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Impact of gastroplasty on salivary characteristics, dental health status and oral sensory aspects: a controlled clinical study

Running title: Gastroplasty, saliva and dental health

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Conflict of interest

The authors declare that they have no conflict of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

Maria Carolina Salomé Marquezin contributed to the conception and design of the study, data collection and analysis. Kelly Guedes de Oliveira Scudine contributed to the interpretation of the results and writing of the manuscript. Elsa Lamy revised the manuscript critically for important intellectual content. Carolina Martins Finassi, Laura Carreira and Wilson Dias Segura contributed to the laboratory analysis of saliva. Irineu Rasera Jr and Elisane Rossin Pessotti were responsible for the study design, resource management and data curation. Paula Midori Castelo contributed to the conception and design of the study, general supervision and was responsible for the statistical analysis of the data. All authors have approved the final article.

Abstract

Background: Saliva is a non-invasive source of biomarkers useful in the study of different pathophysiological conditions. The qualitative and quantitative study of saliva, as well as the assessment of oral health, can be particularly useful for a better understanding of obesity due to its importance in the food oral perception and ingestion.

Objectives: To evaluate the effect of treatment of morbid obesity (dietary counselling *versus* gastroplasty) on salivary characteristics, oral sensory perception and dental health in a controlled study.

Methods: 73 adults (60 females; 19-59 years) with morbid obesity were divided in: Control group (CG; n=34) followed-up during a 6-months dietary program, and Gastroplasty group (GG; n=39) evaluated immediately before, 3, and 6 months after gastroplasty. Dietary habits, Oral Health Impact Profile and xerostomia complaints were investigated by interview. The clinical examination included anthropometric and caries experience evaluation. Salivary flow rate, buffering capacity, total protein and alpha-amylase levels, and sensitivity for the 4 basic tastes were assessed. Two-way mixed model and sign test were applied.

Results: Physical and clinical aspects did not differ between groups in the beginning of the study, and GG showed a rapid weight loss after surgery ($p<0.001$). An improvement in most of the dietary aspects was observed, especially in the GG. A worsening in the dental health status was observed over time in both groups, with an increase in the number of filled and decayed teeth. CG showed a better oral health-related quality of life, while xerostomia complains increased in GG after gastroplasty. Salivary flow rate remained stable in both groups, but a decrease in buffering capacity, total protein, and alpha-amylase activity was observed in GG after 6-months; taste sensitivity increased from baseline to 6-months in GG ($p<0.05$).

Conclusion: After 6-months of follow-up, patients undergoing gastroplasty presented an improvement in dietary habits and taste sensitivity. However, changes in saliva composition and a worsening in dental health status and xerostomia complaints were also observed.

Key-words: Morbid obesity, Oral health, Taste, Saliva

Data availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

BACKGROUND

Saliva is a unique biologic fluid with a large number of properties and functions which are indispensable for both oral and general health. These functions include lubrication of oral mucosa, formation of the food bolus, taste perception, inhibition of dental demineralization, in addition to presenting immunological properties.[1] Salivary secretion is stimulated by taste, chewing, thinking and smell.[2] Nowadays, saliva has also been considered a source of biomarkers of different pathophysiological conditions and a reliable non-invasive alternative to blood.[3,4] Concerning obesity, the role of saliva composition on oral health and nutrition has been little addressed.[5]

Quantitative and qualitative changes in salivary secretion can affect the oral health. In patients with chronic diseases and/or receiving pharmacological treatment, one of the most commonly reported complaints is dry mouth,[6] which has two aspects: xerostomia (subjective) and hyposalivation (objective),[7] which are not always correlated. In younger adults, hyposalivation was associated with BMI>25 (obesity), while in those older than 50 years hyposalivation was associated with medication use.[8] These aspects are of clinical importance, as they can impair masticatory and swallowing functions, consequently influencing quality of life.[9]

The importance of saliva constituents was also described in its involvement in the occurrence and progression of dental caries,[10] which has been recently associated with obesity.[11,12] The salivary buffer capacity, mainly through bicarbonate system, is recognized as an important caries defense mechanism by neutralizing lactic acids produced by plaque bacteria and reducing demineralization.[10] Furthermore, supersaturation of saliva with calcium, phosphate and fluoride allows remineralization of teeth in early stages.[13] The identification of changes in saliva composition and its defense mechanism in patients with obesity is of interest to understand the relationship between dental caries and excess weight. It was reported that overweight and obesity lead to alterations in the concentrations of phosphate, free sialic acid and proteins, and in the peroxidase activity, that is, favorable conditions for the development of dental caries.[14]

