Research letter

Gastroenterology

The effect of bariatric surgery on periodontal health: systematic review and meta-analyses

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Abstract

Introduction: We aimed to determine whether periodontal health deteriorates after bariatric surgery (BS).
Methods: A search was performed in Medline and Embase, for prospective cohort studies with data on change in periodontal parameters after BS. Meta-analysis was performed with available data.
Results: The results of 4 included studies consistently show significant ($p < 0.05$) worsening of bleeding on probing (4.21% (95% CI: 0.32, 8.11)), clinical attachment loss (0.16 mm (95% CI: 0.05, 0.27)), periodontal pocket depth (PPD) (0.14 mm (95% CI: 0.06, 0.23)) and percentage of PPD 4–5 mm: 1.72% (95% CI: 0.11, 3.34) 6 months after BS, but no change after 12 months.
Conclusions: BS may have a transient negative effect on periodontal health.

Key words: obesity, bariatric surgery, periodontitis, weight loss, periodontal index.

Obesity has a high prevalence worldwide and many negative consequences for an individual's health [1–4]. Bariatric surgery (BS) is an efficient method for the treatment of morbid obesity and obesity-related health consequences [5]. The most commonly performed BS procedures are laparoscopic sleeve gastrectomy and laparoscopic Roux-en-Y gastric bypass [6]. BS has many already recognized negative sequelae for oral health, such as an increase in severity of tooth erosion, hypersensitivity of the teeth, and the number of carious lesions [7, 8]. Most of the observational studies evaluating patients before BS report a high prevalence of periodontitis (between 50% [9] and 70% [10]), which corroborates the observation that obesity is a risk factor for periodontitis [11]. Periodontitis is a highly prevalent chronic inflammatory disease of periodontal tissue caused by dysbiosis within dental plaque biofilm. During periodontitis development, most tissue damage results from the host response mechanisms, eventually leading to tooth loss [12]. The consequences of periodontitis extend beyond the oral cavity and may negatively affect obesity and obesity-related comorbidities [13, 14]. Despite lowering of some risk factors for periodontitis (diabetes mellitus, obesity and systemic inflammation), most observational and cross-sectional studies revealed an increase in periodontitis prevalence [10, 15], worsening of periodontitis-related diagnostic parameters [16–18] and an increase in the number

of periodontopathogenic bacteria after BS [16, 19]. Accordingly, we initiated a systematic literature review to evaluate all existing research outputs on the periodontal consequences of BS procedures. Our focused PICO question was: Do obese patients undergoing the BS procedure experience worsening of periodontal health-related parameters 6 to 12 months after BS, compared with their measurements before BS?

Methods. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [20] guidelines were followed. The study protocol was registered at Prospero and the full protocol is available: PROSPERO CRD42020165031.

To find eligible studies, an electronic search of the Medline database and Embase was conducted, with an additional manual search. The search was performed on 26th December 2019. The search strategy consisted of terms and MESH headings that stand for bariatric surgery and periodontal disease and were searched for in both titles and abstracts. Two authors (DČ, ACK) independently selected appropriate studies from the list of studies found by the search strategies. Any disagreement was resolved by a third author (RG). Included studies had to be conducted on humans, published in the English language, including early view articles from journals, also with the date of the publication between 2000 and 2019, and with access to the full-text article. The population of interest comprised obese patients undergoing BS, older than 18 years, both sexes, who voluntarily gave consent to be a part of the study, and who received clinical periodontal examinations before the surgery and at the follow-up.

Prospective cohort studies on the influence of BS on the periodontal status, with data recorded before and at least once within 6 to 12 months after BS, were included. Studies were excluded if they were retrospective cohort studies, cross-sectional studies, or case reports; if they were not in the English language; if a clinical periodontal examination was not performed; if periodontal therapy was conducted during the observational period; and if larger (> 30%) patient drop-out occurred at the follow-ups.

The primary outcomes were focused on the change in the clinical periodontal parameters (percentage of bleeding on probing sites (BOP), clinical attachment level (CAL), periodontal pocket depth (PPD), percentage of sites with PPD greater than 4–5 mm (% PPD 4–5 mm), percentage of sites with plaque, percentage of sites with calculus, change in periodontal and gingival indexes, oral hygiene indexes, and radiological analysis), and the prevalence of periodontitis and gingivitis. The secondary outcomes were focused on the change in anthropometric parameters, body mass index (BMI), waist circumference, blood analysis for fasting glucose level (FGL), C-reactive protein (CRP), lipid profile, and the presence of obesity-related comorbidities.

