Association between bariatric surgery and oral health: a literature review

Associação entre cirurgia bariátrica e saúde bucal: uma revisão de literatura

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Abstract

Objective: to review the literature on the relationship between oral health and bariatric surgery in obese individuals. Methods: articles published until March 2021 were searched in the Medline/PubMed, LILACS, BBO, and Web of Science databases. The search used a combination of descriptors related to the words: obesity, bariatric surgery, and oral health. Results: one hundred thirty-five studies were identified in the database search. Of these, 47 were included in this review. The oral changes investigated in the literature for individuals who underwent bariatric surgery were dental caries, tooth wear/erosion, hypersensitivity, periodontal disease, hyposalivation, halitosis, and changes in mastication and oral soft tissue. The evaluated articles showed methodological controversy regarding the study design, follow-up period, sample size, and assessed clinical parameters, which complicated the comparison of studies. Final considerations: there is no consensus in the literature regarding the relationship between oral health and bariatric surgery in obese individuals. Further prospective cohort studies should be conducted to investigate this association better.

Keywords: obesity; bariatric surgery; oral health; dental erosion; dental caries.

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Introduction

Obesity is a form of malnutrition associated with many health problems that cause considerable morbidity and mortality[1-4]. Its prevalence has steadily increased in developed countries since the early 1980s and developing countries since the 1990s[5].

Bariatric surgery (BS) has emerged as an effective treatment for morbid obesity (≥40 kg/m^2)[3,6] and, depending on the type of anatomical changes in the gastrointestinal tract, may affect appetite, eating behavior, glucose homeostasis, and lipid metabolism[3]. Malnutrition, anemia, vitamin and mineral deficiencies (iron, copper, calcium, folic acid, vitamin B_1, vitamin $B_{12,}$ and vitamin D), food intolerance, gastroesophageal reflux, nausea, vomiting, and dehydration, among others, are also often verified[1,4,7-9].

The oral cavity is part of the digestive system; therefore, adverse effects of BS may reflect on the oral cavity[4]. Dental caries, periodontal diseases, dentin hypersensitivity, dental erosion, and xerostomia have been reported[4,7,10-12]. However, Cardozo *et al*.[13] (2014) described oral health improvements in patients undergoing BS.

Systematic reviews on this topic have been published in search of evidence and found that patients undergoing BS presented a higher prevalence of tooth wear[14,15] and deterioration of the periodontal status after the surgery[16,17], but one review did not find differences[18]. The risk of dental caries could be higher after BS[19] because of the salivary flow rate, but the findings did not suggest significant changes[20]. A literature review including an overview of the topic is essential to update multi-professional teams because of the high amount of data.

This study aimed to review the literature on the relationship between oral health and BS in obese individuals.

Materials and methods

An electronic search of articles published until March 2021 was performed in the Medline/PubMed, LILACS, BBO, and Web of Science databases. The review included all study designs, and there were no language restrictions. The keywords were searched in DeCs and MeSH. Keywords and free-text terms were used in the following search strategy, in either titles or abstracts: (obesity OR obes* OR "body weight" OR overweight OR BMI OR "body mass index" OR "morbid obesity" OR "morbidly obese") AND ("bariatric surgery" OR gastroplasty OR bariatric* OR "gastric bypass" OR "bariatric surgery procedure") AND ("oral health" OR "dental caries" OR "dental decay" OR "tooth decay" OR "dental erosion" OR "tooth erosion" OR "periodontal disease*" OR gingiv* OR periodont*). The search strategy was customized as appropriately before being applied to each database. A manual search was also performed to identify other studies not found in the searched databases. The articles were selected according to their titles and abstracts, and the full articles were assessed.

Results

The search resulted in 135 studies. After applying the exclusion criteria, 47 studies were selected (Figure 1).

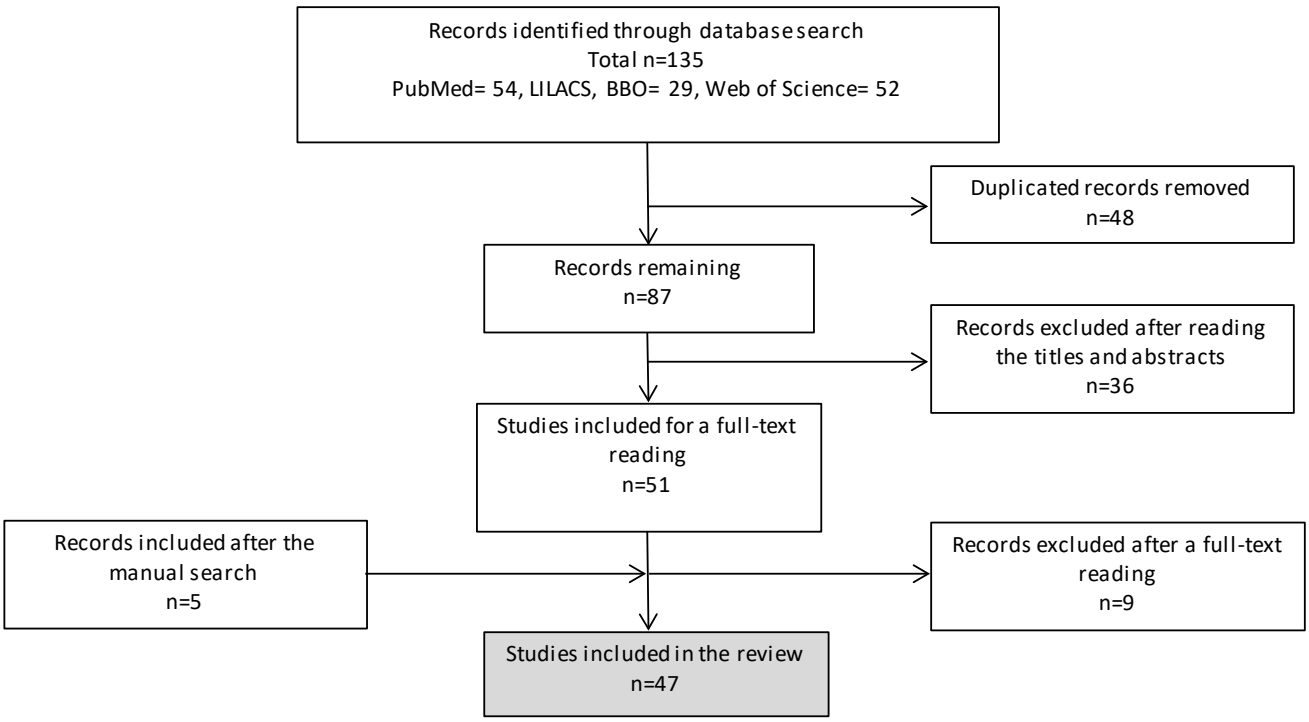

Figure 1 – Flowchart of the search results

Source: elaborated by the authors.