Previous studies also suggested that the amount of saliva secretion and subjective oral dryness play a role for taste.[15,16] Therefore, one can expect that changes in saliva composition will result in variations on oral sensory perception and, ultimately, affect the food choice and nutrition. Saliva composition has an influence on the sensitivity to basic tastes and other oral sensations, contributing to both flavour (taste and aroma) and texture perception.[17] Specific salivary proteins have been identified, which are related to individual sensitivity for basic tastes.[18,19] For example, salivary alpha-amylase is involved in carbohydrate digestion and absorption, having a role in the perception of starchy foods.[20] Therefore, the presence of specific salivary proteins increases acceptance for bitter foods that would otherwise be rejected.[21]

Considering the role of saliva in food oral perception and ingestion, the study of this fluid composition can be particularly useful for the study of obesity. However, few studies have been conducted on the biochemical characteristics of saliva in individuals with obesity, and even less information is available about the changes in the composition of saliva as a result of obesity treatment. A previous study showed that the levels of carbonic anhydrase VI and amylase, which have been reported as potentially associated with taste perception, are different between individuals with normal-weight, obesity, and those submitted to gastroplasty; however, the referred study was cross-sectional and included only women.[5] In addition, most research has focused on the relation of salivary parameters and dental caries, and due to the limited information available this study aimed to evaluate the changes in oral health aspects and saliva composition as a result of the treatment of morbid obesity. The hypothesis tested was that the treatment of obesity by means of dietary program or gastroplasty may lead to changes in saliva composition that are linked to both dental health status and oral sensory aspects.

MATERIALS AND METHODS

Study design

This is a controlled clinical study approved by the Ethical Research Committee of the Federal University of São Paulo (Protocol No. 1201/2017) and registered in the Brazilian Registry of Clinical Trials (Rebec / TRIAL: RBR-2NJHWN). All the participants read and signed an informed consent form to take part in the study in accordance with the Declaration of Helsinki.

Sample

The study included a convenience sample of 73 adults, aged between 19 and 59 years with morbid obesity in the Bariatric Clinic of Piracicaba (SP, Brazil), between the years 2018 and 2019. Of them, 60 were females.

The inclusion criteria were individuals with morbid obesity (BMI of 40 Kg/m^2 or higher) of both sexes, with at least 20 natural teeth or who use dental prosthesis. The exclusion criteria included conditions that are known to affect salivary characteristics: individuals presenting epilepsy, cancer, rheumatoid arthritis, bucco-dentofacial diseases or traumas, tobacco use, illicit drugs, Sjögren's syndrome, systemic lupus erythematosus, sarcoidosis, alcoholic beverage, and extensive tooth loss. [21,22]

The sample consisted of patients who were candidates for gastroplasty, allocated into two groups according to the stage of treatment. The Control group (CG; n=34) included participants who were followed-up during a 6-months dietary program prior to gastroplasty, and were evaluated at baseline, and 3 and 6 months later; the Gastroplasty group (GG; n=39) included other participants who also participated in a 6-months dietary program and were evaluated three times: immediately before, and 3 and 6 months after the gastroplasty. Thus, both groups were evaluated three times: at baseline, 3 months, and 6 months of follow-up. Table 1 shows the description of the sociodemographic characteristics of the clinical groups and Figure 1 provides more details on group follow-up.

The individuals in the Control group attended meetings with a nutritionist and received guidance for changing eating behavior and routine organization, including low-calorie food planning, aiming at the adoption of new and healthier eating habits and weight loss. There were no dietary restrictions, but it was advisable to stop the consumption of alcoholic and carbonated drinks, sugary and fatty foods, and related preparations. Counseling was provided during the meetings through exhibition lectures, open to questions and testimonies of individual adaptations and/or difficulties encountered. Regarding physical activity, it was reinforced the importance of physical exercises under medical supervision, who would provide the best indication given the physical and health limitations.

The Gastroplasty group also participated in the 6-months dietary program, which is mandatory before gastroplasty. This group was submitted to the Vertical Roux-en-Y Gastroplasty, a mixed procedure (restrictive and malabsorptive) in which the remaining stomach and the first segment of small intestine are bypassed, thus reducing the space for food; in addition, the participants were encouraged to change their lifestyle habits to favor weight loss and control of associated diseases, such as high blood pressure and diabetes, guided by a multidisciplinary team. In the preoperative period, patients consumed a liquid diet for 3 days; in the postoperative period, patients received a liquid diet for 20 days and, further, a pasty consistency diet for 15 days; the solid consistency diet was introduced 35 days after the surgical procedure. Participants received counseling to adapt eating behavior and routine organization to cope with the difficulties encountered with the new reduced food reservoir and rapid weight loss.

The sample size was calculated considering the results found by Lamy et al. (2015) who found greater levels of salivary alpha-amylase in women with morbid obesity compared to ones who were submitted to gastroplasty in a cross-sectional design study.[5] Considering a 95% confidence and a power of 80%, and the minimum sample size to detect a difference of that magnitude and adopting a normal distribution, a minimum of 30 participants per group was required.

Anamnesis and interview

Data collection was performed by means of a structured questionnaire applied during an interview (for more details, please see Marquezin et al., 2020).[24] The following data were investigated: date of birth, age, declared ethnic group (black/white/mixed), marital status, educational level, family income, weight, height, use of chronic medications and any diseases or health conditions (hypertension, diabetes mellitus, dependent insulin), in addition to dental history.

