

Sleeve Gastrectomy as Sole and Definitive Bariatric Procedure: 5-Year Results for Weight Loss and Ghrelin

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Abstract

Background Due to excellent efficacy for weight loss in the short-term follow-up, sleeve gastrectomy (SG) has gained enormous popularity as bariatric procedure, not only as first step in high-risk or super-obese patients but mainly as a sole and definitive operation in morbidly obese. In contrast to a large number of short and intermediate-term results, no series of SG with a follow-up of 5 years or more has been published so far.

Methods We report on the weight loss results of our first consecutive 26 patients with a complete follow-up of 5 years. Furthermore in a subgroup of 12 patients, plasma ghrelin levels were measured preoperatively, and up to 5 years following SG.

Results Weight loss defined as mean percent excess weight loss (%EWL) was found as 57.5 ± 4.5 , 60.3 ± 5.0 , 60.0 ± 5.7 , 58.4 ± 5.4 , and 55.0 ± 6.8 (not converted, $n=21$) for the first 5 years. Weight regain of more than 10 kg from nadir was observed in five (19.2%) of the 26 patients. Four of the patients (15.4%) were converted to gastric bypass due to severe reflux ($n=1$, 3.8%) and weight loss failure ($n=3$, 11.5%). A total of eight patients (30.8%) were at chronic need for proton pump inhibitor medication due to severe

reflux. Plasma ghrelin levels were reduced from 593 ± 52 to 219 ± 23 pg/ml 12 months postoperatively, with a slightly, non-significant increase toward the 5-years values of mean 257 ± 23 pg/ml.

Conclusions At 5-year follow-up, a mean EWL of $55.0 \pm 6.8\%$ was achieved, indicating that SG leads to stable weight loss. Beside significant weight regain, severe reflux might necessitate conversion to gastric bypass or duodenal switch. After an immediate reduction postoperatively, plasma ghrelin levels remained low for the first 5 years postoperatively.

Keywords Sleeve gastrectomy · Gastric bypass · Weight loss · Weight regain · Reflux · Ghrelin

Introduction

A widening field of indications for sleeve gastrectomy (SG) is available today, from a procedure introduced as first step for high-risk or super-obese patients intended for a second intervention, such as the Roux-en-Y gastric bypass (RYGB) [1, 2] or bilio-pancreatic diversion with duodenal switch (BPDDS) [3, 4]. In these settings, a significant weight regain in the longer follow-up was of no consequence, as the second intervention was scheduled within a short period of time to benefit from the initial weight loss.

With short-time results [5–8] comparable to more invasive procedures like gastric bypass, SG has gained enormous popularity in the bariatric world and is performed as sole and definitive bariatric procedure in the majority of patients today [9, 10].

Recently, we addressed plasma levels of ghrelin as short-time result of SG. As an appetite-inducing peptide hormone mainly deriving from the gastric fundus resected in SG,

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reduced plasma levels were found at 6 months after sleeve gastrectomy [11]. This might partially explain the reduced sensation of appetite of SG patients in the early postoperative period [12], supporting weight loss. However, a compensatory increase of plasma ghrelin levels in the longer follow-up might contribute to weight regain and, thus, limit the success of SG in the longer follow-up.

In contrast to a large number of short [5, 6, 13–16] and intermediate [10, 17, 18] term results, no series of SG with a longer follow-up has been presented so far.

We report on 5-year weight loss results of our first 26 consecutive patients, who underwent SG as sole and definitive procedure. Furthermore we analyzed plasma ghrelin levels including 5-year follow-up.

Materials and Methods

From December 2002 to October 2004, a total of 26 patients underwent sleeve gastrectomy at the Department of Surgery, Medical University of Vienna. Twenty-three were performed laparoscopically, and in three patients, SG was performed in open technique due to multiple prior open operations. Demographic data of the study population is listed in Table 1.