The year of publication ranged from 2000 to 2021 (Figure 2), with the most manuscripts published in 2012 and 2020. Regarding the study design, of the 47 studies included in this review, there were eight systematic reviews, two clinical trials, 11 prospective cohorts, two cross-sectional and prospective cohorts, three case-controls, seven cross-sectional studies, one case series, eight case reports, and five literature reviews.

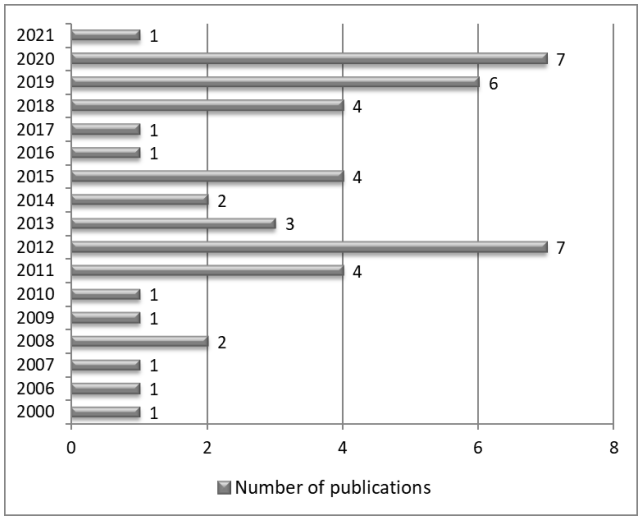

Figure 2 – Manuscript distribution according to the year of publication

Source: elaborated by the authors.

The studies addressed the following oral health topics in descending order of the number of studies: periodontal disease, salivary flow rate, dental caries, dental erosion, hypersensitivity, changes in the oral soft tissue, halitosis, and masticatory function (Figure 3). Table 1 presents a summary of the included studies.

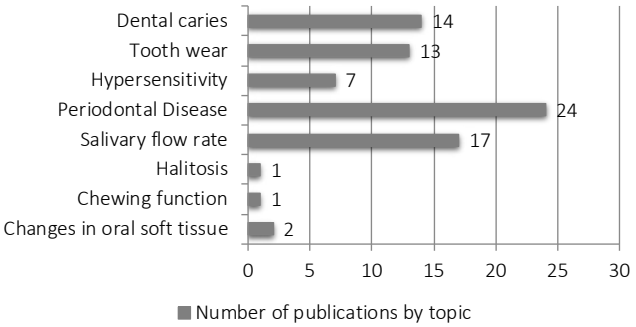

Figure 3 – Number of publications addressing oral health topics

Source: elaborated by the authors.

Table 1 – Characteristics of the included studies

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Author, year, country, study design	Objective	Sample characteristics	Methods	Main findings
Greenway and Greenway, 2000[23], United States, **Case-control**	To confirm the association of root surface caries with JI bypass and explore the mechanisms by which it occurs.	Phase I: 18 underwent BS (average of 10 years later), and five control patients. Phase II: n=8, four underwent BS 25 to 30 years earlier, and four healthy controls. Type of surgery: JI bypass.	Phase I: Patients were asked the number of root surface cavities they had experienced per year after BS and an equal time before BS. Stimulated saliva for measuring chloride level, bicarbonate level, and pH. Phase II: three 2-minute saliva samples stimulated for measuring volume.	Root surface caries are more prevalent after JI bypass ($p<0.01$). This may be due to decreased saliva flow ($p<0.02$) and a reduced salivary buffering capacity ($p<0.05$).
Heling *et al.*, 2006[7], Israel, **Cross-sectional**	To investigate the self-assessment of bariatric patients regarding their dental health status.	n=113 (underwent BS 1-10 years earlier), 21-66 years old, type of surgery: SRVG or LAGB.	Mailed questionnaire.	Vomiting was a typical phenomenon after BS (79%); 37% reported higher DH after BS. There were significant associations between reported DH and vomiting ($p=0.013$) and between DH and indigestion ($p=0.021$).
Archer-Dubon *et al.*, 2007[54], Mexico, **Case report**	To report the unusual case of a patient who developed bilateral palatal ulcers after intense vomiting caused by gastric band tightening.	55-year-old woman underwent LAGB.	Oral clinical examination. An upper gastrointestinal series and panendoscopy. Biopsy and cultures of palatal ulcers. Routine laboratory analyses.	The patient developed extensive palatal ulcers after intense vomiting due to severe gastric pouch outlet occlusion caused by gastric band over-tightening. The diagnosis was traumatic ulcers. Healing the ulcers, the remission of vomiting and nausea, and the production of a protective palatal denture were required. At three weeks, the ulcers had healed completely.
Mandel and da Silva, 2008[53], United States, **Case report**	To describe a patient who engaged in self-induced vomiting after BS performed 26 years earlier.	44-year-old woman underwent BS 26 years earlier.	Clinical examination stimulated right and left parotid salivary volumes measured with a Carlsen-Crittenden collector and a computed tomography scan of parotid glands.	Chronic stimulation from constant multiple emetic episodes over 25 years could have caused parotid hypertrophy. The diagnosis was vomiting-induced parotid hypertrophy.
Hangue and Baechle, 2008[10], United States, **Case report**	To describe a patient with a significant increase in dental caries after gastric bypass surgery.	48-year-old woman underwent RYGB 5 years earlier.	Oral examination, dental radiographs, PI, and salivary test (stimulated and resting salivary flow rates, pH, and buffering capacity). Dietary, bacterial, and salivary risk assessments.	Saliva production was low, with a very low buffering ability and high PI and cariogenicity, and caries activity increased after surgery. It supports the hypothesis that bariatric patients may be at an increased risk of dental caries.
Gonçalves *et al.*, 2010[34], Brazil, **Cross-sectional**	To evaluate the oral health of patients submitted to the surgical procedure.	n=30 (underwent BS ≥6 months earlier), 19-64 years old.	Questionnaire via interview and oral examination to investigate the periodontal condition (GBI, PSR), caries (DMFT), and saliva flow rate.	DMFT: 9.9 ± 6 teeth, the presence of periodontal pockets (30%) and dental erosion (63.3%), and report of vomiting episodes (64%). There were frequent hyposalivation and a low occurrence of gingival bleeding and decayed teeth. High DMFT was mainly associated with a history of the disease (items F and M).
Barbosa *et al.*, 2009[36], Brazil, **Literature review**	To present a summary of dental manifestations in bariatric patients.	Not applicable.	No information.	The data indicate that recommended post-surgical meal patterns and gastric reflux might increase the risk of dental lesions, particularly in the presence of other risk factors, such as consuming sweet-tasting foods and acidic beverages.
Marsicano *et al.*, 2011[4], Brazil, **Prospective cohort**	To verify oral changes in patients before and after BS; identify the occurrence of dental caries, periodontal diseases, and tooth wear; and correlate oral health to quality of life in these patients.	Obese subjects before BS (n=54), and 3 months (n=24) and 6 months (n=16) after BS; 40.5±9.7 years old. Type of surgery: RYGB.	Oral examination to evaluate caries (DMFT), periodontal condition (CPI), tooth wear (TWI), and stimulated salivary flow. OIDP questionnaire to assess the oral health impact on quality of life.	The prevalence of periodontal diseases increased in the two evaluation periods after BS compared to before BS, and salivary flow rates were 0.8±0.5 ml/min, 0.9±0.5 ml/min, and 1.1±0.5 ml/min, respectively ($p>0.05$). After BS, patients showed an increased occurrence of dental caries ($p=0.004$) and severity of tooth wear ($p=0.012$), but these changes in oral health status did not affect the quality of life.