The quality of included studies was tested with a set of specific questions formulated to fit the review question. The original questions, that were modified for the review, were taken from the Newcastle Ottawa scale [21], and the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies from the National Heart, Lung, and Blood Institute USA [22]. The questions were as follows: Did the study have an adequate cohort group? Was the observational period long enough? Who performed the periodontal examination? Were patients lost to follow-up? Did patients experience tooth loss during the study period? Did patients receive any periodontal therapy during the study period? Were the periodontal data missing? Were patients a part of another study? The grades high, medium, and low were awarded to each question and combined into the final study grade. Only studies with the final grade of high or medium were included in the review.

The meta-analysis compared measures before BS with measurements 6 and 12 months after BS for the following parameters: BOP, CAL, PPD, % PPD 4–5 mm, percentage of sites with plaque, percentage of sites with calculus, BMI, and FGL. Change in other primary and secondary outcomes could not be calculated as the data were missing or presented in one study only. Heterogeneity among the studies was measured with I^2 values (high heterogeneity, I^2 >75%; medium, $I^2 \approx 50\%$; low, $I^2 < 25\%$). Software Review Manager 5.3 Cochrane Collaboration was used for the meta-analysis [23].

Results. The search strategy led to identification of 79 articles, after duplicate removal. The full process of article selection is presented in Figure 1. In the end, four studies [16–18, 24] fulfilled all criteria to be included in the synthesis. The characteristics of the included studies are shown in Table I. All included studies were graded with an intermediate quality, mostly due to relevant data missing and lack of information regarding periodontal therapy during the observational period in all studies. In addition, some concerns were raised regarding tooth loss during the study period, as studies reported either significant tooth loss [24] or the data were missing [18].

The results of the meta-analysis 6 months after BS are shown in Figure 2. A statistically significant change 6 months after BS was observed as an increase (i.e., worsening) in some periodontal parameters i.e., BOP, CAL, PPD, and % PPD 4–5 mm, and as a decrease (i.e., improvement) in obesity-related parameters i.e., BMI and FGL. There was no statistically significant change 6 months after BS in

