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

Dejana Čolak[1], Rok Gašperšič[1], Alja Cmok Kučič[1], Tadeja Pintar[2], Boris Gašpirc[1]

[1]Department of Oral Diseases and Periodontology, Dental Clinic, University Medical Centre Ljubljana, Slovenia
[2]Department of Abdominal Surgery, University Medical Centre Ljubljana, Slovenia

Corresponding author:
Dejana Čolak PhD student
Department of Oral
Diseases and
Periodontology
Dental Clinic
University Medical
Centre
Ljubljana, Slovenia
E-mail: dejana.colak.23@
gmail.com

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

AMS

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 the presence of teeth calculus. The heterogeneity between the included studies was low for most of

Dejana Čolak, Rok Gašperšič, Alja Cmok Kučič, Tadeja Pintar, Boris Gašpirc
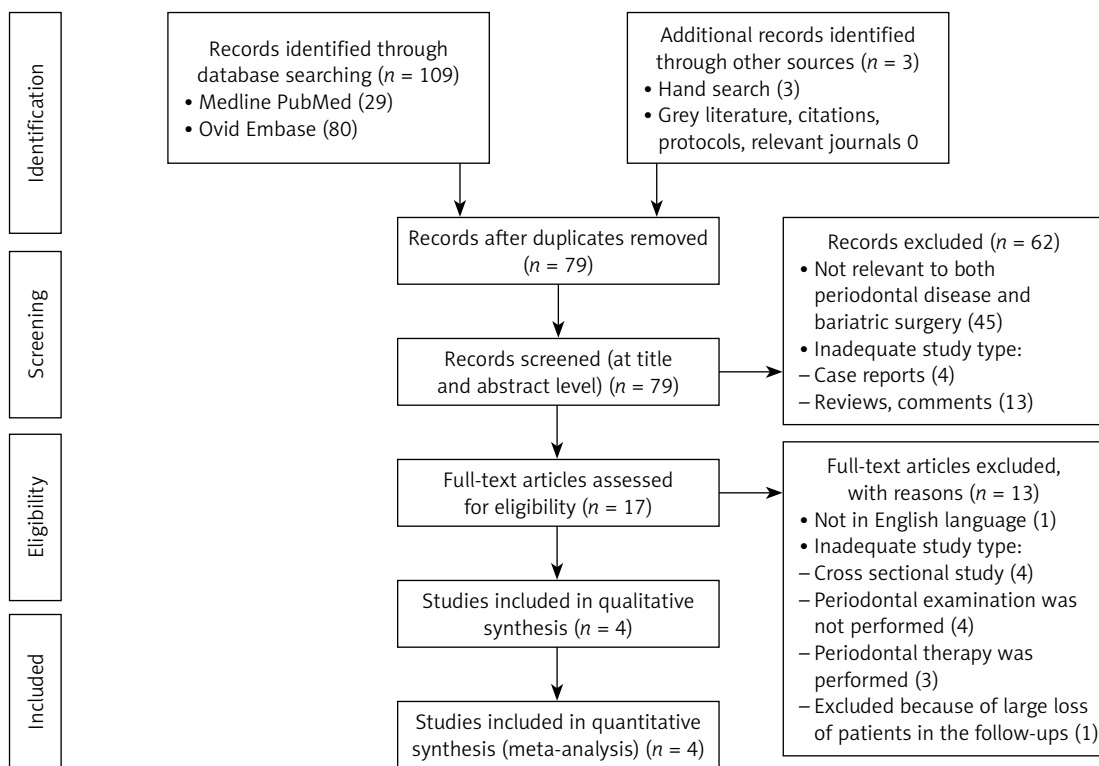
Figure 1. Flow diagram of the study selection process

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 affect periodontal tissues [9].

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/m², FGL – fasting glucose level, mg/dl, PPD – 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, PPD 4–5 mm – periodontal pocket depth, 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, percentage of tooth sites, BS – bariatric surgery, *p < 0.05 in the individual studies.

Dejana Čolak, Rok Gašperšič, Alja Cmok Kučič, Tadeja Pintar, Boris Gašpirc

Study or subgroup	BOP 6 months after BS			BOP before BS			Weight (%)	Mean difference IV, fixed, 95% CI (%)
	Mean (%)	SD (%)	Total	Mean (%)	SD (%)	Total		
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: $Z = 2.12$ ($p = 0.03$)

Study or subgroup	PPD 6 months after BS			PPD before BS			Weight (%)	Mean difference IV, fixed, 95% CI [mm]
	Mean [mm]	SD [mm]	Total	Mean [mm]	SD [mm]	Total		
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: $Z = 3.31$ ($p = 0.0009$)

Study or subgroup	CAL 6 months after BS			CAL before BS			Weight (%)	Mean difference IV, fixed, 95% CI [mm]
	Mean [mm]	SD [mm]	Total	Mean [mm]	SD [mm]	Total		
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: $Z = 2.77$ ($p = 0.006$)