The assessment of dietary habits was performed using a brief questionnaire proposed by the Brazilian Ministry of Health (Brazil, 2015),[25] which identifies the eating behavior and the consumption of healthy foods like fruit, vegetables, meat and beans, and unhealthy foods such as sausages, artificial juices, soft drinks, instant noodles, cookies, snacks and sweets (processed and ultra-processed food). Participants answered questions regarding the consumption of these items in the day before interview (yes/no). Questions also covered the habit of watching TV, using the computer and/or cell phone during the meal and the number of meals per day (day to day).

The Brazilian-validated version of the Oral Health Impact Profile (OHIP-14) was applied during the interview and provided a comprehensive measure of the self-reported dysfunction, discomfort and disability attributed to the oral condition.[26] This scale consists of 14 items divided in 7 domains (functional limitation, pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap). For each OHIP-14 item, participants were asked how frequently they had experienced the impact of that item. Responses were made on a 5-point Likert scale: 0 “never,” 1 “hardly ever,” 2 “occasionally,” 3 “fairly often,” 4 “very often.” OHIP-14 total scores, ranging from 0 to 56 points, were obtained by summing the responses on all 14 questions. Higher scores imply poorer oral health-related quality of life and thus, lower satisfaction, as described earlier.

Xerostomia was measured using the Portuguese version of Xerostomia Inventory XI.[27] Items were scored on a five-point unidirectional rating scale that rated the frequency of experiencing dry mouth symptoms from “Never” to “Very often”. The scores range from 11 (no xerostomia) to a maximum of 55 (severe xerostomia).

Clinical examination

Physical examination was carried out at the clinic by a trained examiner (MCSM) and assessed measures of body mass index (BMI Kg/m^2), waist, and hip circumferences. Waist circumference was measured to the nearest centimeter between the iliac crest and the lower rib and hip circumference is measured at the height of the largest horizontal diameter.[27] All measurements were performed twice with a one-minute interval between two measurements and the mean was considered as the final value.

The oral examination was also performed at the outpatient clinic, in a dedicated room by a trained researcher (MCSM), using a clinical mirror, probe and mouth retractors, according to the World Health Organization recommendations.[29] The decayed, missed and filled permanent teeth (DMFT) index dental health exam was performed by a dentist previously trained and calibrated by a gold standard examiner (Kappa coefficient=0.97). During the follow-up period, counselling was provided on preventive measures to improve oral health and control of biofilm, and the participant was referred for dental treatment when necessary.

Evaluation of salivary parameters

Unstimulated saliva was collected from participants at baseline, and 3 and 6 months of follow-up using the drainage method for 5 minutes into a cooled tube, in the morning, with all of them having refrained from eating, drinking or brushing their teeth for a minimum of 2 h before collection for the purpose of measuring total protein and alpha-amylase concentrations. Stimulated saliva was collected by chewing on 0.3 g of an inert and tasteless material (Parafilm, Merifeld, USA) for the purpose of measuring flow rate and buffering capacity, as described in Freitas et al. (2017).[30] A cut-off of 0.7 mL/min was used to classify individuals with reduced stimulated salivary flow. [31]

Total protein was determined by the Bradford method in duplicates and Elisa microplate reader, using a wavelength of 595 nm and standard curve with 6 points (Bio-Rad Protein Assay, No. 500-0008, Biorad Lab., USA). Salimetrics® kit was used to determine the enzymatic activity of salivary amylase according to the manufacturer’s recommendations, as previously described.[32] Saliva samples were diluted and applied on the microplate in duplicate, followed by application of a substrate (2-chloro-p-nitrophenol) preheated to 37°C. The plate was read at 405 nm and 37°C in a plate reader spectrophotometer, every minute for 5 minutes. The delta absorbance between 1 and 3 minutes was considered in the formula used to calculate the final concentration.

Taste sensitivity

The evaluation of taste sensitivity was performed just after the saliva collection using an adaptation of the three-drop-method, which originally uses 4 concentrations of each basic tastes (salty, sweet, sour and bitter).[33] In this study, only the lowest concentration of each stimuli was tested, which is near to the limit threshold: salty - sodium chloride (0.016 g/mL), sweet - sucrose (0.05 g/mL), acid - citric acid (0.0125 g/mL), bitter - quinine hydrochloride (0.0001 g/mL), administered in a dropper (three drops) on the back of the tongue, being 1 drop of the tastant solution and 2 drops of distilled water

The order of presentation of the tests was drawn for each individual. The participant should choose, for each of the tests, one of the four options: sweet, salty, bitter or acid (sour), with no time limit for the test (forced choice). Between each test, individuals were instructed to rinse their mouths with mineral water to avoid residual taste that could confuse them. For each test correctly identified, the participant received 1 point (maximum of 4 points).