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Author, year, country, study design	Objective	Sample characteristics	Methods	Main findings
Moravec and Boyd, 2011[11], United States, **Case report**	This report provides dental professionals with an overview of dental considerations to enhance their ability to provide bariatric patients with high-quality preventive care and non-surgical periodontal therapy, as prescribed.	54-year-old man underwent gastric lap band surgery nine years earlier.	Oral examination, dental radiographs, caries risk assessment, diet recall, oral hygiene instructions, monitoring and periodontal maintenance once every 3 months, fluoride therapy, and nutrition counseling.	Generalized moderate chronic periodontitis; GBI: 39.8%; PI: 100%; DH. The severity of GER might have contributed to generalized occlusal erosion, dentin hypersensitivity, and dental caries based on the high incidence of GER in obesity and post–gastric lap band surgery.
Moreira *et al.*, 2011[28], Brazil, **Cross-sectional and prospective follow-up**	To evaluate the effect of post-surgery weight loss on changes in the nutritional status and oral cavity.	n=101 (cross-sectional), 39.9±9.2 years old. n=16 (prospective follow-up), 43.6±10.5 years old, Type of surgery: RYGB.	Oral examination: dental caries (DMFT index), salivary flow rate, and buffer capacity. Prospective follow-up evaluation: before BS, 1, 3, 6, and 12 months after surgery.	Individuals with BMI≥30 kg/m^2 had a higher DMFT index. DMFT decreased (p=0.037) with the number of decayed teeth and increased with the number of filled teeth (p=0.005) at 12 months compared to before BS. Salivary flow decreased (p=0.044) in the 1st month and increased (p=0.006) in the 3rd month compared to before BS, achieving a normal level.
Godlewski *et al.*, 2011[52], France, **Prospective cohort**	To compare changes in masticatory function before and after BS in three groups of obese patients differing in dental status.	n=46 obese women, 41.9 ±11.3 years old, three groups: n=23 FD; n=15 PD; n=8 DW. Type of surgery: RYGB .	Chewing time, the number of chewing cycles, chewing frequency, and the median particle-size distribution of the pre-swallowed bolus were measured. Evaluation before and three months after BS.	Before BS, the PD and DW groups exhibited a higher mean of the number of chewing cycles and chewing time than the FD group (p<0.05) and produced a bolus with higher granulometry (p<0.05) than the FD group. After BS, chewing time and the number of chewing cycles increased in all groups. The resulting changes in bolus granulometry depended on both food and dental status.
de Moura-Grec *et al.*, 2012[44], Brazil, **Brief review and case report**	To review the effects of obesity surgery on oral health and present a case report of the periodontal condition of an obese woman who underwent BS.	51-year-old woman evaluated before BS and followed up for two years.	Search of studies on BS and oral health in PubMed. Case report: BMI, stimulated salivary flow, PPD, and bone loss with CBCT. Evaluation: before and one and two years after BS.	The oral health problems found in the review were tooth wear, periodontal diseases, xerostomia, and dental caries. Case report: salivary flow increased in 2 years, changing from low to normal, and the mean probing depth increased (p<0.001). The difference in bone loss with CBCT from 1 to 2 years was 0.93 mm, and it was higher two years after BS (p=0.006).
Alves *et al.*, 2012[32], Brazil, **Cross-sectional epidemiological study**	To determine the prevalence of tooth wear and the risk level in a sample of bariatric patients in a Brazilian public hospital.	n=125, 3 categories: n=41 bariatric group (≥6 months after BS); n=42 obese group (waiting list for BS); n=42 control group; 16-70 years old.	Questionnaire and oral examination using the BEWE scoring system.	Bariatric patients showed the highest prevalence of NCDL, reflux, and vomiting and the highest risk level of NCDL compared with the other groups. However, reflux and vomiting did not seem to positively affect the appearance of NCDL (p>0.05). Regardless of the group, there was no association between reflux, vomiting, and NCDL.
Lakkis *et al.*, 2012[48], United States, **Clinical trial**	To assess whether significant weight loss from BS improves the response to non-surgical periodontal therapy.	n=30 (obese patients with chronic periodontitis): 2 groups: n=15 BS group, and n=15 patients (control) who neither underwent BS nor lost weight. 47.1 (±11.5) years old.	All participants received non-surgical periodontal therapy. PPD, CAL, BOP, GI, and PI were measured at baseline and 4 to 6 weeks after the periodontal treatment.	The BS group showed more improvement in mean PPD, CAL, and GI compared to the control group (p=0.007, p=0.03, and p=0.001, respectively). The reduction in the percentage of BOP sites was higher in the BS than in the control group (p= 0.001). The results show a better response to non-surgical periodontal therapy in participants who underwent BS.
Marsicano *et al.*, 2012[27], Brazil, **Cross-sectional**	To compare the prevalence of dental caries, periodontal diseases, and tooth wear in bariatric and morbidly obese patients and correlate the oral health conditions to the salivary flow.	n= 102, 2 groups: 52 BS group (16.9 ±20.7 months) and 50 obese BS candidates. 37.6±10.0 years old. Type of surgery: RYGB.	Clinical examinations for dental caries (DMFT), periodontal condition (CPI), tooth wear (TWI), and salivary flow (stimulated saliva).	Bariatric patients showed a prevalence of oral diseases similar to that of obese patients. Nevertheless, bariatric patients showed a more prevalent condition of periodontal pockets (p=0.02). The presence of periodontal pockets was associated with patients who underwent BS (OR=3.29; p<.039). All patients had some degree of tooth wear, and most patients presented hyposalivation.

