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Variations of Weight Loss Following Gastric Bypass and Gastric Band

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Abstract

Objective—To compare and describe the weight loss outcomes from gastric bypass and gastric band so as to define the variation of excess weight loss (EWL) among individual patients, the time to onset of effect, and the durability of weight loss in severely obese adults.

Summary Background Data—Gastric bypass and gastric band are the most common operations for obesity performed in the United States, but few reports have compared these 2 procedures.

Methods—Patients (N = 1733, aged 18–65 years) met National Institutes of Health criteria for obesity surgery and underwent either gastric bypass or gastric band between March 1997 and November 2006. The selection of bypass versus band was based on patient/surgeon discussion. The evaluable sample consisted of 1518 patients. The percentage of EWL was assessed over 2 years. Successful weight loss was defined a priori as 40% EWL in each of four 6-month postoperative measurement periods. The analyses included a mixed model and generalized estimating equation (GEE) model with repeated measures. Odds ratios and descriptive analyses were also provided.

Results—Gastric bypass was associated with less individual variation in weight loss than gastric band. Both procedures were associated with a significant EWL benefit (Treatment Group effect $P < 0.0001$), but they differed in terms of time to effect (Treatment Group $\times$ Period interaction effect $P < 0.0001$). The mean EWL for gastric bypass was greater at each measurement period (6, 12, 18, 24 months) compared with gastric band ($P < 0.0001$). Furthermore, at each of the postoperative measurement periods within each treatment group (bypass and band), the mean EWL was greater for those who had preoperative body mass index (BMI) $\leq 50 \text{ kg/m}^2$ than for those who had preoperative BMI $> 50 \text{ kg/m}^2$ ($P < 0.0001$). Gastric bypass was consistently associated with a greater likelihood of at least a 40% EWL in each of the 6-month postoperative measurement periods (GEE, $P < 0.0001$). The odds ratio estimates at months 6, 12, 18, and 24 were 18.2, 20.6, 15.5, and 9.1, respectively. Despite these clinically meaningful outcome differences, nearly all

(93%) bypass and band patients who had 40% EWL at 6, 12, or 18 months postoperatively maintained at least this level of success at 2 years.

Conclusions—Gastric bypass produced more rapid, greater, and more consistent EWL across individuals over a 2-year postoperative period than gastric band.

Obesity is prevalent and associated with multiple medical comorbidities, including early death from heart disease and cancer.^{1,2} Weight loss yields improvement of these comorbidities^{3,4} and decreases mortality.^{5,6} Although lifestyle and medical interventions may be effective for some patients, surgical interventions lead to significant, durable weight loss.^{3,7} Safety concerns, however, have previously limited surgical options. Improved safety, development of minimally invasive surgical techniques, and celebrity endorsement may have contributed to a 726% increase of bariatric procedures from 1998 to 2004.⁸ At least 121,055 bariatric procedures were performed in the United States in 2004,⁸ with estimated increases to 140,000 in 2005⁹ and 200,000 in 2006.¹⁰

Gastric bypass and gastric band are the most common bariatric procedures. With gastric bypass, weight loss is more rapid. As a group, patients lose 50% to 77% excess weight loss (EWL) 1 year after gastric bypass^{7,11,12} as compared with 30% to 52% EWL 1 year after gastric band.^{13–16} At 3 years post operation, total weight loss seems to not differ between the 2 procedures.^{17,18} The equivalence in weight loss outcome, however, is based on a small number of previous studies with adequate follow-up.

Safety profiles and follow-up of gastric bypass and gastric band are different. Mortality rates are low for both operations—approximately 1% for gastric bypass and 0.1% for gastric band.^{19–21} The perioperative risk for severe complications is greater with gastric bypass than with gastric band,^{22–24} but the lifetime risk for complications requiring reoperation may be greater for gastric bands.^{25,26} Postoperative care generally entails more treatment visits for band than bypass patients because band adjustments are needed every 2 to 6 weeks. Gastric bypass patients, however, need only to return to clinic 3 to 4 times per year following surgery. Risk/benefit ratios and the patients' ability to return to clinic are critical factors in choosing which procedure better suits a particular patient. Although weight loss outcomes following gastric bypass and gastric band are known, the variation between and course of weight loss among individuals following each procedure is less clear.

This study examined the effect of gastric bypass versus gastric band on excess weight loss in severely obese adults to address the following questions: (1) What is the variation in excess weight loss over a 2-year postoperative period among individuals following either gastric bypass or gastric band? (2) What are the odds of clinically meaningful weight loss, defined as 40% EWL, at various postoperative time periods? (3) What proportion of patients with at least 40% EWL, at various postoperative time periods (6, 12, 18 months), maintained this degree of EWL at 2 years post operation?