Statistical Analysis

Statistical analysis was performed using SPSS 27.0 software considering an alpha level of 5% by an Applied Statistics Spec (PMC). The hypotheses of the study and the analytic plan were specified before the data were collected. Descriptive analysis consisted of means, standard deviation, median and percentages. Normality was checked using the Shapiro-Wilk test; non-normal distribution variables were transformed using the natural logarithm, when necessary. No data imputation or elimination was performed.

A general linear model – Two-way mixed model ANOVA - was used to test the effects of within-subjects factor (time: baseline, 3 and 6 months) and the between-subjects factor (group: Control and Gastroplasty) and the interaction time*group in the observed variance of anthropometric measures, DMFT index, OHIP-14 and Xerostomia XI scores, and salivary parameters (considered as dependent variables). The effect size (partial *Eta* squared) and the power of the test for each model were also obtained. The results of the Box's test, Mauchley's sphericity test and Levene's equality of variances test were evaluated as assumptions; when necessary, the Huynh-Feldt correction was applied. One-way ANOVA repeated measures was applied to confirm the differences between time-points. Outliers were considered when the studentized residual was greater than ±3 SD.

The sign test was used to determine the median difference between paired ordinal data of taste scores.

RESULTS

A total of 73 individuals with morbid obesity were included in this controlled clinical study. As shown in Table 1, the two groups showed similar sociodemographic characteristics, and included patients who sought treatment at the Bariatric Clinic; no other sociodemographic difference between participants existed, other than the treatment they received during the study: the 6-month dietary program prior to gastroplasty or the gastroplasty.

The physical and clinical aspects did not differ between groups at the beginning of the study ($p>0.05$). The anthropometric measurements of BMI and waist, abdomen, and hip circumferences significantly changed overtime in the Gastroplasty group as a consequence of the surgical procedure, confirming the rapid weight loss, while in the Control group the measurements of waist and abdomen were relatively stable and the BMI decreased about 1 point as a result of the dietary program, as shown in Table 2.

However, an increase in the DMFT index was observed over time in both groups, with an increase in the number of filled teeth in both groups and in the number of decayed teeth in the Control group (Table 2).

The evaluation of the oral health impact profile (OHIP-14) showed that while the Control group showed a decrease in the OHIP-14 scores, the scores of the Gastroplasty group remained stable overtime (Table 3); a closer look at the scale showed that the aspects that contributed most to this difference in the Control group were "Feel embarrassed with problems with teeth/mouth/denture" and "Feel that life was less satisfying because of problems with teeth/mouth/dentures", that improved over time.

Xerostomia complains decreased in the Control group from baseline to 6-months of follow-up, while they increased in the Gastroplasty group after 3-months of the surgery procedure. In the Control group, the question that contributed most to this result was "I sip liquids to aid in swallowing food", showing a change in the behavior of drinking while eating. In the Gastroplasty group, the perception of dry skin and dry lips increased at 3 months.

Stimulated salivary flow rate, buffering capacity, total protein concentration and alpha-amylase activity did not differ between groups at baseline ($p>0.05$). Additionally, 18% of the sample were considered as having hyposalivation (7 out of 39 individuals for the Gastroplasty group and 6 out of 34 for the Control group). While the salivary flow rate remained relatively stable over time in both groups a significant decrease in the buffering capacity was observed in the Gastroplasty group with a large effect size (Figure 2; $p=0.010$; *Eta* partial^2=0.173; power=74%). In addition, a decrease in total protein concentration was observed between 3 and 6 months ($p=0.019$; *Eta* partial^2=0.13) in the Gastroplasty group and a decrease in alpha-amylase activity was observed after 6 months of follow-up with a large effect size ($p=0.029$; *Eta* partial^2=0.14) (Table 3).

Concerning the dietary and eating behavior changes overtime, a trend to an improvement in most of the dietary aspects investigated is notable, such as avoiding the use of distractors during meals (both groups), higher percentages for the consumption of beans, fruit and vegetables (Gastroplasty group), lower percentages for the consumption of processed meat and sugary drinks (Gastroplasty group), and lower percentages for the consumption of sweets (Control group), as shown in Table 4. However, the number of positive responses for the consumption of sweets increased in the Gastroplasty group. In addition, during the 6-months of follow-up, the mean number of meals increased in both groups: in the Control group, the means were 3.1, 3.4, and 3.8, and in the Gastroplasty group the means were 3.6, 4.5, and 4.3 at baseline, 3 months, and 6 months of follow-up, respectively ($p<0.05$; ANOVA repeated measures).

The evaluation of taste sensitivity showed that the percentage of correctly identified tastants increased in the Gastroplasty group for all tastes; in the Control group the percentages for sweet and bitter increased, while for sour and salty tastes they remained stable (Table 4). The overall taste score increased significantly from baseline to 6-months follow-up only in the Gastroplasty group (Sign test; $p=0.041$).