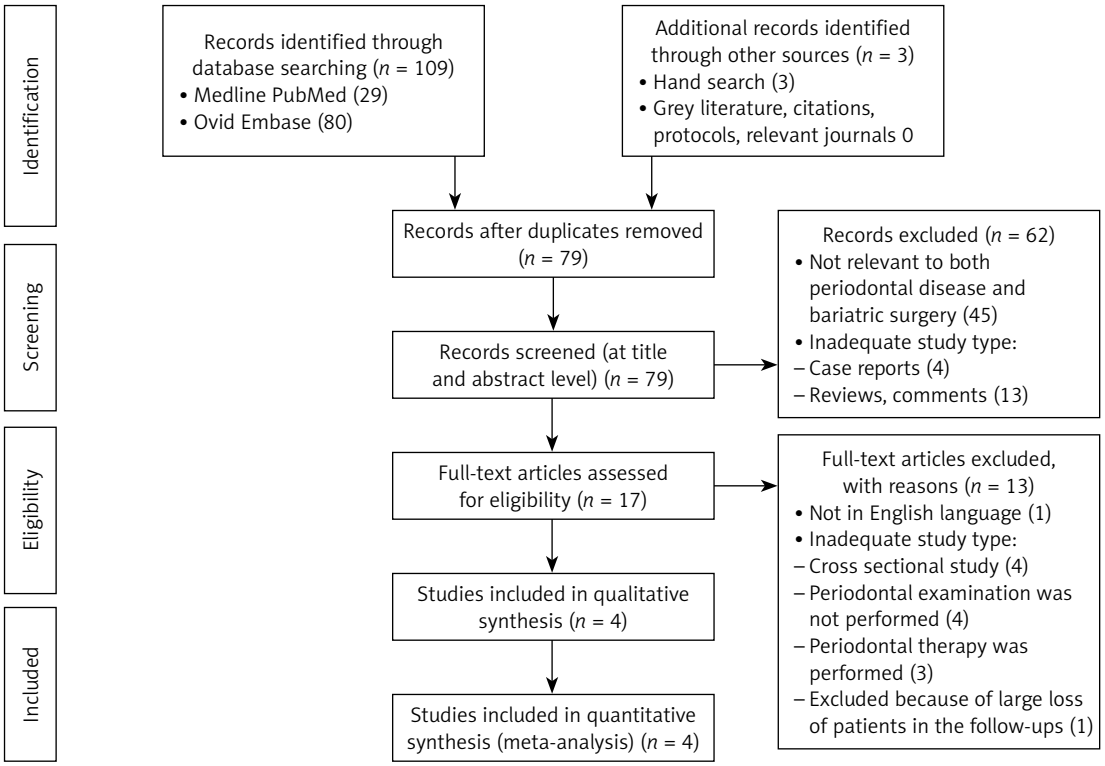


Figure 1. Flow diagram of the study selection process

the presence of teeth calculus. The heterogeneity between the included studies was low for most of the parameters tested 6 months after BS, except for PPD, which showed high levels of heterogeneity. The exact change in respective parameters 6 months after BS was: BOP: 4.21% (95% confidence interval (CI): 0.32, 8.11), $p = 0.03$, $I^2 = 0\%$; CAL: 0.16 mm (95% CI: 0.05, 0.27), $p = 0.006$, $I^2 = 50\%$; PPD: 0.14 mm (95% CI: 0.06, 0.23), $p = 0.0009$, $I^2 = 83\%$; % PPD 4–5 mm: 1.72 (95% CI: 0.11, 3.34), $p = 0.04$, $I^2 = 0\%$; calculus: 0.57% (95% CI: –1.77, 2.91), $p = 0.63$, $I^2 = 0\%$; BMI 13.84 kg/m^2 (95% CI: 12.39, 15.29; $p < 0.001$; $I^2 = 0\%$); FGL 22.96 mg/dl (95% CI: 15.38, 30.55; $p < 0.001$; $I^2 = 0\%$).

The results of the meta-analysis 12 months after BS are shown in Figure 3. A statistically significant change 12 months after BS was observed as a decrease (i.e., improvement) in obesity-related parameters, i.e., BMI and FGL. There was no statistically significant change 12 months after BS in periodontal parameters. The heterogeneity between the included studies was for some parameters low (i.e., BOP, calculus, FGL), for one medium (i.e., CAL), and the rest high (i.e., PPD, BMI). The exact change in respective parameters 6 months after BS was: BOP: 2.78 (–1.68, 7.24), $p = 0.22$, $I^2 = 0.22$; CAL: 0.08 mm (95% CI: –0.05, 0.21), $p = 0.24$, $I^2 = 33\%$; PPD: 0.02 mm (95% CI: –0.08, 0.12), $p = 0.69$, $I^2 = 75\%$, calculus: 0.29% (95% CI: –2.70, 2.12), $p = 0.81$, $I^2 = 0\%$; BMI 16.16 kg/m^2 (95% CI: 14.89, 17.44; $p < 0.001$; $I^2 = 71\%$); FGL 21.7 mg/dl (95% CI: 13.12, 30.28; $p < 0.001$; $I^2 = 0\%$).

Discussion. The meta-analysis of data pooled from only four medium-quality studies fulfilling inclusion criteria revealed worsening of BOP, CAL, PPD and % PPD 4–5 mm 6 months after BS. These findings were similar to the reviews by Miranda dos Santos *et al.* [25] and by Fontanille *et al.* [26], but differ from the review by Maria de Souza *et al.* [27]. The significant decrease in BMI and FGL after BS indicated that the included patients experienced the expected improvement in weight and fasting glucose after BS [5, 28].

The worsening in BOP 6 months after BS indicates increased inflammation of the periodontium during BS recovery. The temporarily consistent increase in CAL, PPD and % PPD 4–5 mm as observed 6 months after BS, but not 12 months after BS, may indicate that during recovery from BS, patients experience progression of periodontal destruction that might be reversible. The noted changes in the periodontal condition could be a consequence of BS complications such as gastroesophageal reflux and vomiting [7], malnutrition [29], postoperative inflammation [30], gut microflora change [31], osteoporosis, and prolonged disbalance of white cell function after BS [32]. Also, frequent meals (5 times a day), and consummation of soft, plaque-promoting food in the first months of recovery from BS, could negatively