METHODS

Study Design and Patients

A quasi-experimental (nonrandomized) design was used to prospectively assess weight loss following obesity surgery for up to 2 years. The study protocol was approved by the Institutional Review Board of The University of Texas Southwestern Medical Center at Dallas. Patients aged 18 through 65 years were included in the current study. Patients who had undergone primary revisional (vertical banded gastroplasty to gastric bypass) surgery (which represented 6% of the total study sample) were also included. National Institutes of Health (NIH) eligibility criteria included either a body mass index (BMI) ≥ 35 kg/m² with life-threatening comorbidities (see below) or a BMI ≥ 40 kg/m², and history of failed dietary or lifestyle interventions for weight loss. Life-threatening comorbidities included diabetes mellitus, hypertension, and obstructive sleep apnea.

The 1733 adult patients who were included in the current study met NIH criteria for obesity surgery²⁷ and underwent either gastric bypass or gastric band between March 1997 and November 2006. Prior to June 2001, the gastric band was not a treatment option. Because of missing observations in the database (before follow-up had begun, which were a result of clerical input errors), the evaluable sample (at the outset of postoperative follow-up) consisted of 1518 patients. The sample size associated with the gastric bypass and gastric band groups at each postoperative measurement period (prospective month), which in part accounts for patient attrition across time, is shown in Table 3. Patients received either gastric bypass or gastric band based on a variety of factors, including patient preference, insurance coverage, and in a small number of cases, surgeon recommendation.

Procedures and Measures

All operations were performed by one of 6 bariatric surgeons at The University of Texas Southwestern Medical Center.

Operative Technique

Open gastric bypass, laparoscopic gastric bypass, and laparoscopic gastric band were performed as outlined by Livingston et al,²⁸ Hamilton et al,²⁹ and Belachew et al,¹⁴ respectively.

Postoperative Inpatient Care

All patients were extubated and transferred to the surgical floor unless they required close observation or ventilatory support in the intensive care unit. Nasogastric tubes were not used postoperatively. Patients were placed on patient-controlled analgesia and encouraged to ambulate on the same day of operation. Gastric bypass patients were allowed ice chips as desired and gastric band patients were given clear liquids. All patients underwent an upper gastrointestinal (UGI) contrast study on postoperative day 1 as per protocol to assess for leak or obstruction.²⁹ After a normal UGI study, gastric bypass patients were advanced to a clear liquid diet. Patients were discharged from the hospital when oral fluid was tolerated and pain was controlled by oral pain medication.

Postoperative Outpatient Care

All patients were seen in The University of Texas Southwestern Medical Center for Obesity Surgery clinic for initial consultation and at 2 weeks post operation. Additionally, depending on the date of operation, gastric bypass patients were seen at about 3, 6, 12, 18, and 24 months postoperative and yearly thereafter. Gastric band patients, depending on the date of operation, were seen at about 4- to 6-week intervals over an 18- to 24-month postoperative period. Gastric band adjustments to outpatients were based on hunger, satiety, volume of food consumed at meals, and weight loss. Initial band adjustment was made at 6 weeks post operation. Dieticians usually consulted with all patients at each visit. No other interventions such as pharmacotherapy or mental health support were routinely prescribed.

Measures

Excess Weight Loss—Weight loss was calculated as the percentage of excess body weight loss. The ideal body weight was derived from Metropolitan Life Insurance tables of height and weight using the middle weight of a medium-framed person.³⁰

$$\%EWL = \frac{[(\text{preoperative weight} - \text{post operative weight})]}{(\text{preoperative weight} - \text{ideal weight})} \times 100_{31}$$

Weights were obtained at baseline (preoperative) and at every postoperative patient encounter up to a 2-year prospective study period. Mutually exclusive postoperative measurement periods were defined as follows: “month 6” (defined as the midpoint of the 3- to 9-month interval); “month 12” (defined as the midpoint of the 9.001- to 15-month interval); “month 18” (defined as the midpoint of the 15.001- to 21-month interval); and “month 24” (defined as the midpoint of the 21.001- to 27-month interval). For each patient who had more than one weight measurement in a measurement period, the average weight was calculated.