DISCUSSION

In the present study, gastroplasty was effective for rapid weight loss and reduction of anthropometric measurements already 3 months after surgery which continued until 6 months of follow-up however, changes in salivary composition and dental health resulted in an increase in the number of caries lesions and xerostomia complaints, as well as changes in buffering capacity after the surgical procedure.

Regarding dietary habits and eating behavior, an improvement in most of the investigated food aspects was observed, especially for the Gastroplasty group. The benefits of dietary advice and pre-operative weight loss include the education in postoperative dietary restrictions, the reduction of perioperative morbidity and the reduction of liver size and operating room time.[34,35] As the most frequent cause of failure in gastroplasty surgery is due to unhealthy eating behavior and the compulsion for palatable foods that might be present before the surgery,[36] it is important to assess and identify the different eating behaviors and continue to encourage change in eating habits. Additionally, the use of distractors (television, computer or cell phone) during meals decreased in both groups, which is also a positive aspect since this habits influence the amount of calories consumed.[37]

The assessment of taste sensitivity showed that the percentage of correct taste recognition increased in the Gastroplasty group for all basic flavors. This finding is especially important since gustatory perception can influence satiation and food choices. Interestingly, a study by Bond et al. found that individuals with morbid obesity presented a delay in sensory perception when facing a gustatory stimulus compared to individuals with normal weight, which suggests that in candidates for gastroplasty, satiety may be impaired and possibly leading to increased energy intake.[38] Corroborating these findings, a recent systematic review concluded that taste sensitivity to sweet and fatty stimuli increase in the post-operative stage.[39] The increased sensitivity to taste may explain, in part, post-operative changes in food choices reported by patients with obesity following surgery.

Nonetheless, the positive changes in dietary and eating behavior prior to and after gastroplasty were concomitant to a worsening in dental health status, as observed by the increase in DMFT index in both groups, which reflects the increase in the number of carious lesions and the subsequent restored teeth, as the patients were instructed to sought dental treatment during the follow-up period when necessary. This result can be explained by the increase in the frequency of meals and sweets consumption, as both are recognized risk factors for caries development.[11,40] Dental caries is a multifactorial disease highly associated with the intake of fermentable carbohydrates, mainly sucrose. Many bacteria involved in dental biofilm formation can metabolize fermentable carbohydrate generating acid byproducts that can lead to pH drop and demineralization of the tooth structure. The period of critically lowered pH needed for demineralization to occur is mainly a function of the type and frequency of carbohydrates consumed.[10] Increasing the frequency of meals can be a natural compensatory reaction to the alteration in the anatomy of the gastrointestinal tract after gastroplasty surgery;[41] however, it can cause more demineralization episodes and increase the risk of dental caries.

A significant decrease in buffering capacity in the Gastroplasty group may also have contributed to the increase in DMFT index and the higher number of restored teeth observed after surgery. Studies have demonstrated that several constituents (mainly fluoride, calcium, and phosphate) and properties of saliva could affect the caries process.[42] The buffering capacity is considered of particular importance in the de- and remineralization dynamic. In line with this result, a clinical prospective study showed that at 12 months after gastroplasty surgery, increased episodes of vomiting and dental hypersensitivity were associated with the reduction in the saliva buffering capacity of 21.3 %.[43] In this case, aside from the frequent intake of sugars, the acid oral environment resulted from the vomiting episodes could alter the oral microbiota and the pH, leading to a reduction in the buffering capacity of saliva and, consequently, facilitating the development of carious lesions in patients subjected to gastroplasty. Other negative outcomes of gastroplasty have also been reported, such as periodontal disease,[44] hyposalivation, tooth sensitivity, and halitosis.[45,46]

In the Gastroplasty group, a decrease in the concentration of salivary total protein was observed over time, which corroborates the results of a cross-sectional study that found differences in the concentrations of total protein and salivary amylase between women with morbid obesity and who had been subjected to gastroplasty.[5] A possible explanation would be that morbid obesity alters the function of the submandibular and parotid glands in the synthesis and/or secretion of proteins. In this line, the activity of alpha-amylase was also shown to be reduced in the saliva of patients subjected to the gastroplasty surgery. Salivary alpha-amylase can modulate cariogenic bacterial colonization and is related to a reducing in the level of these microorganisms, consequently reducing the risk of developing dental caries lesions.[47] In agreement with these results, a negative association between dental caries and alpha-amylase activity has been reported, and children who showed salivary alpha-amylase activity lower than 122.8 U/mL had 3.3 times greater risk of developing early childhood caries than their counterparts.[48]

Alpha-amylase is also involved in oral sensory perception, namely in sweet taste sensitivity[19] or in the perception of starchy foods.[20] In animal models, it was observed that the induction of changes in the levels of specific salivary proteins results in the acceptance of foods that would otherwise be rejected.[21] Thus, it can be expected that qualitative and quantitative changes in the composition of saliva may have an influence on the digestion, oral sensory perception and taste sensitivity and, consequently, affect the food choice and nutrition. These findings open new avenues of research by highlighting the association between salivary composition, dental health status and taste sensitivity related to the treatment of obesity, which are usually studied independently.