Table I. Periodontal data and the main conclusion from the included studies

Study	Cohort group data			Extension of the periodontal examination	Relevant periodontal data NOT collected	Other data collected	Conclusion on the effect of bariatric surgery on periodontal health
	Before BS	6 month after BS	12 month after BS				
de Carvalho Sales-Peres *et al.* 2017 [18]	NoP 110 BOP* 24.6 (23.4) PPD 1.77 (0.5) CAL 1.86 (0.6) BMI 49.8 (8.4)	NoP 90 BOP* 32 (23.4) PPD 1.74 (0.5) CAL 1.89 (0.6) BMI 35.8 (6.2)	NoP 110 BOP* 30.8 (25) PPD 1.70 (0.5) CAL 1.88 (0.6) BMI 32 (6)	Full mouth, at 6 places around every tooth	Plaque presence, tooth loss, prevalence of periodontitis or gingivitis, dental radiography analysis, information on periodontal therapy during observational period	Diabetes mellitus present, smoking habits	BS had a negative effect on periodontal health 6 and 12 months post-op.
de Carvalho Sales-Peres *et al.* 2015 [10]	NoP 50 Number of teeth 25.6 (6.1) PPD* 1.84 (0.5) CAL* 1.96 (0.6) GI 24.7 (17.5) PPD 4–5 mm: 3.3 (4) Calculus: 25.7 (6.1) BMI 49.7 (9) FGL 103.5 (36.4)	NoP 50 Number of teeth 25.4 (6.5) PPD* 2.14 (0.4) CAL* 2.24 (0.6) GI 26.6 (19.4) PPD 4–5 mm: 5.1 (8) Calculus: 25.5 (6.5) BMI 36 (5) FGL 81.9 (14.8)	NoP 50 Number of teeth 25.4 (6.4) PPD* 2.07 (0.4) CAL* 2.15 (0.5) GI 22.25 (18) PPD 4–5 mm: 4.6 (9) Calculus: 25.5 (6.4) BMI 32.2(5.8) FGL 83.3(15)	Full mouth, at 6 places around every tooth	Plaque presence, prevalence of periodontitis or gingivitis, dental radiography analysis, information on periodontal therapy during observational period	CRP, glucose levels, diabetes mellitus present Smokers were excluded from the study.	BS had a negative effect on periodontal status measured 6 and 12 months post-op.
de Moura-Grec *et al.* 2014 [17]	NoP 59 Number of teeth 26.9 PPD* 1.8 (0.4) CAL* 1.96 (0.6) BOP 22 (17.2) PPD 4–5 mm* 3 (3.8) PPD > 6 mm 0.6 (2) Calculus 21.9 (20.2) 45% of patients had periodontitis 10% were healthy BMI 49.3 (8.8) FGL 108 (38.6)	NoP 59 Number of teeth 25.9 PPD* 2.11 (0.4) CAL* 2.2 (0.5) BOP 24.9 (19) PPD 4–5 mm* 4.6 (7.4) PPD > 6 mm 0.79 (2) Calculus 18.5 (17.6) BMI 35.5 (8.1) FGL 83.8 (14.7)	No data	Full mouth, at 6 places around every tooth	Plaque presence, prevalence of gingivitis before BS, prevalence of periodontitis and gingivitis at follow-up, dental radiography analysis, information on periodontal therapy during observational period	CRP, glucose levels, diabetes mellitus present	BS had a negative effect on periodontal status 6 months post-op.
Weinberg *et al.* 2018 [24]	NoP 50 Number of teeth 25.7* PI 1.56 PPD 2.4 (0.7) BOP 61 (37.6) Calculus 38 (34.2) BMI 42.7 (5.4) FGL 114 (47.6)	No data	NoP 50 Number of teeth 25.4* PI 1.54 PPD 2.3 (0.8) BOP 68 (33.7) Calculus 35.9 (29.3) BMI 28.7 (5) FGL 90 (15)	On 6 Ramfjord index teeth (16, 21, 24, 44, 41, 46) at 6 places around tooth	CAL, full mouth examination, prevalence of periodontitis or gingivitis, dental radiography analysis, information on periodontal therapy during observational period	Glucose levels, diabetes mellitus present	BS had no effect on periodontal status 12 months post-op.

*All values are presented as mean value (standard deviation). NoP – number of patients, BMI – body mass index, kg/m^2, FGL – fasting glucose level, mg/dl, PPD – periodontal pocket depth, mm, PPD 4–5 mm – periodontal pocket depth between 4 and 5 mm, percentage of tooth sites, PPD > 6 mm – periodontal pocket depth deeper than 6 mm, percentage of tooth sites, CAL – clinical attachment loss, mm, BOP – bleeding on probing, percentage of tooth-sites, CI – calculus index, percentage of teeth, GI – gingival index, percentage of tooth sites, PI – plaque index, BS – bariatric surgery, *p < 0.05 in the individual studies.*