We defined a clinically meaningful degree of weight loss categorically with at least a 40% EWL at each postoperative measurement period for individual patients; That is, these patients were considered to have a “successful” degree of weight loss. Patients with <40% EWL were considered “unsuccessful” or “treatment failures”. We chose a priori to employ a response definition of 40% EWL because it is well within the range (10%–50% EWL) commonly used in previous studies that evaluated excess weight loss and improvement of comorbidities, decreased mortality, or improvement in quality of life.^{3–6,32–34}

Patient Characteristics—Various patient characteristics were collected at baseline (preoperative) to describe the sample and to test for group differences (gastric bypass versus gastric band): age, gender, race, height, weight, BMI, and comorbidities. For the current study, and to examine EWL by initial BMI status, preoperative BMI was also operationally defined as a categorical (binomial) variable: >50 kg/m² and ≤50 kg/m².

Data Analysis

Descriptive Data Analysis—To understand the pattern of variation in excess weight loss over this 2-year prospective study among individuals who underwent either gastric bypass or gastric band, we used a series of line plots of EWL for each individual patient by treatment group. A series of bar charts of EWL were used to define the proportion of patients who had either successful weight loss ($\geq 40\%$ EWL) or unsuccessful weight loss ($<40\%$ EWL) at various postoperative periods (6, 12, 18 months) and who went on to have either successful or unsuccessful EWL at 2 years post operation. To assess the extremes of weight loss, we also looked at those patients who had at least 75% EWL and less than 25% EWL at 2 years post operation.

Data Analysis for Continuous Outcomes—To compare gastric bypass and gastric band (across the postoperative measurement periods), we used a mixed linear model analysis of repeated measures with EWL as a continuous outcome variable. Restricted maximum likelihood estimation and Type 3 tests of fixed effects were used, with the Kenward-Roger correction³⁵ applied to the unstructured covariance model. The main treatment group effect (bypass versus band) and the treatment group $\times$ measurement period interaction effect were examined. Simple treatment group effects in each period were also assessed. To control for probability of Type I error, multiple comparisons for the test of simple effects were carried out using the Tukey procedure. A separate mixed model analysis of repeated measures similar to that described above was also used to evaluate preoperative BMI status (>50 kg/m² versus ≤ 50 kg/m²) on EWL (across the postoperative measurement periods) within each treatment group (bypass and band). The level of significance was set at $P = 0.05$.

Data Analysis for Categorical Outcomes—The primary data analysis of the repeated categorical EWL outcomes (successful versus unsuccessful weight loss) was a treatment group (gastric bypass versus gastric band) $\times$ measurement period (months 6, 12, 18, 24) repeated measures analysis using a generalized estimating equation (GEE) model. Maximum likelihood estimation and Type 3 tests were applied to the unstructured covariance model. The main effect of treatment group and the treatment group $\times$ measurement period interaction effect were examined. Odds ratios were estimated for each measurement period from the corresponding 2 independent proportions (treatment group versus successful/unsuccessful EWL). Odds ratios were also estimated in each postoperative measurement period from the corresponding 2 independent proportions (preoperative BMI status versus successful/unsuccessful EWL) and represented the odds of successful weight loss for those who had preoperative BMI >50 kg/m² versus those who had preoperative BMI ≤ 50 kg/m² within each treatment group (bypass and band). A Wald χ^2 was used to test for a significant association between the treatment group and successful/unsuccessful EWL in each period and a likelihood ratio χ^2 was used to test for a significant association between preoperative BMI status and successful/unsuccessful EWL in each period; P values were adjusted using the false discovery rate.³⁶ The level of significance was set at $P = 0.05$.

RESULTS

Patient Characteristics

The sample (at date of operation) consisted of 1733 patients: 1474 females (85.1%) and 259 males (14.9%). The age range was 18 to 65 years (with an average age of 43.7 years, SD = 10.5). Patients included 1107 (72.6%) whites, 332 (21.8%) blacks, and 85 (5.6%) Hispanics. We note that there were 209 missing observations in the database for race. The average preoperative weight was 310.6 lbs., SD = 74.3 (range = 167–825 lbs.). The average preoperative excess weight was 162.4 lbs., SD = 67.6 (range = 30–654 lbs.). The average preoperative BMI was 50.2 kg/m², SD = 10.3 (range = 28.4–115.5 kg/m²). Patient characteristics were similar between groups (Table 1). The 2 groups also had similar rates of medical comorbidities (Table 2).

Descriptive Results of Excess Weight Loss

The descriptive analysis (line plots) revealed that gastric bypass patients had less individual variation in weight loss than gastric band patients (Fig. 1). Weight loss for individuals after bypass was greater, faster, and less likely to be negated by intermittent transient weight gains than after gastric band (Fig. 1). In addition, when examining the extremes of weight loss, a larger percentage of band (18.1%) than bypass (2.6%) ($P < 0.0001$) patients had <25% EWL at month 24. More bypass (53.2%) than band (9.8%) patients had at least a 75% EWL by study exit ($P < 0.0001$).