Of the 73 participants with morbid obesity, 18% showed reduced stimulated salivary flow at baseline. Although salivary flow was stable over the follow-up period in both groups, xerostomia complaints increased in the Gastroplasty group 3 months after the surgical procedure, with predominant participation of symptoms of dry skin and lips. While the self-perceived oral health did not change over time in the Gastroplasty group, an improvement was observed in the Control group after 6 months of follow-up; the questions that contributed most to this difference in the Control group were "Feel embarrassed with problems with teeth/mouth/denture" and "Feel that life was less satisfying because of problems with teeth/mouth/dentures", that is, issues related to self-esteem. It is possible that the inclusion of the control participants in the dietary program and the sessions of counselling they received may have contributed to a better self-perception of oral health, such as a 'positive reinforcement' effect. However, in a Swedish study that used a questionnaire mailed to patients 2 years after bypass surgery, most participants reported problems with their oral health, especially difficulty chewing and tooth hypersensitivity.[49] As the Gastroplasty group showed changes in salivary composition and symptoms of dry mouth, as well as a greater number of decayed and restored teeth, the changes in oral health-related quality of life may only be perceived in the long-term.

A strength of the present study was the choice of validated methods widely used in the scientific literature to assess dental health status. The DMFT index has the advantage of indicating both current and past caries experience, allowing the appropriate assessment of individual aspects under adapted conditions the dental clinic (as in the present study).[50] However, it has inherent problems since it gives an equal weight to decayed, restored and missing teeth and has less sensitivity to detect caries lesions at an early stage and risk assessment to generate prevention.[51] In addition, the present study has a longitudinal design, which allowed us to propose causative inferences. An important limitation that should be mentioned is the short follow-up, which comprised six months.

Obesity and dental caries are prevalent diseases with multifactorial etiology related to food intake that share common influences, such as dietary, genetic, socioeconomic and behavioral factors.[52-55] Gastroplasty leads to rapid weight loss with a positive effect on the treatment and/or control of comorbidities; however, based on the results found, the maintenance of educational and preventive measures in oral health is of importance to the success of treatment and to control the side-effects related to oral health. Thus, the findings of this study emphasize the need for greater attention to the oral and dental aspects of individuals subjected to gastroplasty in order to monitor the possible oral manifestations related to changes in salivary composition and eating habits, and a longer follow-up time is also necessary to know whether these changes will continue over time and how they will impact the oral health status and nutrition.

CONCLUSION

After 6-months of follow-up, patients undergoing gastroplasty presented an improvement in dietary habits and taste sensitivity. However, changes in saliva composition and a worsening in dental health status and xerostomia complaints were also observed.

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Table 1. Description of the sociodemographic characteristics of the clinical groups

		Control group	Gastroplasty group
	n	34	39
Age (years)	*Mean (±SD)*	38.9 (9.5)	34.6 (8.4)
Females	*n*	27	33
Declared ethnic group (black/white/mixed)	*n*	9/19/6	5/22/12
Marital status (married or cohabiting couple)	*%*	69	44
Schooling (>8y)	*%*	94	100
Income (number of min wages)	*Mean*	2.2	2.2
Diabetic patients	*n*	5	8
Insulin users	*n*	1	2

Table 2. Clinical characteristics of the control (CG) and gastroplasty group (GG) at baseline and 3-6 months of follow-up: a Two-way ANOVA Mixed model

	BMI (Kg/m2)	**Waist (cm)**	**Abdomen (cm)**	**Hip (cm)**	**DMFT index**	**Decayed teeth**	**Missed teeth**	**Filled teeth**
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
CG baseline	45.5 (6.6)	117.6 (13.4)	134.0 (15.1)	138.0 (12.8)	10.5* (7.1)	0.6* (0.9)	2.8 (4.3)	7.1* (5.2)
CG 3 months	44.6 (6.5)	116.4 (12.1)	134.8 (14.9)	136.9 (12.5)	11.2 (6.9)	0.9 (0.9)	2.8 (4.3)	7.5 (5.0)
CG 6 months	44.3 (6.6)	117.0 (13.4)	134.1 (15.7)	137.9 (12.4)	11.2* (6.9)	0.9* (1.0)	2.8 (4.3)	7.6* (5.0)
GG baseline	47.9^{A} (9.8)	127.3^{A} (18.4)	138.6^{A} (18.4)	145.8^{A} (16.0)	10.3* (6.6)	0.5 (0.9)	3.2 (4.6)	6.6* (4.9)
GG 3 months	39.3^{B} (8.2)	106.5^{B} (12.6)	124.5^{B} (18.1)	130.4^{B} (14.7)	10.5 (6.9)	0.3 (0.5)	3.3 (4.8)	6.9 (5.3)
GG 6 months	36.0^{C} (8.0)	100.2^{C} (11.7)	115.2^{C} (18.9)	122.8^{C} (14.6)	10.8* (7.0)	0.5 (0.9)	3.3 (4.8)	7.1* (5.2)
Two-way Mixed ANOVA *(p-value)*								
Time effect	<0.001	<0.001	<0.001	<0.001	**0.011**	0.391	0.938	**0.027**
Group*time effect	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.461	**0.016**	0.267	0.825