The mean BMI at time of the surgery was 48.2 ± 1.3 kg/m² (range 40.1–73.1 kg/m²), with 29.6% of the patients being super-obese. The mean body weight was 134.5 ± 3.8 kg (range 100–187 kg). In all but seven patients, the SG was their first surgical intervention. The latter had previously a BioEnterics intragastric balloon ($n=1$), liver transplantation ($n=1$), gastric stimulator ($n=1$), lap-band ($n=2$), vertical banded gastroplasty ($n=1$), and a Hartmann procedure ($n=1$).

Surgical Technique

As published previously, SG was performed as standardized operation [15]. The stomach was reduced to a narrow gastric tube with a 48-Fr bougie used to avoid stenosis at the lesser curvature, eliminating the fundus and part of the corpus and gastric antrum. The staple line was over-sewn by a running suture to prevent bleeding and leakage.

Leakage was further tested postoperatively after 24 h with a water-soluble contrast medium. A semi-liquid diet

was started for 4 days. Patients were advised to take oral multivitamin supplement daily.

Follow-up visits were scheduled for 3, 6, 9, 12, 18, and 24 months postoperatively, followed by yearly visits thereafter. These examinations also included blood sampling for calcium, vitamin B₁₂, folate, iron, PTH, and vitamin D.

Weight loss is expressed as percent excess weight loss (EWL) based on the Metropolitan Life Tables [19] as well as percent excess BMI loss (%EBL). Significant weight regain was defined as an increase of body weight of more than 10 kg from the nadir. Clinically significant reflux was defined as the necessity to take anti-acid drugs, chronically.

Ghrelin Assay

Venous blood samples were obtained in pre-chilled tubes containing aprotinin/EDTA at different times. After centrifugation at 4°C, plasma was stored at –20°C until analysis. Plasma ghrelin was assayed by radioimmunoassay (Peninsula Laboratories, San Carlos, CA, USA) using ¹²⁵I-labeled ghrelin as the tracer and a rabbit polyclonal antibody against the C-terminal end of human ghrelin.

Statistical Analysis

Results are expressed as mean $\pm$ standard error of the mean. Statistical evaluation was performed by a *t* test. Statistical significance was set at a *p* value of <0.05 .

Results

Weight Loss and Weight Regain

For the first 26 consecutive SG patients, weight loss defined as mean EWL was (excluding post conversion values) $57.5 \pm 4.5\%$, $60.3 \pm 5.0\%$, $60.0 \pm 5.7\%$, $58.4 \pm 5.4\%$, and $55.0 \pm 6.8\%$ for the first 5 years. This corresponds to a mean %EBL of 58.7 ± 4.1 , 61.4 ± 5.1 , 62.9 ± 4.9 , 58.7 ± 5.5 , and 55.3 ± 6.9 for the same period.

The evolution of %EWL and %EBL on SG patients is depicted in Fig. 1. Excluding four patients who were converted to gastric bypass, overall weight loss was found stable comparing %EWL at 1 and 5 years ($p=n.s.$).

As with other bariatric procedures, a proportion of patients showed weight regain following SG. Weight regain (WR) of more than 10 kg from nadir was observed in five (19.2%) of the 26 patients. Relative weight loss (RWL) was calculated as the percent change from the previous year body weight. Fig. 2 shows the RWL of patients with stable weight loss (SWL) and WR along the 5-year follow-up.

In the SWL group, the initial EWL at 1 year was $59.4 \pm 4.3\%$ ($n=21$). The %EWL slightly increased throughout the

Table 1 Demographic data of the study population

<i>N</i>	26
Gender (f/m)	19/7
Age (years)	46.2 ± 2.5
Body weight (kg)	134.5 ± 3.8
BMI (kg/m ²)	48.2 ± 1.3
Super-obese	8 (29.6%)