Continuous and Categorical Results of Excess Weight Loss

When considering excess weight loss as a continuous variable, the mixed model repeated measures analysis revealed a significant treatment group effect (bypass versus band; $F = 868.88$, $df = 1$, 1468, $P < 0.0001$). That is, across the measurement periods, EWL was significantly greater in bypass than in band patients. In addition, we found a significant treatment group $\times$ measurement period interaction ($F = 68.22$, $df = 3$, 761, $P < 0.0001$). There was a significant difference in rapidity of weight loss in bypass than in band patients. Simple treatment group effects were significantly different on EWL in each of the 4 postoperative measurement periods ($F > 472.14$, $P < .0001$). The mean excess weight loss for gastric bypass was greater than for gastric band at each of the 4 measurement periods. Least-squares means and standard errors for EWL associated with gastric bypass versus gastric band at 6, 12, 18, 24 months are shown in Table 3.

The mixed model repeated measures analysis also revealed, within each treatment group, a significant difference in excess weight loss for those who had preoperative BMI ≤ 50 kg/m² compared with those who had preoperative BMI > 50 kg/m² ($F > 45.60$, $P < .0001$). That is, at each of the 4 postoperative measurement periods within each treatment group (bypass and band), the mean excess weight loss was greater for those who had preoperative BMI ≤ 50 kg/m² than for those who had preoperative BMI > 50 kg/m². Least-squares means and standard errors for EWL associated with preoperative BMI status for gastric bypass and gastric band at 6, 12, 18, 24 months are shown in Table 4.

A comparison of outcomes using the categorical definition of successful weight loss ($\geq 40\%$ EWL) revealed a significant treatment group effect (bypass versus band; $\chi^2 = 291.64$, $df = 1$, $P < 0.0001$) and a significant treatment group $\times$ measurement period interaction ($\chi^2 = 8.62$, $df = 3$, $P = 0.03$) with the GEE analysis. In addition, we found a significant relationship between the treatment group (bypass versus band) and the odds of successful weight loss ($\geq 40\%$ EWL) at each of the 4 postoperative measurement periods ($\chi^2 > 58.36$, $df = 1$, $P < 0.0001$). The odds ratio estimates at months 6, 12, 18, and 24 were 18.2, 20.6, 15.5, and 9.1, respectively. These results suggest that at month 6, for example, the gastric bypass group had 18.2 times greater odds of successful weight loss ($\geq 40\%$ EWL) than the gastric band group (Table 3). These results are shown graphically in Figure 2.

We examined the relationship between preoperative BMI status ($\text{BMI} > 50 \text{ kg/m}^2$ versus $\text{BMI} \leq 50 \text{ kg/m}^2$) and the odds of successful weight loss ($\geq 40\%$ EWL) within each treatment group (bypass and band) at each of the postoperative measurement periods. The odds ratio estimates within the gastric bypass group at months 6, 12, 18, and 24 were 0.12, 0.42, 0.51, and 0.66, respectively. The odds ratio estimates within the gastric band group at months 6, 12, 18, and 24 were 0.13, 0.29, 0.31, and 0.43, respectively. These results suggest that at month 6 within the gastric band group, for example, those who had preoperative $\text{BMI} > 50 \text{ kg/m}^2$ had 0.13 times the odds of successful weight loss ($\geq 40\%$ EWL) than those who had preoperative $\text{BMI} \leq 50 \text{ kg/m}^2$. The preoperative BMI odds ratio results are shown in Table 5.

Durability and Timing of Benefits for Individual Groups

Gastric Bypass—To determine whether success or failure at 6, 12, or 18 months was indicative of success/failure at 24 months, we examined groups that had both 6- and 24-month (Fig. 3A), 12- and 24-month, and 18- and 24-month (Fig. 3B) weights. Figure 3 shows results for gastric bypass. For those with weight loss data at both 6 and 24 months overall, 234 of 247 patients (94.7%) had successful weight loss by 2 years. At 6 months post operation, 78.9% (195/247) of the sample had successful weight loss. Most (192/195) (98.4%) who had success at 6 months retained that success at 24 months. However, 42 patients (17.0% of the total bypass sample) did not have success at 6 months but did have success at 2 years. Thus, success at 6 months was highly indicative of success at 2 years. Gastric bypass patients who were unsuccessful at 6 months ($n = 42 + 10 = 52/247 = 21.0\%$) still had a good chance (42/52) (80.1%) of success at 2 years.