BMI, body mass index; DMFT index, number of decayed, missed and filled teeth.
A≠B≠C (p<0.001; group*time effect, Anova Mixed model)
* p<0.05 (One-way ANOVA repeated measures)

Table 3. Oral health perception, xerostomia complaints and salivary characteristics of the control (CG) and gastroplasty group (GG) at baseline and 3-6 months of follow-up: a Two-way ANOVA Mixed model

	OHIP-14 total score	Xerostomia XI total score	Salivary flow rate (mL/min)	Buffering capacity	Total Protein (µg/mL)	Alpha-amylase activity (U/mL)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
CG baseline	12.4* (12.5)	14.9* (7.5)	1.3 (0.5)	4.5 (1.2)	758.6 (443.1)	57.4 (44.3)
CG 3 months	12.0 (11.6)	11.4* (7.2)	1.2 (0.6)	4.5 (1.2)	897.4 (477.9)	62.9 (45.8)
CG 6 months	7.8* (8.4)	12.4 (8.8)	1.2 (0.6)	4.4 (1.0)	804.9 (415.9)	68.3 (51.5)
GG baseline	13.1 (14.0)	14.6* (8.0)	1.0 (0.4)	4.3* (0.9)	767.1 (470.4)	42.9* (30.5)
GG 3 months	14.3 (15.6)	16.9* (8.9)	0.9 (0.3)	3.9 (0.9)	784.1* (442.1)	34.5 (31.3)
GG 6 months	14.0 (15.1)	14.5 (8.1)	1.1 (0.4)	3.7* (1.4)	647.1* (533.9)	31.1* (22.6)
Two-way Mixed ANOVA *(p-value)*						
Time effect	0.101	0.393	0.469	**0.030**	**0.045**	0.691
Group*time effect	**0.041**	**0.008**	0.070	0.071	0.139	**0.023**

OHIP-14, Oral health impact profile.
* p<0.05 (One-way ANOVA repeated measures)

Table 4. Percentages of correctly identified tastants and frequency (%) of positive answers regarding the consumption of items in the day before interview and behavior (use of TV/PC/Cell phone) (Food consumption markers in primary health care; Brazilian Ministry of Health, 2015), according to group and follow-up

	Gastroplasty group			Control group		
	baseline	**3 months**	**6 months**	**baseline**	**3 months**	**6 months**
Sweet tastant	85	77	94	85	81	92
Sour tastant	85	82	94	85	85	85
Salty tastant	82	85	88	92	92	92
Bitter tastant	82	79	85	58	85	81
Overall taste score (median)	3	3.5	4	3	4	4
TV/PC/Cell phone	73	72	64	75	54	62
Beans	55	52	64	60	65	56
Fruit	49	73	64	48	58	46
Vegetables	66	76	73	73	73	72
Processed meat	42	19	36	28	44	27
Sugary drink	73	27	42	58	77	58
Noodle/salty snack	27	15	30	32	23	23
Sweets	39	24	56	58	39	36

FIGURE CAPTION

Figure 1. Flowchart of sample allocation in groups and follow-up.

Figure 2. Measures of buffering capacity overtime (estimated means and 95% confidence interval; Log transformation). A significant decrease was observed overtime in the Gastroplasty group ($p=0.010$; *Eta* partial$^2=0.173$; power=74%; One-way ANOVA repeated measures).