Study or subgroup	BOP 6 months after BS Mean (%)	SD (%)	Total	BOP before BS Mean (%)	SD (%)	Total	Weight (%)	Mean difference IV, fixed, 95% CI (%)
de Maura-Grec *et al.* 2014	24.99	19.04	59	22.09	17.19	59	35.4	2.90 [-3.65, 9.45]
Sales-Peres *et al.* 2015	26.56	19.41	50	24.67	17.49	50	28.9	1.89 [-5.35, 9.13]
Sales-Peres *et al.* 2017	32	23.4	90	24.6	23.4	110	35.7	7.40 [0.88, 13.92]
Total (95% CI)			**199**			**219**	**100.0**	**4.21 [0.32, 8.11]**

Heterogeneity: $\chi^2 = 1.47$, $df = 2$ ($p = 0.48$); $I^2 = 0\%$

Test for overall effect: $Z = 2.12$ ($p = 0.03$)

Mean difference IV, fixed, 95% CI (%)

−10 −5 0 5 10

Decrease after BS Increase after BS

Study or subgroup	PPD 6 months after BS Mean [mm]	SD [mm]	Total	PPD before BS Mean [mm]	SD [mm]	Total	Weight (%)	Mean difference IV, fixed, 95% CI [mm]
de Maura-Grec *et al.* 2014	2.11	0.38	59	1.86	0.44	59	32.9	0.25 [0.10, 0.40]
Sales-Peres *et al.* 2015	2.14	0.4	50	1.84	0.47	50	24.8	0.30 [0.13, 0.47]
Sales-Peres *et al.* 2017	1.74	0.47	90	1.77	0.47	110	42.3	-0.03 [-0.16, 0.10]
Total (95% CI)			**199**			**219**	**100.0**	**0.14 [0.06, 023]**

Heterogeneity: $\chi^2 = 11.94$, $df = 2$ ($p = 0.003$); $I^2 = 83\%$

Test for overall effect: $Z = 3.31$ ($p = 0.0009$)

Mean difference IV, fixed, 95% CI [mm]

−0.5 −0.25 0 0.25 0.5

Decrease Increase

Study or subgroup	CAL 6 months after BS Mean [mm]	SD [mm]	Total	CAL before BS Mean [mm]	SD [mm]	Total	Weight (%)	Mean difference IV, fixed, 95% CI [mm]
de Maura-Grec *et al.* 2014	2.2	0.49	59	1.96	0.57	59	33.4	0.24 [0.05, 0.43]
Sales-Peres *et al.* 2015	2.24	0.58	50	1.96	0.61	50	22.6	0.28 [0.05, 0.51]
Sales-Peres *et al.* 2017	1.89	0.6	90	1.86	0.6	110	44.0	0.03 [-0.14, 0.20]
Total (95% CI)			**199**			**219**	**100.0**	**0.16 [0.05, 0.27]**

Heterogeneity: $\chi^2 = 4.00$, $df = 2$ ($p = 0.14$); $I^2 = 50\%$

Test for overall effect: $Z = 2.77$ ($p = 0.006$)

Mean difference IV, fixed, 95% CI [mm]

−0.5 −0.25 0 0.25 0.5

Decreases after BS Increases after BS

Study or subgroup	%PPD 4–5 mm 6 months after BS Mean (%)	SD (%)	Total	%PPD 4–5 mm before BS Mean (%)	SD (%)	Total	Weight (%)	Mean difference IV, random, 95% CI (%)
de Maura-Grec *et al.* 2014	4.65	7.41	59	3.03	3.8	59	57.7	1.62 [-0.50, 3.74]
Sales-Peres *et al.* 2015	5.18	7.97	50	3.32	4.07	50	42.3	1.86 [-0.62, 4.34]
Total (95% CI)			**109**			**109**	**100.0**	**1.72 [0.11, 3.34]**

Heterogeneity: $\tau^2 = 0.00$; $\chi^2 = 0.02$, $df = 1$ ($p = 0.89$); $I^2 = 0\%$

Test for overall effect: $Z = 2.09$ ($p = 0.04$)

Mean difference IV, random, 95% CI (%)

−10 −5 0 5 10

Decrease Increase

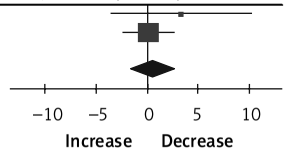
Figure 2. Meta-analysis 6 months after bariatric surgery

BMI – body mass index, kg/m², glucose – fasting glucose level, mg/dl, PPD – periodontal pocket depth, mm, PPD 4–5 mm – periodontal pocket depth between 4 and 5 mm, percentage of tooth sites, CAL – clinical attachment loss, mm, BOP – bleeding on probing, percentage of tooth sites, BS – bariatric surgery, SD – standard deviation, CI – 95% confidence interval.