By 12 months, most of the 24-month gastric bypass successes had already been successful. Only 3/222 (1.3%) gastric bypass patients who were 6-month successes were not successful at 24 months. Of those gastric bypass patients who failed at 12 months ($n = 12$), 4 (33.3%) became successes by 24 months. Similar results were obtained at 18 months post operation. Nearly all of the 18-month successes (185/187) were successes at 24 months (Fig. 3B). Failure at 18 months ($n = 9$), as shown in Figure 3B, led to success at 24 months in only 2/9 (22%) gastric bypass patients.

Gastric Band—Figure 4 shows analogous results for gastric band patients. Figure 4A shows that success at 6 months was highly indicative of success at 24 months (30/31) (96.7%). But failure at 6 months ($n = 94 + 70 = 164$) was not indicative of failure at 2 years.

In fact, 94 of the 164 gastric band patients who failed at 6 months ultimately succeeded at 2 years (57.3%). Gastric band patients who failed at 12 months ($48 + 51 = 99$) still had a 48.4% ($48/99$) chance of success at 2 years post operation. Again, most of the successful gastric band patients at 12 months ($69/74 = 93.2\%$) were successes at 2 years. As shown in Figure 4B, failure at 18 months ($n = 56 + 14 = 70$), led to success at 24 months in only 14/70 (20.0%) gastric band patients.

DISCUSSION

This study examined excess weight loss associated with gastric bypass versus gastric band in adults who met NIH criteria for obesity surgery. Gastric bypass was associated with greater average EWL than gastric band at each postoperative measurement period (6, 12, 18, and 24 months) over the 2-year study period. Furthermore, the odds of successful weight loss,

40% EWL, were higher for gastric bypass than for gastric band at 6, 12, 18, and 24 months post operation. Ultimately, fewer gastric band patients experienced successful weight loss by 2 years. Thus, there was a higher success rate and fewer treatment failures with gastric bypass than with gastric band. This basic finding is consistent with previous research comparing EWL of gastric bypass versus gastric band surgery.³⁷

We also found that, across the postoperative measurement periods within the gastric bypass and gastric band groups, average EWL was greater for those who had preoperative BMI ≤ 50 kg/m² than for those who had preoperative BMI >50 kg/m². In other words, the odds of successful weight loss, 40% EWL, were lower for those who had preoperative BMI >50 kg/m² than for those who had preoperative BMI ≤ 50 kg/m².

In addition, less variation in weight loss was experienced among individuals undergoing gastric bypass than patients undergoing gastric band. That is, for individual gastric band patients weight changes were more variable over time. Also, for the extremes of weight loss, more band than bypass patients did not reach at least a 25% EWL, and conversely more bypass than band patients had at least a 75% EWL by 2 years.

For both procedures, early success was indicative of later success when defined as 40% EWL. For both procedures lack of early successful EWL was not necessarily indicative of failure at 2 years post operation. About half of the gastric band patients who experienced failure at 6 and 12 months post operation went on to achieve success by 2 years post operation (57% and 49%, respectively) and about half remained failures (43% and 51%, respectively). In contrast, most gastric bypass patients who experienced early failure at 6 and 12 months post operation achieved success by 2 years post operation (80% and 33%, respectively). More gastric bypass than band patients experienced a rapid and consistent weight loss over the 2-year postoperative period, without multiple interim weight gains.

Gastric bypass produced rapid weight loss over the first 12 months post operation, which was maintained at 2 years following surgery. That is, early weight loss failures were uncommon after gastric bypass, and early weight loss success following gastric bypass was indicative of success at 2 years after operation.

The weight loss following gastric bypass most likely results from anatomic changes that confer hormonal and malabsorptive weight loss advantages in addition to restriction. The gradual weight loss with gastric band mimics weight loss resulting from low-fat, low-calorie dietary interventions. Weight loss after gastric band is thought to depend on adequate band adjustments to optimize restriction and dietary compliance. Behavioral practices may be more critical to weight loss success in gastric band than in gastric bypass. Gastric band patients lack the changed physiology that promotes weight loss. Gastric band patients, thus, may require the entire multidisciplinary armamentarium offered to patients who undergo dietary and lifestyle interventions for weight loss without surgery.

The difference in individual variation in weight loss (between the 2 operative techniques) has not previously been highlighted because previous studies have generally focused on mean weight loss for patient groups, without scrutinizing individual weight loss patterns. Moreover, the odds of early postoperative successful weight loss for subsequent postoperative successful weight loss between these 2 operative procedures have not been studied. The current study is the first, to our knowledge, to address these issues.