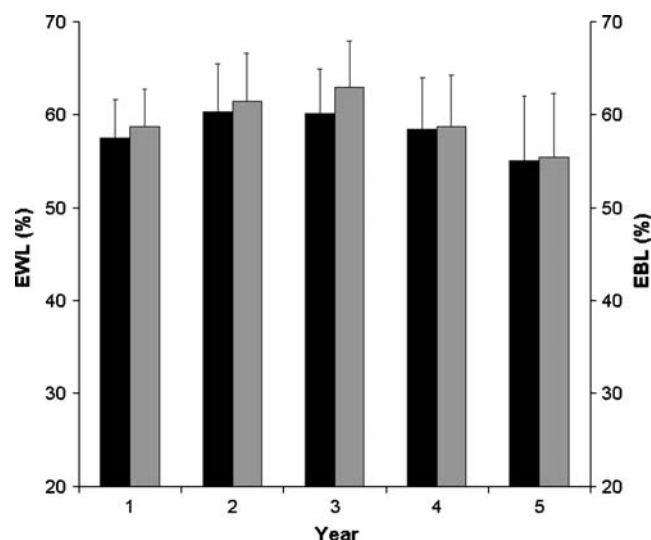


Fig. 1 Excessive weight loss (%EWL) and excessive BMI loss (%EBL) following laparoscopic sleeve gastrectomy

second year to the fourth years ($>60\%$), reaching 60.8 ± 6.0 by the fifth year, ($n=20$, one patient with good WL was converted due to reflux, see below). Expressed as RWL, most of the weight was lost in the first year ($27.0 \pm 2.7\%$), followed by further gains in the second year ($3.4 \pm 1.6\%$), remaining stable thereafter (range $-0.4 \pm 1.0\%$ to $1.8 \pm 1.9\%$ throughout the third and fifth year follow-ups).

In the WR group ($n=5$), the first year %EWL was similar as in the other subjects ($50.9 \pm 9.8\%$, $p=n.s.$), but decreased by the second year to 20.8 ± 17.1 ($p<0.05$), resulting in a negative weight loss representing weight

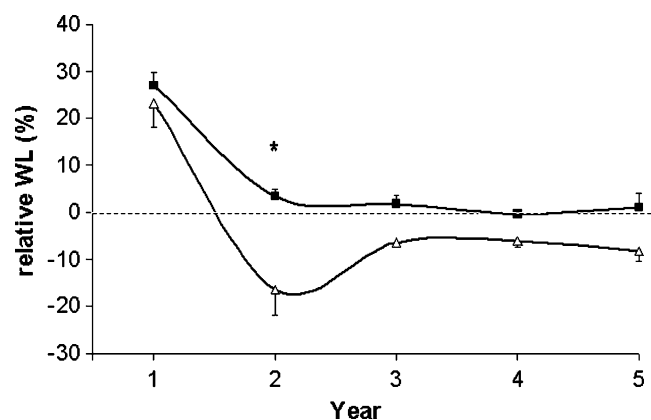


Fig. 2 RWL following laparoscopic sleeve gastrectomy comparing weight stable (SWL) and patients with WR. The RWL calculated as the percent change in body weight from year to year [it is actually = $100 - (\text{weight } t / \text{weight } t+1) \times 100$] for the SWL group (squares) and the WR group (triangles) for the 5-year follow-up. As approaching the 0% line, the patients of the SWL group gradually stopped to further lose weight. The WR group shows maximal SG effect by the first year post-op, but RWL was found negative as weight regain thereafter ($n=5$ at years 1 and 2, $n=3$ at years 3 and 4, and $n=2$ thereafter). A significant difference was found for mean RWL of both groups at the second year (* $p<0.05$)

regain. The mean WL reflects the relative change from year to year of the non-converted patients, which remained negative although stable for the remaining follow-up period. Thus, two patients were converted to bypass after the second year. A third patient steadily gaining weight was converted after 4 years.

Conversion to Gastric Bypass

A total of four patients (15.4%) underwent laparoscopic conversion from SG to RYGB due to reflux ($n=1$) or weight regain ($n=3$). Preoperative workup included gastroscopy, upper GI double contrast studies, and pH-metry in case of reflux.