Study or subgroup	Calculus % before BS Mean (%teeth)	SD (%teeth)	Total	Calculus % 6 months after BS Mean (%teeth)	SD (%teeth)	Total	Weight (%)	Mean difference IV, fixed, 95% CI (%teeth)
de Maura-Grec *et al.* 2014	21.93	20.18	59	18.56	17.64	59	11.7	3.37 [-3.47, 10.21]
Sales-Peres *et al.* 2015	25.67	6.14	50	25.47	6.55	50	88.3	0.20 [-2.29, 2.69]
Total (95% CI)			**109**			**109**	**100.0**	**0.57 [-1.77, 2.91]**

Heterogeneity: $\chi^2 = 0.73$, $df = 1$ ($p = 0.39$); $I^2 = 0\%$

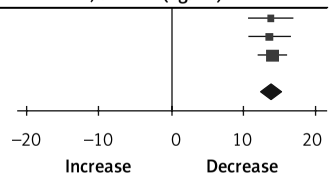
Test for overall effect: $Z = 0.48$ ($p = 0.63$)



Study or subgroup	BMI before BS Mean (kg/m²)	SD (kg/m²)	Total	BMI 6 months after BS Mean (kg/m²)	SD (kg/m²)	Total	Weight (%)	Mean difference IV, fixed, 95% CI (kg/m²)
de Maura-Grec *et al.* 2014	49.3	8.8	59	35.5	8.12	59	22.6	13.80 [10.74, 16.86]
Sales-Peres *et al.* 2015	49.7	9	50	36.1	5	50	25.9	13.60 [10.75, 16.45]
Sales-Peres *et al.* 2017	49.78	8.4	110	35.8	6.2	90	51.4	13.98 [11.95, 16.01]
Total (95% CI)			**219**			**199**	**100.0**	**13.84 [12.39, 15.29]**

Heterogeneity: $\chi^2 = 0.05$, $df = 2$ ($p = 0.98$); $I^2 = 0\%$

Test for overall effect: $Z = 18.67$ ($p < 0.00001$)



Study or subgroup	Glucose before BS Mean (mg/dl)	SD (mg/dl)	Total	Glucose 6 months after BS Mean (mg/dl)	SD (mg/dl)	Total	Weight (%)	Mean difference IV, fixed, 95% CI (mg/dl)
de Maura-Grec *et al.* 2014	108	38.6	59	83.8	14.7	59	51.7	24.20 [13.66, 34.74]
Sales-Peres *et al.* 2015	103.5	36.49	50	81.86	14.77	50	48.3	21.64 [10.73, 32.55]
Total (95% CI)			**109**			**109**	**100.0**	**22.96 [15.38, 30.55]**

Heterogeneity: $\chi^2 = 0.11$, $df = 1$ ($p = 0.74$); $I^2 = 0\%$

Test for overall effect: $Z = 5.94$ ($p < 0.00001$)

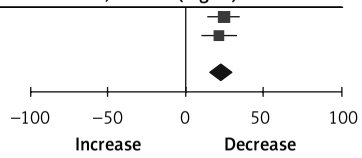


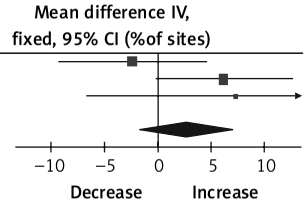
Figure 2. Cont.

BMI – body mass index, kg/m², glucose – fasting glucose level, mg/dl, PPD – periodontal pocket depth, mm, PPD 4–5 mm – periodontal pocket depth between 4 and 5 mm, percentage of tooth sites, CAL – clinical attachment loss, mm, BOP – bleeding on probing, percentage of tooth sites, BS – bariatric surgery, SD – standard deviation, CI – 95% confidence interval.

Study or subgroup	BOP 12 months after BS Mean (% of sites)	SD (% of sites)	Total	BOP before BS Mean (% of sites)	SD (% of sites)	Total	Weight (%)	Mean difference IV, fixed, 95% CI (% of sites)
Sales-Peres *et al.* 2015	22.25	18	50	24.6	17.4	50	41.3	-2.35 [-9.29, 4.59]
Sales-Peres *et al.* 2017	30.8	25	110	24.6	23.4	110	48.6	6.20 [-0.20,12.60]
Weinberg *et al.* 2018	68.3	33.7	50	61	37.6	50	10.2	7.30 [-6.70, 21.30]
Total (95% CI)			**210**			**210**	**100.0**	**2.78 [-1.68, 7.24]**