These results must be considered in the context of 4 key limitations. First, without randomization, we cannot be certain that the differential weight loss effects are entirely due to surgical differences. Second, the measurement period was limited to 2 years and thus longer term outcomes are not known. Bypass patients may experience weight regain^{7,38,39} and gastric band patients may experience additional weight loss with additional time.^{17,18} Third, patient attrition over the 2-year postoperative period may provide an incomplete picture of the overall group outcome. Fourth, generalizability may be limited given the high proportion of women and non-Hispanic whites in our sample.

Despite these limitations, the current study has strengths, including large samples of adult patients (aged 18–65 years) who met NIH criteria for obesity surgery and who were followed for up to 2 years postoperatively.

CONCLUSION

Gastric bypass produced more rapid and greater mean weight loss with less individual variation in weight loss over a postoperative 2-year period compared with gastric band. The odds of successful weight loss (≥ 40% EWL) were greater for gastric bypass than for gastric band patients (and for those who had preoperative BMI ≤ 50 kg/m² than for those who had preoperative BMI >50 kg/m²) at 6, 12, 18, and 24 months post operation. Despite its higher operative risk, gastric bypass may be a better choice for selected patients. However, a randomized trial with at least a 5-year follow-up in a larger generalizable sample is needed to more fully evaluate the risks, benefits, and costs of gastric bypass versus gastric band surgery for severely obese adult patients.

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FIGURE 1.

A, Excess weight loss over the 2-year postoperative study period for individual patients after gastric bypass (n = 958). B, Excess weight loss over the 2-year postoperative study period for individual patients after gastric band (n = 560).

FIGURE 2.

Comparison of successful weight loss for gastric bypass versus gastric band at the postoperative periods. Success was defined as 40% EWL.

FIGURE 3.

A, Percent weight loss success at 6 months versus 24 months after gastric bypass. Successful weight loss: $\geq 40\%$ EWL; unsuccessful weight loss: $<40\%$ EWL. B, Percent weight loss success at 18 months versus 24 months after gastric bypass. Successful weight loss: $\geq 40\%$ EWL; Unsuccessful weight loss: $<40\%$ EWL.

FIGURE 4.

A, Percent weight loss success at 6 months versus 24 months after gastric band. Successful weight loss: $\geq 40\%$ EWL; unsuccessful weight loss: $<40\%$ EWL. B, Percent weight loss success at 18 months versus 24 months after gastric band. Successful weight loss: $\geq 40\%$ EWL; unsuccessful weight loss: $<40\%$ EWL.

TABLE 1

Patient Characteristics by Treatment Group

Patient Characteristic	Treatment Group		P
	Gastric Bypass (n = 1102)	Gastric Band (n = 631)	
Age in years			0.0007 [*]
Mean (SD)	43.1 (10.0)	44.8 (11.1)	
Range	18–65	18–65	
Preop. weight in lbs.			<.0001 [*]
Mean (SD)	316.2 (75.3) [‡]	300.7 (71.4)	
Range	167–825	177–673	
Preop. excess weight in lbs.			<.0001 [*]
Mean (SD)	168.0 (69.3) [‡]	152.7 (63.3)	
Range	30–654	58–497	
Preop. BMI in kg/m ²			<.0001 [*]
Mean (SD)	51.1 (10.7) [‡]	48.6 (9.4)	
Range	28.3–115.5	33.3–103.6	
Gender, N (%)			0.10 [§]
Female	949 (86.2)	525 (83.2)	
Male	153 (13.8)	106 (16.8)	
Race, N (%) [¶]			0.001 [§]
White	675 (75.5)	432 (68.6)	
Black	183 (20.5)	149 (23.6)	
Hispanic	36 (4.0)	49 (7.8)	

The means presented in this table are the arithmetic means.

^{*} F statistic was used to test for mean difference between the 2 treatment groups.

[§] χ^2 test was used to test for differences between the 2 treatment groups.

[‡] 5 missing observations;

[‡] 8 missing observations;

[¶] 208 missing observations associated with the gastric bypass group and 1 missing observation associated with the gastric band group.

SD indicates standard deviation.