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Author, year, country, study design	Objective	Sample characteristics	Methods	Main findings
de Moura-Grec *et al.*, 2012[2], Brazil, **Literature review**	To identify the postoperative consequences of BS and verify its repercussions on oral health.	Not applicable.	The Virtual Health Library was used (BIREME) and included articles published over the last 10 years.	Chronic reflux and nutritional deficiency are complications of BS, which may impact the oral cavity and cause diseases such as dental erosion, bone loss, and dental caries. The suggested effect of systemic disease control makes patients less vulnerable to complications related to oral health.
Netto *et al.*, 2012[37], Brazil, **Prospective cohort**	To investigate the effect of RYGB surgery on vitamin C and MPO levels and disease development in the oral cavity.	n=52; 2 groups: n=26 (control/eutrophic subjects), n=26 (bariatric group). Type of surgery: RYGB.	Questionnaire via interview. The serum concentrations of vitamin C, MPO, stimulated salivary flow, and buffering capacity were evaluated. The participants did not undergo a clinical periodontal examination. Assessment in the basal period and 12 and 24 months after BS. The control group was assessed only once.	One year after BS, there were increased reports of vomiting episodes ($p<0.001$) and dental hypersensitivity ($p=0.012$). Two years after BS, salivary flow increased ($p<0.001$). Vitamin C serum was lower ($p<0.001$) and MPO values were higher than in the basal period ($p=0.032$). The results showed that vitamin C deficiency and increased vomiting after RYGB for morbid obesity might increase periodontal disease.
Pataro *et al.*, 2012[42], Brazil, **Cross-sectional**	To determine the association between periodontal status and overweight/obese pre-BS and post-BS populations in Brazil.	n=345, 3 groups: n=133 preoperative group, n=72 postoperative ≤6 months group, and n=140 post-surgery >6 months group; 18-60 years old.	Complete periodontal examination: PPD, CAL, BOP, suppuration. Individuals were examined only once. Medical records.	There were differences in the periodontal condition of individuals at different times of the BS, showing a high prevalence of periodontitis at both preoperative and postoperative follow-up. There was a statistically significant difference in the prevalence of periodontitis among the preoperative (70.7%), postoperative ≤6 months (91.7%), and post-surgery >6 months (77.9%) groups ($p=0.040$).
Patiño *et al.*, 2013[38], Brazil, **Case report**	To determine oral changes following BS.	2 cases: 29-year-old man, BMI 53, underwent RYGB; 42-year-old woman, BMI 42, underwent RYGB, follow-up of 2 years.	Oral examination. Analysis of hemoglobin and hematocrit, vitamin B12, folic acid, iron, and calcium were also evaluated.	Dietary complications (frequent vomiting), nutrient deficiencies (iron, vitamin B12, calcium, folic acid, and zinc) and xerostomia, dental caries, sensitivity, and periodontal diseases were seen in both cases.
Souza *et al.*, 2013[51], Brazil, **Case-control**	To assess and compare the occurrence of halitosis among patients before and after RYGB and verify its relationship with the salivary flow rate, tongue coating index, and plaque index.	n=62; two groups: n=31 (control group/BS candidates), n=31 (case group/underwent RYGB).	Questionnaire and oral clinical examination. Halitosis was measured with an organoleptic scale and a portable sulfide monitor (Halimeter). Unstimulated salivary flow rate, tongue coating index, and PI were assessed.	There was no difference in the prevalence of halitosis between the two groups ($p=0.48$). Only the salivary flow rate was decreased in the control group compared with the case group ($p=0.02$). There was no statistical difference between the mean concentrations of volatile sulfur compound and the mean tongue coating index and PI values in the groups. The data suggest no significant association between halitosis and RYGB.
Weideman and Heuberger, 2013[35], United States, **Literature review**	To examine the effects of BS on periodontal disease.	Not applicable.	No information.	The synergistic relationship between BS and appropriate dietary patterns is required to prevent periodontal disease. The nutrient deficiencies caused by improper diet habits of the bariatric patient need continued research with emphasis on oral health.
Cardozo *et al.*, 2014[13], Brazil, **Prospective cohort**	To investigate the association between BS and changes in the oral health status of morbidly obese patients.	n= 39, evaluation 1 day before surgery and 6 months after it. 27-64 years old. Type of surgery: RYGB.	Questionnaires, oral examinations, dental caries (ICDAS system), stimulated and resting salivary flow.	The mean number of total surfaces with non-cavitated and cavitated carious lesions before and after BS were not statistically different. Dry mouth sensation decreased ($p<0.01$), and stimulated salivary flow increased ($p=0.004$) after BS. The oral health of patients who underwent BS improved.