Heterogeneity: $\chi^2 = 3.60$, $df = 2$ ($p = 0.17$); $I^2 = 44\%$

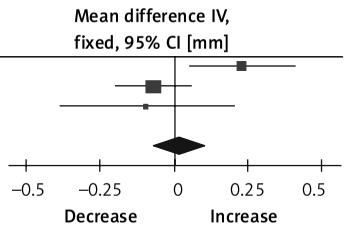
Test for overall effect: $Z = 1.22$ ($p = 0.22$)



Study or subgroup	PPD 12 months after BS Mean [mm]	SD [mm]	Total	PPD before BS Mean [mm]	SD [mm]	Total	Weight (%)	Mean difference IV, fixed, 95% CI [mm]
Sales-Peres *et al.* 2015	2.07	0.43	50	1.84	0.47	50	30.7	0.23 [0.05, 0.41]
Sales-Peres *et al.* 2017	1.7	0.5	110	1.77	0.47	110	58.2	-0.07 [-0.20, 0.06]
Weinberg *et al.* 2018	2.37	0.8	50	2.46	0.7	50	11.0	-0.09 [-0.38, 0.20]
Total (95% CI)			**210**			**210**	**100.0**	**0.02 [-0.08, 0.12]**

Heterogeneity: $\chi^2 = 7.86$, $df = 2$ ($p = 0.02$); $I^2 = 75\%$

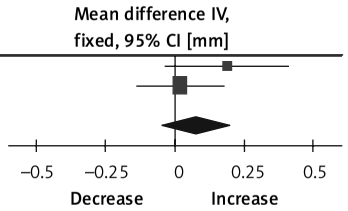
Test for overall effect: $Z = 0.40$ ($p = 0.69$)



Study or subgroup	CAL 12 months after BS Mean [mm]	SD [mm]	Total	CAL before BS Mean [mm]	SD [mm]	Total	Weight (%)	Mean difference IV, fixed, 95% CI [mm]
Sales-Peres *et al.* 2015	2.15	0.52	50	1.96	0.61	50	33.7	0.19 [-0.03, 0.41]
Sales-Peres *et al.* 2017	1.88	0.6	110	1.86	0.6	110	66.3	0.02 [-0.14, 0.18]
Total (95% CI)			**160**			**160**	**100.0**	**0.08 [-0.05, 0.21]**

Heterogeneity: $\chi^2 = 1.49$, $df = 1$ ($p = 0.22$); $I^2 = 33\%$

Test for overall effect: $Z = 1.17$ ($p = 0.24$)



Study or subgroup	Calculus 12 months BS Mean (%teeth)	SD (%teeth)	Total	Calculus before BS Mean (%teeth)	SD (%teeth)	Total	Weight (%)	Mean difference IV, fixed, 95% CI (%teeth)
Sales-Peres *et al.* 2015	25.45	6.39	50	25.67	6.14	50	96.3	-0.22 [-2.68, 2.24]
Weinberg *et al.* 2018	35.9	29.3	50	38	34.2	50	3.7	-2.10 [-14.58,10.38]
Total (95% CI)			**100**			**100**	**100.0**	**-0.29 [-2.70, 2.12]**

Heterogeneity: $\chi^2 = 0.08$, $df = 1$ ($p = 0.77$); $I^2 = 0\%$

Test for overall effect: $Z = 0.24$ ($p = 0.81$)

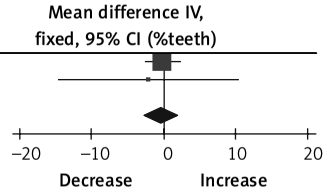


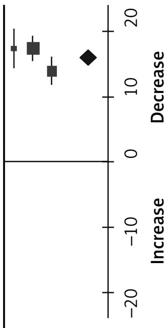
Figure 3. Meta-analysis 12 months after bariatric surgery

BMI – body mass index, kg/m², glucose – fasting glucose level, mg/dl, PPD – periodontal pocket depth, mm, CAL – clinical attachment loss, mm, BOP – bleeding on probing, percentage of tooth sites, BS – bariatric surgery, SD – standard deviation, CI – 95% confidence interval.