TABLE 2

Patient Comorbidities by Treatment Group

Patient Comorbidity	Treatment Group		<i>P</i> *
	Gastric Bypass (n = 1102)	Gastric Band (n = 631)	
Depression, N (%)	146 (13.2)	60 (9.5)	0.08
Diabetes, N (%)	288 (26.1)	182 (28.8)	0.53
Gastroesophageal reflux, N (%)	473 (42.9)	267 (42.3)	0.93
Hyperlipidemia, N (%)	210 (19.1)	225 (35.6)	0.001
Hypertension, N (%)	579 (52.5)	347 (54.9)	0.75
Irregular menses, N (%)	55 (5.0)	54 (8.5)	0.02
Joint disease, N (%)	1,088 (98.7)	617 (97.7)	0.93
Sleep apnea, N (%)	420 (38.1)	242 (38.3)	0.93
Stress incontinence, N (%)	24 (2.2)	33 (5.2)	0.01

* Likelihood ratio χ^2 test, in a negative binomial log linear model was used to test for differences between the 2 treatment groups, and *P* values are adjusted using the false discovery rate described by Benjamini and Hochberg (1995).

N indicates disease frequency per group; depression, depression, anxiety, depressive disorder; diabetes, mellitus, Type 2; irregular menses = menstrual irregularity $\pm$ infertility; joint disease, degenerative joint disease, joint pain, and low back pain.

TABLE 3

Treatment Effect and Treatment $\times$ Time Period Simple Effects for Mean EWL Associated With Gastric Bypass Versus Gastric Band and Odds Ratios for Successful Weight Loss

Prospective Month	Excess Weight Loss (%)					Successful Weight Loss*			
	M	SE	95% CI for M	F	P	n	Odds Ratio [†]	95% CI for Odds Ratio	χ^2 P
Month 6				810.16	<.0001		18.18	13.79–23.96	423.23 <.0001
Gastric bypass	52.18	0.51	51.18–53.18			898			
Gastric band	28.34	0.67	27.03–29.64			538			
Month 12				894.41	<.0001		20.60	14.18–29.92	252.29 <.0001
Gastric bypass	70.31	0.69	68.96–71.65			650			
Gastric band	36.64	0.89	34.89–38.39			401			
Month 18				734.41	<.0001		15.54	9.54–25.30	121.55 <.0001
Gastric bypass	75.48	0.79	73.91–77.04			412			
Gastric band	40.61	1.01	38.63–42.59			289			
Month 24				472.14	<.0001		9.10	5.16–16.04	58.36 <.0001
Gastric bypass	75.06	0.91	73.28–76.85			267			
Gastric band	43.53	1.13	41.31–45.75			204			
Overall (months 6–24)				868.88	<.0001		13.79	10.64–17.88	393.87 <.0001
Gastric bypass	68.26	0.64	66.99–69.52			958			
Gastric band	37.28	0.83	35.65–38.91			560			

The total evaluable sample (at the outset of postoperative follow-up) consisted of 1518 patients.

* Successful weight loss was a binomial variable defined as 40% EWL at each prospective study period for individual patients and unsuccessful weight loss was defined as <40% EWL.

[†] Odds ratios were estimated from the corresponding 2 independent proportions (Treatment Group vs. Successful/Unsuccessful EWL) and represented the odds of successful weight loss for the gastric bypass group vs. the gastric band group.

EWL indicates excess weight loss; overall, 24-month average and represents the main effect of the treatment group; M, least-squares means; SE, standard error; 95% CI, 95% confidence interval for the expected EWL mean value and for the estimated odds ratio; F statistic was used to test for mean EWL differences between the two treatment groups; χ^2 , Wald χ^2 test statistic associated with the estimated odds ratio; P, P value associated with an upper one-tailed test; P values for the F test are adjusted using the Tukey procedure and P values for the χ^2 test are adjusted using the false discovery rate; n = sample size per group.

TABLE 4

Preoperative BMI and Preoperative BMI $\times$ Time Period Simple Effects for Mean EWL Associated With Gastric Bypass and Gastric Band