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Author, year, country, study design	Objective	Sample characteristics	Methods	Main findings
de Moura-Grec *et al.*, 2014[33], Brazil, **Prospective cohort**	To verify periodontal conditions and changes in tooth wear after BS.	n=200, n=51 (control group/ non-obese subjects), n=90 (before RYGB), n=59 (6 months after RYGB). Evaluation before and six months after BS. 38.90±10.13 years old. Type of surgery: RYGB.	Oral examinations: tooth wear (TWI), periodontal condition (PPD, CAL, the presence of calculus, and BOP). The stimulated salivary flow was evaluated, and BMI, C-reactive protein, and glucose levels were obtained from medical files.	The percentage of surfaces with tooth wear in dentine was higher after BS (p=0.002), and it decreased in the enamel (p=0.019). There was a slight increase in salivary flow (p>0.05), increased prevalence of periodontal pockets (p= 0.022), and increased mean PPD (p<0.001). There was no difference in BOP. BS may improve systemic conditions. However, it harmed oral health because of an increase in periodontal disease and tooth wear.
Sales-Peres *et al.*, 2015[12], Brazil, **Prospective cohort**	To investigate whether significant weight loss from RYGB would decrease the presence of periodontopathogenic bacteria and periodontal disease in morbidly obese patients in a 12-month follow-up.	n=50 morbidly obese patients, 38.90 (±10.13) years old. Type of surgery: RYGB.	Medical records. Oral examination: GI, calculus index, PPD, and CAL. Detection of *Porphyromonas gingivalis, Tannerella forsythia, Treponema denticola,* and *Prevotella intermedia* of crevicular fluid. Evaluations: pre-operative, and 6 and 12 months postoperative.	All clinical variables for the periodontal conditions assessed indicated worse conditions between pre-operative and six months, and there was a slight improvement between 6 and 12 months. The severity of periodontal disease and the levels of *P. gingivalis* increased after BS.
Hashizume *et al.*, 2015[26], Brazil, **Prospective cohort**	To evaluate the salivary conditions of morbidly obese patients before and six months after BS.	n=27, 33-61 years old; evaluation before and 6 months after BS. Type of surgery: RYGB.	Questionnaire and oral examinations. Salivary flow rate, pH, buffering capacity, microbial levels of mutans streptococci, *Lactobacillus* spp., and *Candida albicans* from saliva.	Values of all salivary variables before and after BS were within the normal range, except for the level of *C. albicans*, which was high at both times. The rate of mutans streptococci increased after BS (p<0.05).
Cummings and Pratt, 2015[57], United States, **Literature review**	To describe the most common BS performed in the United States. It focuses on nutritional and oral complications.	Not applicable.	No information.	Nutritional and anatomic changes after BS may increase the risk of selected oral complications and diseases.
Jaiswal *et al.*, 2015[58], India, **Prospective cohort**	To verify changes in the periodontal status of patients before and after BS and evaluate a potential correlation between diet changes, oral prophylaxis, and periodontal status of these patients.	n=224 obese subjects diagnosed with periodontitis classified as mean clinical attachment loss of >2mm, and the presence of more than 20 teeth. 18-64 years old.	Patients were advised on diet changes with supragingival scaling and oral health care regime after BS, with a 6-month follow-up. Complete periodontal examination before and six months after BS.	The results showed a reduction in the bleeding score, plaque, and mean GI after BS (p<0.001). There were no statistical differences in CAL and PPD at baseline and after BS measurements. A fibrous diet and good periodontal care can help improve the oral hygiene status of patients undergoing BS.
Pataro *et al.*, 2016[59], Brazil, **Cross-sectional**	To evaluate the oral and stomach presence of some target periodontal pathogens and *H. pylori* in BS-treated obese individuals.	n=154, 4 groups: n=40 (BS group with periodontitis), n=39 (BS group without periodontitis), n=35 (control group- obese subjects with periodontitis), n= 40 (control group- obese subjects without periodontitis); 18-65 years old. Type of surgery: RYGB.	Oral pathogens *Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans, Parvimonas micra, Treponema denticola, Tannerella forsythia, Campylobacter rectus,* and *Helicobacter pylori* were detected with a polymerase chain reaction technique. Oral examination: PPD, CAL, BOP, and PI.	Stomach biopsies showed a high frequency of five oral species in both BS candidates (91.6%) and bariatric (83.3%) groups. Obese individuals had high periodontopathogens and *H. pylori* levels in their mouths and stomachs. Nearly all periodontal pathogens were in the stomach, at significantly lower levels in the bariatric group. BS had an inverse effect on oral and gastric microbial profiles, revealing higher oral and lower gastric bacterial levels.

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Author, year, country, study design	Objective	Sample characteristics	Methods	Main findings
Sales-Peres *et al.*, 2017[46], Brazil, **Prospective cohort**	To explore whether weight loss after BS was associated with changes in periodontal measures over 12 months.	n=110 morbidly obese patients with periodontal data in at least two of the three evaluations: (baseline n=110 and six months n=90 or 12 months n=110 after RYGB).	Medical records and a full-mouth periodontal examination: PPD, CAL, and BOP, evaluation at baseline and six and 12 months after surgery.	The findings suggest weight loss was associated with increased gingival bleeding, peaking six months after BS. Periodontal pocket and attachment loss remained unchanged in the 12 months. BMI was negatively associated with the rate of changes in the proportion of sites with BOP. BMI was not associated with baseline PPD and CAL or the changes in these periodontal outcomes.
Salgado-Peralvo *et al.*, 2018[19], Spain, **Systematic review**	To review the current literature to establish the potential association of patients who underwent BS with a higher risk of dental caries.	Not applicable.	An electronic search was performed in the Medline via PubMed database over the last 10 years. Only clinical trials and case series were selected.	Nine studies were included. The studies evaluating the number of teeth lost or affected by caries separately six months post-surgery observed significant differences. Patients who underwent BS have a higher risk of dental caries.
de Souza *et al.*, 2018[18], Brazil, **Systematic review and meta-analysis**	To investigate the effect of BS on periodontal status.	Not applicable.	An electronic search was conducted in PubMed, VHL, Web of Science, Science Direct, Scopus, and Cochrane databases. A search strategy was adapted to the characteristics of each database. Only observational studies were selected.	Nine studies were included in the qualitative analysis and five in the meta-analysis. The quantitative analysis showed that CAL, GI, the percentage of bleeding sites, and PPD were not different before and after BS, and PI was lower after than before BS. The heterogeneity among the studies was high. In the quality analysis, the studies achieved moderate and good results.
Karlsson *et al.*, 2018[55], Sweden, **Case-control**	To survey the perceived oral health among individuals who underwent BS and compare the measures with two cohorts consisting of healthy individuals with a BMI score, respectively, below and above 30.	The samples consisted of individuals that underwent BS n=77 and healthy obese n=45 and nonobese individuals n=71.	The study participants completed, online, a validated oral health-related quality of life scale - OHIP-S.	The subjects that underwent BS reported significantly more oral health problems than the participants of the other two groups. Their perception of oral health-related quality of life was higher or similar to the obese participants and lower than nonobese participants.
Fontanille *et al.*, 2018[16], France, **Systematic review and meta-analysis**	To evaluate the current literature on the effect of BS on periodontal status.	Not applicable.	A search was conducted in MEDLINE, EMBASE, Thesis, and the Cochrane Library databases. Cross-sectional and prospective studies focusing on BOP, PPD, and CAL were selected.	Ten studies were included in the qualitative analysis and four studies in the quantitative analysis. Four studies were included in the meta-analysis at six months of follow-up and three studies at 12 months of follow-up. The 6-month follow-up showed increased periodontal inflammation (p=0.03) and destruction. The difference between bariatric and control subjects was not significant 12 months after BS. In the quality assessment and the risk of bias, four showed a moderate risk, and six showed a low risk.
Porcelli *et al.*, 2019[49], Brazil, **Randomized clinical trial**	To evaluate the effect of an oral health educational/ preventive program developed with patients submitted to BS.	n= 109; two groups: intervention group (n= 55), participated in total health promotion program; control group (n = 54), only received usual care from the bariatric clinic staff.	Oral examination: dental caries (ICDAS system), periodontal disease (CPI), tooth wear (TWI), PI, and salivary flow. Evaluation: before BS, 1 and 6 months post-surgery. Preventive actions 1 and 3 months after BS.	After BS, the intervention group showed less changes in enamel (6 months: $p = 0.004$), dentin (6 months: $p = 0.005$), and BOP (6 months: $p < 0.0001$); reduction in PI (1 and 6 months: $p < 0.0001$); and increase in salivary flow (6 months: $p = 0.039$), compared to the control group. Incipient tooth wear was reported in both groups. Severe tooth wear was not diagnosed in any of the groups.