Reflux

Gastroesophageal reflux disease (GERD) symptoms appear immediately after the procedure in some patients, with Himpens et al. [18] suggesting it to be caused by the removal of the angle of His by SG. In our series, most patients complained about reflux after the intervention, sporadically or chronically. Among others, pantoprazole and omeprazole were most commonly used as anti-acid medication. One patient out of 26 (3.8%) had to be converted to gastric bypass exclusively due to intolerable reflux 15 months following surgery, having achieved an EWL of 98%. In two other patients, conversion to gastric bypass was performed due to a combination of weight regain (12 and 15 kg) and severe reflux symptoms. Table 2 shows the incidence of reflux defined by the timing of anti-acid drug application in this series of 26 patients. Diagnosis of reflux was based on symptoms and not on histopathology [20].

Ghrelin

As a consequence of SG, plasma ghrelin levels were reduced in not converted patients from 593 ± 52 to 247 ± 52 pg/ml at 6 months postoperatively ($p<0.05$, $n=12$). At 1 and 5 years following SG, mean values of 219 ± 23 and 258 ± 23 pg/ml were found, respectively. Thus, the reduction of plasma ghrelin levels was stable for the entire follow-up, and these values were significantly reduced

Table 2 Use of anti-acid or proton pump inhibitor (PPI) medication in the postoperative period following SG

Frequency	No. of patients	Percentage
None	3	12
4 weeks post-op	4	15
Occasionally	11	42
Chronic	8	31

comparing to preoperative data. Plasma ghrelin levels were slightly higher in weight regain patients, but due to the small number of patients ($n=3$), no significant differences were observed. Fig. 3 shows the evolution of ghrelin.

Discussion

We report on the first weight loss data available for a 5-year follow-up following sleeve gastrectomy. With a 5-year % EWL of 54.8 ± 6.9 , comparable to the results at 1 year, SG leads to stable weight loss in the long-term follow-up. Furthermore, plasma ghrelin levels, which were significantly reduced in the early postoperative time [11], remained low for a 5-year follow-up. Beside this, 23% of the patients were converted to gastric bypass due to severe reflux or weight regain.

Despite the lack of long-term follow-up data, sleeve gastrectomy has gained an enormous popularity as sole bariatric procedure in the last years based on the encouraging short and intermediate-term results [5–8]. In the early period, SG was performed only in high-risk patients [3, 21, 22] or as the first part in a two-step approach [1–4]. Today, sleeve gastrectomy has joined LAGB, RYGB, bilio-pancreatic diversion (BPD), and BPDDS as bariatric procedure offered not only to selected patients.

In a two-step approach, some weight regain is of no consequence, as SG is primarily performed to achieve some extent of weight loss intended for risk reduction at the second and definitive procedure. In contrast to that, weight regain might limit the success of SG as sole and definitive bariatric procedure. In our series, only three patients had to be converted to gastric bypass exclusively due to inadequate WL in the first 5 years after the procedure, suggesting the SG as a valid and definitive option to achieve stable weight loss. Significant weight regain was limited to five patients (19.2%).

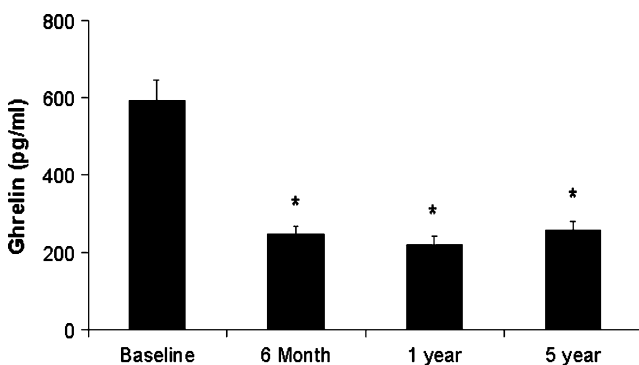


Fig. 3 Plasma ghrelin levels following sleeve gastrectomy. Ghrelin levels decreased significantly after the procedure ($p < 0.05$) and remained stable in non-converted patients for the duration of the follow-up

Although not clear in its definitive role, sleeve dilation was suggested as a possible reason for weight regain [15]. Recently, a computer tomography-based volumetry was presented for accurate assessment of sleeve dilation [23]. Some reports attempting to correct SG dilation by a second resection [24, 25] have suggested this is a viable procedure to tackle weight regain. Comparable to the definitive surgical treatment of gastric banding failure, where conversion from a strictly restrictive procedure to RYGB combining restriction with a mild malabsorption leads to weight loss success [26], we recommend conversion from sleeve gastrectomy to RYGB for weight loss failure.