Prospective Month	Gastric Bypass (n = 958)					Gastric Band (n = 560)				
	M	SE	Excess Weight Loss (%)			M	SE	Excess Weight Loss (%)		
			95% CI for M	F	P			95% CI for M	F	P
Month 6				279.35	<.0001				49.27	<.0001
Preop. BMI >50	43.55	0.71	42.16–44.95			22.83	0.92	21.01–24.65		
Preop. BMI 50	59.74	0.65	58.45–61.03			30.85	0.67	29.54–32.16		
Month 12				215.56	<.0001				47.85	<.0001
Preop. BMI >50	60.41	0.93	58.58–62.24			28.34	1.41	25.57–31.10		
Preop. BMI 50	79.03	0.85	77.34–80.71			40.42	1.03	38.39–42.45		
Month 18				131.72	<.0001				35.83	<.0001
Preop. BMI >50	66.18	1.09	64.02–68.34			32.01	1.63	28.80–35.21		
Preop. BMI 50	83.43	1.02	81.42–85.44			44.22	1.22	41.81–46.62		
Month 24				88.54	<.0001				24.51	<.0001
Preop. BMI >50	67.21	1.17	64.90–69.51			34.27	2.01	30.32–38.22		
Preop. BMI 50	82.41	1.11	80.23–84.59			46.65	1.49	43.73–49.58		
Overall (months 6–24)				201.95	<.0001				45.60	<.0001
Preop. BMI >50	59.33	0.86	57.63–61.04			29.36	1.33	26.74–31.98		
Preop. BMI 50	76.15	0.80	74.57–77.73			40.54	0.98	38.61–42.46		

The total evaluable sample (at the outset of postoperative follow-up) consisted of 1518 patients.

BMI measured in kg/m².

P value associated with an upper one-tailed test; P values for the F test are adjusted using the Tukey procedure; F statistic was used to test for mean EWL differences between the two preoperative BMI groups (>50 vs. 50) within each treatment group.

EWL indicates excess weight loss; overall, 24-month average and represents the main effect of preoperative BMI (>50 vs. 50); M, least-squares means; SE, standard error; 95% CI, 95% confidence interval for the expected EWL mean value.

TABLE 5

Preoperative BMI Odds Ratios for Successful Weight Loss Associated With Gastric Bypass and Gastric Band

Prospective Month	Gastric Bypass (n = 958)						Gastric Band (n = 560)							
	Successful Weight Loss*					Successful Weight Loss*								
	N (%) EWL	40% EWL	N (%) EWL	Odds Ratio [†]	95% CI for Odds Ratio	χ^2	P	N (%) EWL	40% EWL	N (%) EWL	Odds Ratio [†]	95% CI for Odds Ratio	χ^2	P
Month 6				0.12	0.08–0.18	136.25	0.0003				0.13	0.06–0.29	40.25	0.0001
Preop. BMI >50	258 (28.7%)		158 (17.6%)							7 (1.3%)			174 (32.3%)	
Preop. BMI 50	449 (50.0%)		33 (3.7%)							84 (15.6%)			273 (50.8%)	
Month 12				0.42	0.21–0.81	6.87	0.0147				0.29	0.18–0.47	29.35	0.0001
Preop. BMI >50	273 (42.0%)		27 (4.2%)							34 (8.5%)			107 (26.7%)	
Preop. BMI 50	336 (51.7%)		14 (2.1%)							134 (33.4%)			126 (31.4%)	
Month 18				0.51	0.21–1.24	2.27	0.1641				0.31	0.19–0.52	21.76	0.0001
Preop. BMI >50	184 (44.7%)		14 (3.4%)							41 (14.2%)			72 (24.9%)	
Preop. BMI 50	206 (50.0%)		8 (1.9%)							113 (39.1%)			63 (21.8%)	
Month 24				0.66	0.24–1.80	0.64	0.4228				0.43	0.24–0.78	7.7	0.0055
Preop. BMI >50	122 (45.7%)		10 (3.8%)							37 (18.1%)			38 (18.6%)	
Preop. BMI 50	128 (47.9%)		7 (2.6%)							89 (43.7%)			40 (19.6%)	
Overall (months 6–24)				0.23	0.15–0.36	49.04	0.0003				0.34	0.22–0.51	28.52	0.0001
Preop. BMI >50	349 (36.4%)		91 (9.5%)							36 (6.4%)			154 (27.5%)	
Preop. BMI 50	488 (50.9%)		30 (3.1%)							151 (27.0%)			219 (39.1%)	

The total evaluable sample (at the outset of postoperative follow-up) consisted of 1518 patients.

BMI measured in kg/m².

* Successful weight loss was a binomial variable defined as 40% EWL at each prospective study period for individual patients and unsuccessful weight loss was defined as <40% EWL.

† Odds ratios were estimated from the corresponding 2 independent proportions (preoperative BMI group vs. successful/unsuccessful EWL) and represented the odds of successful weight loss for the preoperative BMI >50 group versus the preoperative BMI 50 group.

EWL indicates excess weight loss; overall, 24-month average; 95% CI, 95% confidence interval for the estimated odds ratio; χ^2 , likelihood ratio χ^2 test statistic associated with the estimated odds ratio; P, P value associated with an upper one-tailed test; P values for the χ^2 test are adjusted using the false discovery rate; N = sample size per group.