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Author, year, country, study design	Objective	Sample characteristics	Methods	Main findings
Farias *et al.*, 2019[20], Brazil, **Systematic review and meta-analysis**	To investigate the relationship between BS and the potential changes in salivary flow in morbidly obese individuals undergoing BS.	Not applicable.	A search for articles published in the Web of Science, PubMed/MEDLINE, and Scopus databases was performed. Two independent authors conducted the electronic selection of articles.	Eight studies were included in this study, of which five showed no significant difference in salivary flow values, two showed an increase in flow rate, and one showed a reduction in the flow rate ($p < 0.05$). Heterogeneity presented a high index. The quality analysis showed a satisfactory level of evidence. The included studies did not show significant changes in the salivary flow rate up to 24 months after BS.
Castilho *et al.*, 2019[14], Brazil, **Systematic review**	To systematically review the literature regarding the effect of BS on GER and tooth wear.	Not applicable.	Two independent examiners accessed the PubMed, Medline, Lilacs, SciELO, and Cochrane databases and applied a search strategy with specific descriptors.	Four articles were included in this study and indicated a high association between GER and tooth wear in patients undergoing BS, which was more evident six months after BS.
dos Santos *et al.*, 2019[17], Brazil **Systematic review and meta-analysis**	To perform a systematic review and meta-analysis to assess whether BS affects clinical periodontal conditions in obese patients.	Not applicable.	A search was performed in the PubMed/MEDLINE, Web of Science, and Cochrane Library databases for randomized clinical trials and observational studies with at least three months of follow-up.	The quantitative analysis did not show differences regarding BOP (p= 0.9; mean deviation:-0.70; CI=-11.43 to 10.04) or PPD (p= 0.41; mean deviation: -0.46; CI=1.55 to 0.63) before and after BS. CAL showed a significant difference (p=0.0002; mean deviation: 0.18;CI:0.07 to 0.30). Therefore, BS can worsen clinical attachment loss.
Klüter *et al.*, 2019[24], United States, **Case report**	To describe a case of a patient that underwent BS and presented a significant increase in dental caries.	54-year-old man underwent gastric bypass surgery in 2011.	Oral examination, dental radiographs, salivary test, oral hygiene plan including oral hygiene instruction, dental radiographs, periodontal scraping, fluoride therapy, and nutrition counseling.	As of 2013, carious lesions increased considerably in number and progression. Saliva examination showed that the number of *Streptococcus mutans*, *Streptococcus sobrinus*, and *Lactobacillus* increased. The saliva pH, buffer capacity, and salivary flow rate were normal.
Bastos *et al.*, 2019[39], Brazil, **Case report**	To present the clinical case of a patient with severe symptoms of DH after BS.	A 40-year-old woman complained of hypersensitivity in all teeth after BS.	Subepithelial connective tissue grafting was performed with either coronal flap displacement techniques or a tunnel-type approach at the sites of gingival recession and/or DH.	Gains in keratinized mucosa and root surface coverage and the remission of pain.
Taghat *et al.*, 2020[56], Sweden, **Cross-sectional**	To examine the self-perception of individuals treated with laparoscopic gastric bypass surgery regarding oral health and oral health-related quality of life.	Individuals underwent laparoscopic gastric bypass surgery; initial n=1215 and final n= 644.	A postal questionnaire was distributed just over two years after BS. The questionnaire comprised items regarding sociodemographic and health-related variables.	Self-perceived oral health was rated low by 45% of participants. The associations between self-reported oral health and oral health-related quality of life were consistent throughout the study. DH generated an OR of 2.28 (95% CI 2.28– 8.46), having a ≥2 impact on oral health-related quality of life.
Azevedo *et al.*, 2020[22], Brazil, **Integrative review**	To identify oral health implications in BS patients presenting morbid obesity and associated factors.	Not applicable.	Search in the MedLine, PubMed, SciELO, LILACS, and Scopus databases for human clinical trials and cohort studies.	Increased food intake at shorter intervals and increased frequency of regurgitation in these patients were associated with the higher development of dental caries, dental erosion, and the salivary flow rate.
Quintella *et al.*, 2020[15], Brazil, **Systematic review**	To evaluate whether BS presented a higher risk of dental erosion.	Not applicable.	A search was performed in the PubMed/MEDLINE, Web of Science, and Cochrane Library databases.	Five articles were included in the qualitative and quantitative analysis. A meta-analysis could not be performed because of the high heterogeneity of the studies. This review showed that patients undergoing BS had a higher incidence of dental erosion. All studies presented a high degree of dental erosion in patients submitted to BS ($p<0.05$).

(conclusão)

Author, year, country, study design	Objective	Sample characteristics	Methods	Main findings
Schwenger *et al.*, 2020[50], Canada, **Cross-sectional and prospective cohort**	To assess the prevalence of hyposalivation in obese patients undergoing BS and determine its association with plasma glucose parameters and the effect of bariatric care.	N= 59 patients undergoing RYGB, 29 of them completed the prospective study.	Anthropometrics, fasting bloodwork measurements, and fasting oral parameters were collected at baseline, after a very low-calorie diet, and 1 and 6 months after BS. Evaluation: salivary flow rate and neutrophil count.	In this research, 29 patients finished the study. At baseline, 54.2% (n=32) patients had hyposalivation before RYGB, which was associated with higher fasting glucose. Six months after BS, all variables significantly improved, except for oral neutrophil count. Hyposalivation persisted in 7 (24%) individuals.
Franco *et al.*, 2020[43], Italy, **Systematic review**	To investigate the effect of BS on the onset, severity, and progression of periodontal disease and the improvement of cardiovascular conditions after BS.	Not applicable.	The study was conducted using the PubMed, Medline, and Web of Science databases. Only clinical trials were selected.	Five studies were included. Different BS techniques can influence the effects on periodontal health. The studies showed scarce literature and did not confirm the reduction of periodontal disease after BS but a decrease in cardiometabolic risk. Thus, periodontal disease does not influence the decreased cardiovascular risk after BS.
Balogh *et al.*, 2020[47], Hungary, **Prospective cohort**	To investigate the differences in crevicular gingival fluid microflora between patients in the obese group and the average (normal body weight) population, and assess the effect of weight loss after BS on crevicular microflora.	N=57; 3 groups: 22 were in the normal control group, 18 in the obese control group, and 17 patients had BS and underwent a repeat sampling 6 to 12 months after the surgery; 18-58 years old.	The crevicular fluid was collected from the crevices of canines and first molars with sterile absorbent paper points. The samples were analyzed with matrix-assisted laser desorption ionization-time of flight mass spectrometry (MALDI-TOF MS). PPD and CAL were also assessed.	The average germ count increased after BS and weight loss, but not significantly. *Candida albicans* and non-albicans *Candida* species appeared after BS ($p < 0.05$) in subjects where *Neisseria* was either absent during or eliminated after BS. *Prevotella* affected a considerably higher rate of individuals after weight loss, but periodontitis did not develop at this time in subjects.
Džunková *et al.*, 2020[60], Slovakia, **Prospective cohort**	To identify bacterial species related to decreasing BMI and assess the effect of subject specificity on the microbiome changes observed after BS.	35 adult obese patients undergoing BS.	Samples of unstimulated saliva were collected before, one day, and three and 12 months after BS. The polymerase chain reaction test was conducted in saliva samples.	The analysis of saliva over time showed that the salivary microbiome changed in individuals, and these changes were heterogeneous. The proportions of *Gemella* species, *Granulicatella elegans*, *Porphyromonas pasteri*, *Prevotella nanceiensis*, and *Streptococcus oralis* decreased, while *Veillonella* species, *Megasphaera micronuciformis*, and *Prevotella* saliva increased in most participants.
Taghat *et al.*, 2021[25], Sweden, **Case series**	To describe the oral health profile of individuals who underwent the most common BS procedures, gastric bypass, or sleeve gastrectomy.	N=14 individuals treated with gastric bypass or sleeve gastrectomy ≥ 2 years earlier and with verified or perceived oral problems.	Clinical and radiographic examinations, biomedical sampling, self-reported diet, and questionnaires were conducted.	Most participants perceived several oral health problems. Eleven of 14 individuals presented severe decay. Oral hygiene was poor (PI mean 59.2%; BOP mean 31.1%), and most individuals had high bacterial counts. Salivary flow rates were extremely low, and hyposalivation was present in 10 of the 14 cases.