When defining success of a bariatric procedure by the incidence of weight regain, we would like to emphasize that the incidence of weight regain after Roux-en-Y gastric bypass, as the most commonly performed weight loss operation today, might be underestimated. Only a small number of reports [27–29] focus this topic, presenting significant weight regain in the longer follow-up after RYGB. Thus, weight regain following SG as observed in this study should not be used as an argument against SG as a definitive bariatric procedure.

Beside weight regain, GERD symptoms appeared immediately after SG in the majority of patients. In the study presenting the longest follow-up after SG so far, Himpens et al. [18] compared GERD in 40 patients with laparoscopic gastric banding to 40 patients with sleeve gastrectomy. They found a higher GERD incidence for the SG group (21.8%) at 1 year, but at 3-year follow-up, only one out of 40 patients (3.1%) was still on proton pump inhibitor (PPI) medication. Therefore, reflux would only be temporary after SG.

In contrast to these findings, we observed clinically significant reflux in a large number of patients in this series, as almost a third of the patients were on chronic anti-acid medication after the procedure. Data on pre-procedure pH-metry is non-existing so far. Thus, we have started to assess pH-metry previous to the procedure to all SG candidates to understand the relation to post-op PPI use. The ability to pinpoint patients that will require chronic PPI medication postoperatively could therefore become an option to consider which kind of bariatric procedure is to be performed. Furthermore, we would not recommend performing SG in patients with clinically significant preoperative reflux.

One contribution to the excellent weight loss success after SG might be the changes in the plasma levels of ghrelin. Ghrelin is the only known peripheral hormone so far, inducing food uptake and increasing appetite [30]. As the gastric fundus, known as the main localization of the ghrelin-producing cells [31, 32] is completely resected in SG, less hunger is expected to favor the restrictive effect of the sleeve on food intake.

We found a significant reduction of the plasma ghrelin levels [11] and a correlation between plasma ghrelin levels and the sensation of hunger in the short-term follow-up following SG [12]. The reduction of ghrelin levels after SG was also confirmed by two studies of Cohen et al. [33] and Karamanakos et al. [34].

In this series, ghrelin levels remained low for a period of 5 years afterward. Thus, no compensatory increase was observed in contrast to stable weight reduction. Focusing on plasma ghrelin in weight regain patients, a slightly higher ghrelin was observed, remaining throughout the period of observation, although the small population and high variability deemed the difference not significant. But the definitive role of ghrelin in bariatric surgery remains controversial [35–37].

Taken together, the results support that SG results in stable weight loss, with %EWL found within the range between gastric banding and RYGB [38]. There is some weight regain that can be tolerable, as it also occurs with bypass patients. In case of failure, conversion to gastric bypass or duodenal switch is recommended as exit strategy.

Compared to more invasive procedures that incorporate some degree of malabsorption, vitamin and mineral deficiencies are expected to occur less frequently in the postoperative period after SG as strictly restrictive bariatric procedure. Patients should be monitored for minerals, but supplementation is not an automatic request of the procedure. Especially for vitamin B₁₂, no long-term data for the longer follow-up after SG exist. Thus, mandatory follow-up should include tests for vitamin B₁₂, besides for iron, calcium, and folate.

Compared to RYGB and BPD, the absence of dumping represents a definitive advantage for the patients' quality of life. Most patients in this group have expressed their satisfaction as to the outcome of the surgical procedure, and would repeat it in spite of anti-acid medication. As long-term follow-up for SG becomes increasingly available, further support for this surgical intervention will grow.

Conflict of interest Gerhard Prager has two educational grants: one from Johnson & Johnson and one from Covidien. The other authors have no conflict of interest.

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