FIGURES

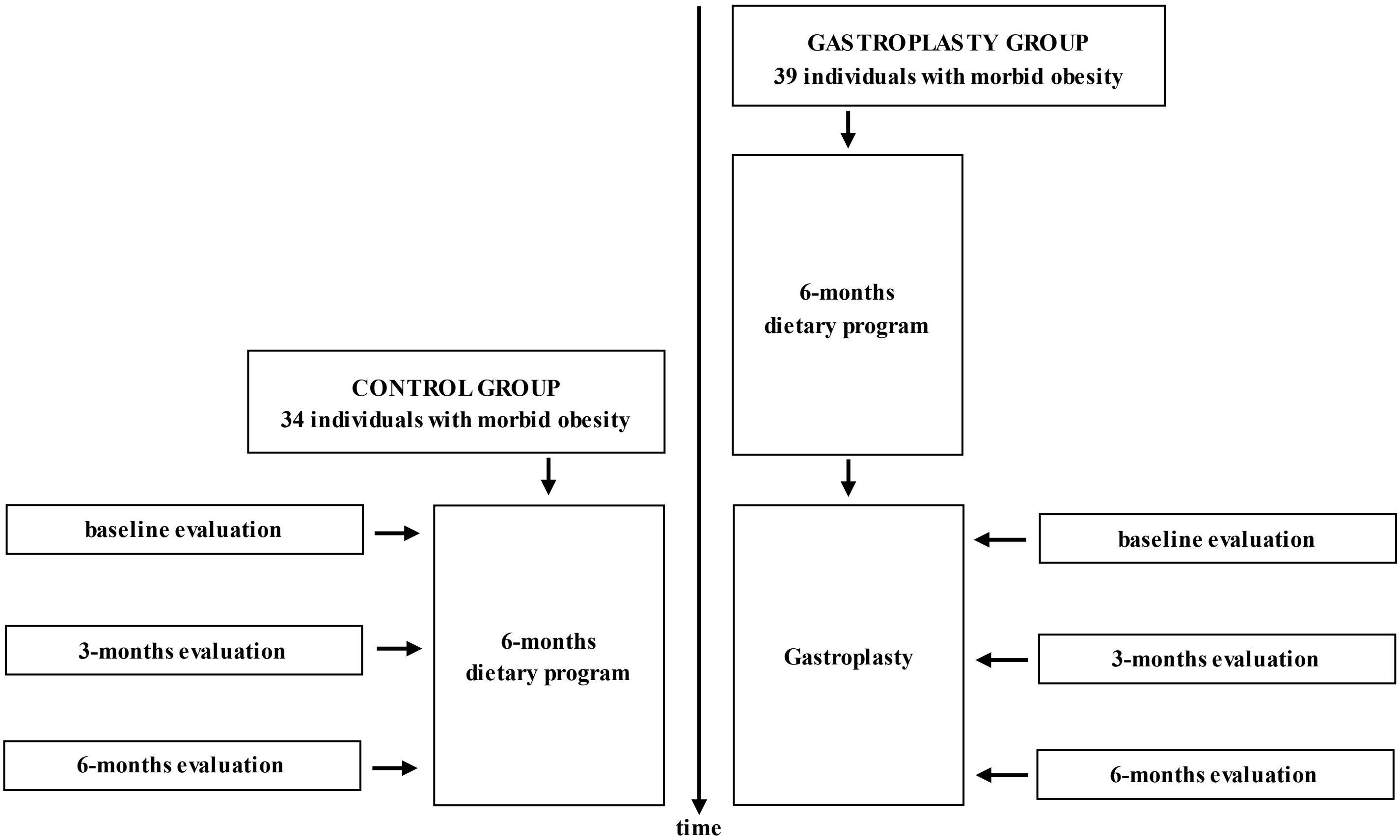
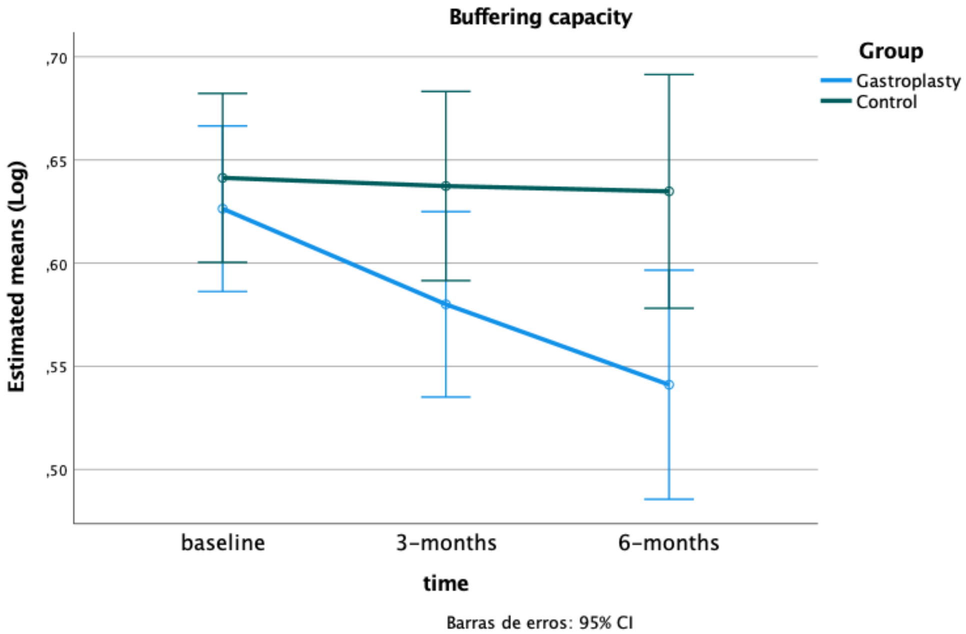


Figure 1. Flowchart of sample allocation in groups and follow-up.


Buffering capacity
Group
Gastroplasty
Control
,70
,65
,60
,55
,50
Estimated means (Log)
baseline
3-months
6-months
time
Barras de erros: 95% CI