JI: Jejunoileal, BS: bariatric surgery; SRVG: silastic ring vertical gastroplasty; LAGB: laparoscopic adjustable gastric banding; DH: dental hypersensitivity; RYGB: Roux-en-Y gastric bypass; PI: plaque index; DMFT: decayed, missing, and filled teeth index; GBI: gingival bleeding index; PSR: periodontal screening and recording; CPI: community periodontal index; TWI: tooth wear index; GER: gastroesophageal reflux; BMI: body mass index; FD: fully dentate; PD: partially dentate without partial dentures; DW: partial and complete denture wearers; PPD: probing pocket depth; CBCT: cone beam computed tomography; NCDL: non-carious dental lesion; CAL: clinical attachment level; BOP: bleeding on probing; GI: gingival index; MPO: myeloperoxidase; G1: diabetic obese group; G2: non-diabetic obese group; G3: eutrophic group; CI: confidence interval.

Source: elaborated by the authors.

Discussion

This review indicated that the information available is limited, and there is controversy in the literature regarding the relationship between oral health and bariatric surgery (BS). The evaluated articles revealed a methodological debate regarding study design, follow-up period, sample size, and assessment of clinical parameters, which complicated the comparison of studies.

Dental caries

Dental caries is the localized destruction of susceptible dental hard tissues by acids produced from the bacterial fermentation of dietary carbohydrates. The disease process starts within the bacterial biofilm that covers a tooth surface[21]. Bariatric patients have a lower stomach volume and require smaller and more frequent meals/snacks throughout the day, which may increase the risk of dental caries[10,22]. If oral hygiene is not performed adequately, the conditions favor the development of cariogenic bacteria[2,21].

Studies report a significant increase in dental caries after gastric bypass surgery[4,10,23-25]. Marsicano et al. (2011) observed that, six months after BS, 25% of patients presented more decayed teeth than before the surgery[4]. Heling et al.[7] (2006) observed that, of 113 patients who underwent BS, 37% reported eating more sweet foods after surgery and only 20% reported oral hygiene improvements. Hashizume *et al.*[26] (2015) observed that salivary levels of sugar-dependent microorganisms (*Streptococcus mutans* and *Streptococcus sobrinus*) increased after BS in morbidly obese patients, which may explain the results aforementioned.

However, Cardozo *et al.*[13] (2014) did not verify differences in the mean of surfaces with non-cavitated and cavitated carious lesions between baseline and six months after BS. A cross-sectional study did not find differences in the decayed, missing, and filled teeth (DMFT) index between patients who underwent and were referred for BS[27]. Controversially, a prospective study by Moreira et al. (2011) observed a 57.7% decrease (p=0.037) in the decayed component and a 20% increase (p=0.005) in the filled element of the DMFT index 12 months after BS compared to baseline[28]. Therefore, these studies did not show consensus on the results described for dental caries.

Tooth wear/erosion

Tooth wear can be defined as the surface loss of dental hard tissues from a distinct process without bacterial involvement. Tooth wear has been subdivided into the following categories: attrition, abrasion, abfraction, and erosion[29-31].

Obese individuals and those who underwent BS show some degree of tooth wear, which is more predominant in the latter group[4,14,15,32,33]. Marsicano *et al.*[27] (2012) found similar tooth wear for both groups, but some studies showed worse tooth wear after BS[4,33]. The studies included in this review showed a frequency of tooth wear in patients undergoing BS from 63.3% to 100%[4,27,32,34]. It is also worth noting that tooth wear may be caused by tooth attrition due to anxiety, which may occur in morbidly obese subjects before BS and remain after it[33]. Therefore, attrition can be defined as the loss of dental hard tissues from toot-to-tooth contact without involving other substances[29-31]. Using different clinical diagnostic methods for tooth wear complicated the comparison of studies.

Among tooth wear, dental erosion was the condition most frequently found in individuals who underwent BS[7,32], and it was associated with frequent vomiting[7]. The studies revealed a frequency of vomiting from 47.8% to 79%[4,7,32,34], most usually caused by dysfunctional eating habits such as overeating, eating too fast, or insufficiently chewing food[9]. This is a risk factor for dental erosion because the gastric acid contact causes an irreversible loss of dental hard tissues[4,32,35].

Hypersensitivity

Tooth wear can expose dentinal tubules, which may cause dental hypersensitivity (DH)[27]. The symptom of DH is a sharp and short pain arising from the dentin exposed to external stimuli[7,36].

Few studies have investigated DH in obese BS candidates and individuals who underwent BS. A cross-sectional study noted that 37% of participants reported higher DH after BS[7]. These data agree with a cohort study that verified significantly more reports of hypersensitive teeth, one (42.3%, p=0.012) and two (34.6%, p=0.048) years after compared to before BS (11.5%)[37]. Moreover, Heling et al.[7] (2006) found significant associations between increased DH and both vomiting (p=0.013) and indigestion (p=0.021). Three case reports of bariatric patients also described DH symptoms[11,38,39].

