complications. We examined the differences—with respect to each procedure—between the MO and SMO groups.
We also examined the differences between procedures for the whole study population. The results were compared using Student's t-test. P values of <0.05 were considered to indicate statistical significance(*).
SMO; super morbid obesity, MO: morbid obesity

Table4 Metabolic profile changes in SMO group

	LSG	LSG/DJB	LRYGB
	number of patients (percent)		
Diabetes mellitus	9 (32.1)	13 (92.9)	6 (30)
At baseline			
mean HbA1c	7.52±0.8	9.08±2.0	8.18±1.9
Treatment			
LSM alone	1	0	1
OA	7	10	4
insulin	1	3	1
At 1yr			
mean HbA1c	5.44±0.6	5.53±0.38	5.21±0.29
HbA1c≦6.0% without medication	7 (77.8)	12 (92.3)	6 (100)
HbA1c≦6.5% without medication	7 (77.8)	12 (92.3)	6 (100)
HbA1c≦7.0%	7 (77.8)	13 (100)	6 (100)
Treatment			
LSM alone	7	12	6
OA	1	1	0
insulin	1	0	0
Hypertension			
At baseline			
HT with medication	11 (39.3)	11 (78.6)	3 (15)
At 1yr			
HT with medication	9 (32.1)	9 (64.3)	0 (0)
Dyslipidemia			
At baseline			
DL with medication	5 (17.9)	8 (57.1)	2 (10)
At 1yr			
DL with medication	2 (7.1)	3 (21.4)	0 (0)

The metabolic profile changes after each procedure in the patients with SMO.
HbA1c: hemoglobin A1c, LSM: life style modification, OA: oral agents,