Study or subgroup	BMI before BS Mean (kg/m²)	SD (kg/m²)	Total	BMI 12 months after BS Mean (kg/m²)	SD (kg/m²)	Total	Weight (%)	Mean difference IV, fixed, 95% CI (kg/m²)
Sales-Peres *et al.* 2015	49.7	9	50	32.2	5.8	50	18.4	17.50 [14.53, 20.47]
Sales-Peres *et al.* 2017	49.8	8.4	110	32.3	6	110	43.5	17.50 [15.57, 19.43]
Weinberg *et al.* 2018	42.7	5.4	50	28.7	5.1	50	38.2	14.00 [11.94, 16.06]
Total (95% CI)			**210**			**210**	**100.0**	**16.16 [14.89, 17.44]**

Heterogeneity: $\chi^2 = 6.87$, $df = 2$ ($p = 0.03$); $I^2 = 71\%$

Test for overall effect: $Z = 24.91$ ($p < 0.00001$)



Study or subgroup	Glucose before BS Mean (mg/dl)	SD (mg/dl)	Total	Glucose 12 months after BS Mean (mg/dl)	SD (mg/dl)	Total	Weight (%)	Mean difference IV, fixed, 95% CI (mg/dl)
Sales-Peres *et al.* 2015	103.5	36.49	50	83.3	15	50	61.5	20.20 [9.26, 31.14]
Weinberg *et al.* 2018	114.1	47.6	50	90	15	50	38.5	24.10 [10.27, 37.93]
Total (95% CI)			**100**			**100**	**100.0**	**21.70 [13.12, 30.28]**

Heterogeneity: $\chi^2 = 0.19$, $df = 1$ ($p = 0.66$); $I^2 = 0\%$

Test for overall effect: $Z = 4.96$ ($p < 0.00001$)

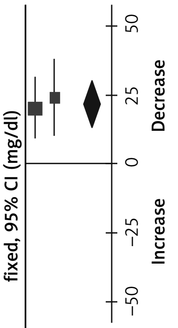


Figure 3. Cont.

BMI – body mass index, kg/m² , glucose – fasting glucose level, mg/dl, PPD – periodontal pocket depth, mm, CAL – clinical attachment loss, mm, BOP – bleeding on probing, percentage of tooth sites, BS – bariatric surgery, SD – standard deviation, CI – 95% confidence interval.

affect periodontal tissues [9].

None of the included studies reported on the baseline prevalence of periodontitis and gingivitis, or their changes during the BS recovery period. From the available data before the BS, we may speculate that not all included patients were periodontally healthy (Table I). If patients have signs of periodontal disease before BS, it is unlikely that there will be an improvement of periodontal parameters without any periodontal intervention after the surgery. The presented evidence of periodontal disease progression after BS supports dental screening of all patients scheduled for bariatric surgery. This is of particular importance due to the recognized negative effects of periodontitis that extend beyond the oral cavity and include effects on cardiovascular diseases, diabetes mellitus and liver disease [33–35]. Furthermore, periodontal therapy has been shown to improve parameters of systemic inflammation [36], insulin resistance [37] and arterial blood pressure [38–40].

From the included studies it is not clear whether patients during the BS recovery period received any kind of periodontal therapy. This could be a confounding factor, compensating the negative effect of BS on the periodontium. Some kind of intervention is likely, as the calculus index in two [17, 24] studies did show a tendency to decrease after BS. Collecting information on periodontal procedures during the BS recovery period is relevant for interpretation of the BS effects on the periodontium. The effect of tooth extraction is the second confounding factor that can impact the results. Extracting teeth with the most severely affected periodontium would give a wrong impression of improvement of periodontal parameters after BS.

However, all included studies reported only a mean value of CAL and PPD per patient. From the reported data we could not preclude the possibility that only a few sites per patient might be responsible for the majority of this shift. The high heterogeneity among studies further hinders interpretation of the results.

A detailed description of systemic parameters and obesity comorbidities, e.g., metabolic syndrome [41], is also missing in all included studies. This information is needed to better understand the risk profile of the patient and to help us explain the consequences of BS for periodontal health.

The main limitation of the systematic review is the low number of studies included in the meta-analysis. The true change in periodontal status was probably hidden in mean values of parameters presented at a group level. Missing periodontal and obesity-related information should be taken into consideration during the interpretation of the results.

There is a need for high-quality observational

studies with a detailed description of baseline oral and obesity-related health parameters and their changes after BS. The evidence showing periodontal disease progression after BS supports future interventional studies, which have so far shown promising results [40].

In conclusion, within the limits of this study, we can conclude that BS may lead to a short-term worsening of periodontal status 6 months after BS, which is not present 12 months after BS. However, future observational studies with proper collection of the data are needed to further explore this finding as studies so far do not present sufficient periodontal and systemic data. Nevertheless, the data presented in our review provides us with a reasonable basis to advise that a dentist should monitor patients before and after BS because they are at potential risk of additional periodontal breakdown.

Conflict of interest

The authors declare no conflict of interest.

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