Periodontal disease

Periodontal health has also been investigated in obese individuals and those who underwent BS. The literature reports that the excess adipose tissue relates to immune and inflammatory systemic changes manifesting in the oral cavity through periodontal disease[12,40,41]. However, a systemic inflammation resolution due to BS does not seem to affect the course of periodontal disease[12]. Some studies have shown a higher prevalence or severity of periodontal disease after than before BS[4,12,16,17,33,42], although one systematic review did not find differences[18].

According to de Moura-Grec *et al.*[33] (2014), unsatisfactory periodontal conditions in obese patients who underwent BS may represent a reason for the worse oral condition in the months following BS. Additionally, bariatric patients may become nutrient deficient and prone to periodontal disease[35,37,43]. A case report identified alveolar bone loss via cone-beam computed tomography in a two-year follow-up of a patient who underwent BS[44]. A literature review on the effect of obesity surgery on bone metabolism concluded that bone loss often occurs after BS[45].

A cohort study found that the periodontal pocket and attachment loss remained unchanged in a one-year follow-up, but weight loss after BS was associated with increased gingival bleeding[46]. In cross-sectional studies, Pataro *et al.*[42] (2012) did not find differences in the periodontal pocket, attachment loss, and gingival bleeding between obese patients and those who underwent surgery, but the prevalence of periodontitis was different. Marsicano *et al.*[27] (2012) obtained different findings, as they did not verify differences in the prevalence of periodontal disease, but there was a difference in pocket depth. The relationship between obesity, BS, and periodontal disease is unclear. Moreover, the studies used different methodologies and approaches to present the findings, which complicated the comparison of results.

Some studies found a high plaque index after BS[10,11,25], which contributes to increased inflammation in periodontal tissues and a consequent progression of periodontal disease. Moreover, Balogh *et al.*[47] (2020) found that the *Prevotella* genera in the crevicular gingival fluid affect a considerably high rate of individuals after weight loss. However, other studies showed a lower plaque index after than before BS[18,48]. After the intervention with an oral health educational program, a clinical trial verified lower plaque index and gingival bleeding[49]. Controlling dental biofilm is essential for improving periodontal health and preventing disease progression.

Salivary flow rate

Saliva has many essential functions in oral health promotion and maintenance, such as lubrication, digestion, anti-microbial activity, protection against plaque build-up, and working as a buffering agent to protect against acids from acidic drinks and vomiting[26,35]. Thus, changes in the rates of salivary flow may affect its composition and compromise its functions.

Lower salivary flow rates were verified for obese patients[4,27,28,33,37,44,50]. A study reported lower salivary flow rates in a group of obese BS candidates and individuals who underwent BS[27]. This was similar to a cohort study that reported this condition before and six months after BS[33]. However, other studies observed a change from low to normal flow rates three[28] and six months[4,50] and one[37] and two years[44] after BS. However, two studies verified normal stimulated salivary flow rates in obese patients before BS[13,26], but six months after surgery, one study showed improvements[13] and the other did not

find differences[26]. Farias *et al*.[20] (2019) concluded there were no significant changes in salivary flow rates for up to 24 months after BS.

Most studies showed BS candidates with lower salivary flow rates and normal values at different postoperative times. Dehydration may occur after bariatric procedures, mainly due to decreased fluid intake, which contributes to xerostomia and may consequently increase caries activity, periodontal disease, and tooth wear[4,9,10]. However, a significant reduction in the number of medications used after BS because of the improvement of pathologies such as hypertension and diabetes, might explain the increase in stimulated salivary flow rates and the reduction in dry mouth sensation[13].

Halitosis

This review found only one study evaluating halitosis in BS candidates and individuals who underwent BS. There was no difference in the frequency of halitosis between the two groups. The study suggests no significant associations between halitosis and Roux-en-Y gastric bypass[51]. Further studies are required to verify a potential relationship between BS and halitosis.

Changes in masticatory function

There was only one study on changes in masticatory function before and after BS evaluating obese patients differing in dental status. It reported that, regardless of dental status, all obese patients improved their masticatory kinematics after BS, complying with the suggestion that foods should be chewed better after the surgery[52].

Changes in the oral soft tissue

There were two case reports on soft tissue changes in subjects who underwent BS. One was about parotid gland hypertrophy[53] and the other about palatal ulcers[54], and both cases reported severe vomiting episodes after BS. The first case refers to a patient who underwent BS 26 years earlier and did not reduce the number of meals because of the satisfaction achieved from eating. One year after BS, the patient began to induce emesis three to four times a day, for 25 years, which could cause an enlargement of the parotid gland[53]. This case report draws attention to the psychological factors of these patients. The second case describes a patient who developed bilateral palatal ulcers after intense vomiting due to gastric band tightening[54]. Both cases show the relevance of monitoring patients after BS to prevent oral complications.

Studies found that individuals who underwent BS reported oral health problems and impacts on oral health-related quality of life[55,56]. Thus, dentists must monitor oral health before and after BS, working on oral health prevention, maintenance, and promotion.

Final considerations

There is no consensus in the literature regarding the relationship between oral health and bariatric surgery in obese individuals. The evaluated studies presented different methodologies, which complicated their comparison. More studies on the topic, mainly prospective cohort studies should be conducted to investigate this association better, because the number of patients in dental offices who will undergo or have undergone BS will grow.

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Resumo

Objetivo: revisar a literatura sobre a relação entre saúde bucal e cirurgia bariátrica em indivíduos obesos. Métodos: foi realizada uma busca de estudos publicados até março de 2021 nas bases de dados Medline/PubMed, LILACS, BBO e Web of Science. Foi utilizada uma combinação de descritores relacionada às palavras: obesidade, cirurgia bariátrica e saúde bucal. Resultados: foram identificados 135 estudos nas bases de dados pesquisadas. Desses, 47 estudos foram incluídos nesta revisão. As alterações bucais investigadas em indivíduos que realizaram

cirurgia bariátrica apresentadas na literatura foram: cárie dentária, desgaste dentário/erosão dentária, hipersensibilidade, doença periodontal, hipossalivação, halitose, alterações da função mastigatória e alterações no tecido mole bucal. Os estudos avaliados mostraram controvérsia metodológica em relação a: tipo de desenho de estudo, tempo de seguimento, tamanho da amostra e parâmetros clínicos avaliados, fato que dificultou comparar os estudos. Considerações finais: não há consenso na literatura sobre a relação entre saúde bucal e cirurgia bariátrica em indivíduos obesos. Mais estudos de coorte prospectivos devem ser realizados para estudar melhor essa associação.

Palavras-chave: obesidade; cirurgia bariátrica; saúde bucal; erosão dentária; cárie dentária.

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