Study or subgroup	%PPD 4–5 mm 6 months after BS			%PPD 4–5 mm before BS			Weight (%)	Mean difference IV, random, 95% CI (%)
	Mean (%)	SD (%)	Total	Mean (%)	SD (%)	Total		
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: $Z = 2.09$ ($p = 0.04$)

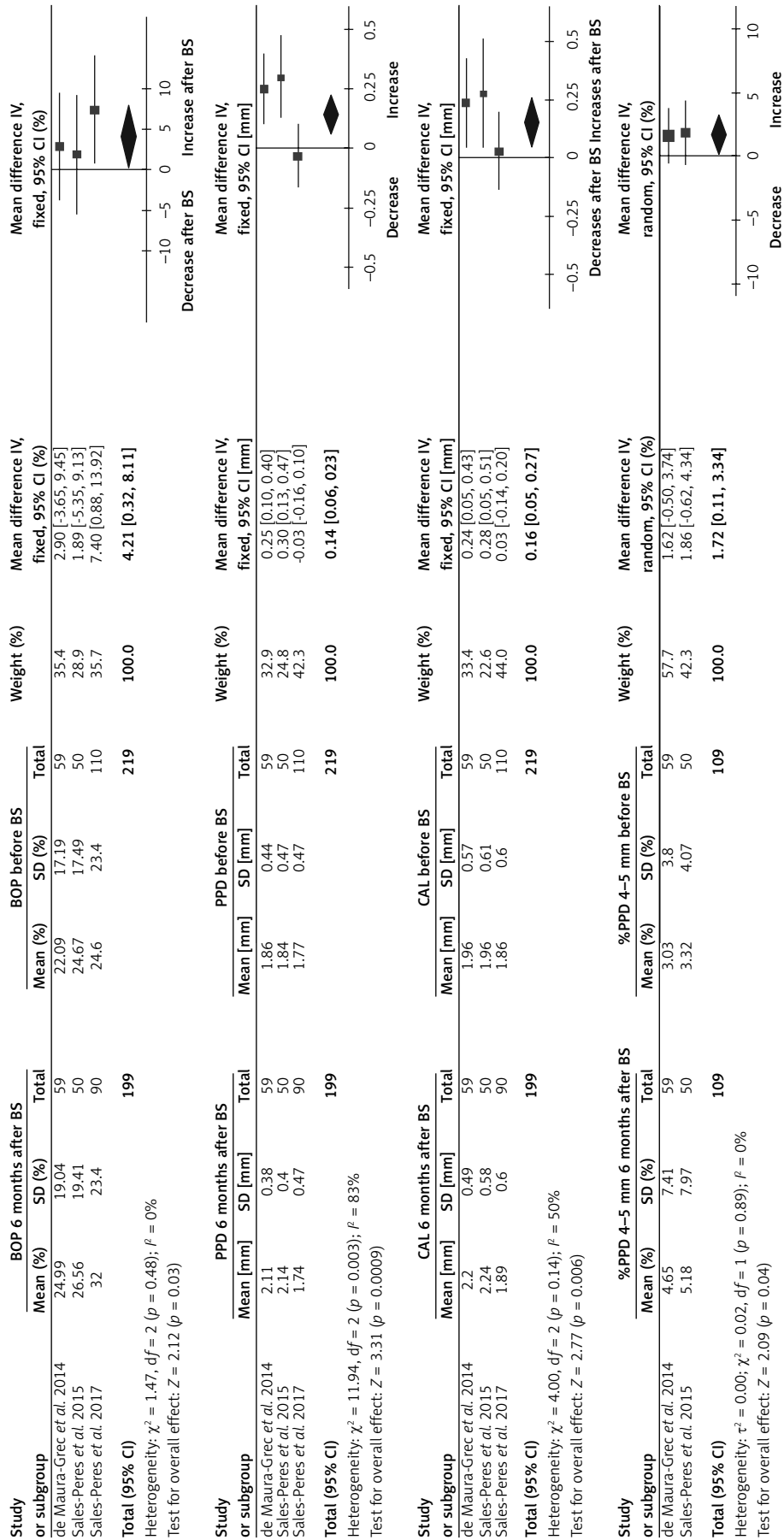**Figure 2.** Meta-analysis 6 months after bariatric surgery

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.

Calculus

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: $Z = 0.48$ ($p = 0.63$)

Mean difference IV, fixed, 95% CI (%teeth)
-10 -5 0 5 10
Increase   Decrease

BMI

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: $Z = 18.67$ ($p < 0.00001$)

Mean difference IV, fixed, 95% CI (kg/m²)
-20 -10 0 10 20
Increase   Decrease

Glucose

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: $Z = 5.94$ ($p < 0.00001$)

Mean difference IV, fixed, 95% CI (mg/dl)
-100 -50 0 50 100
Increase   Decrease

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.
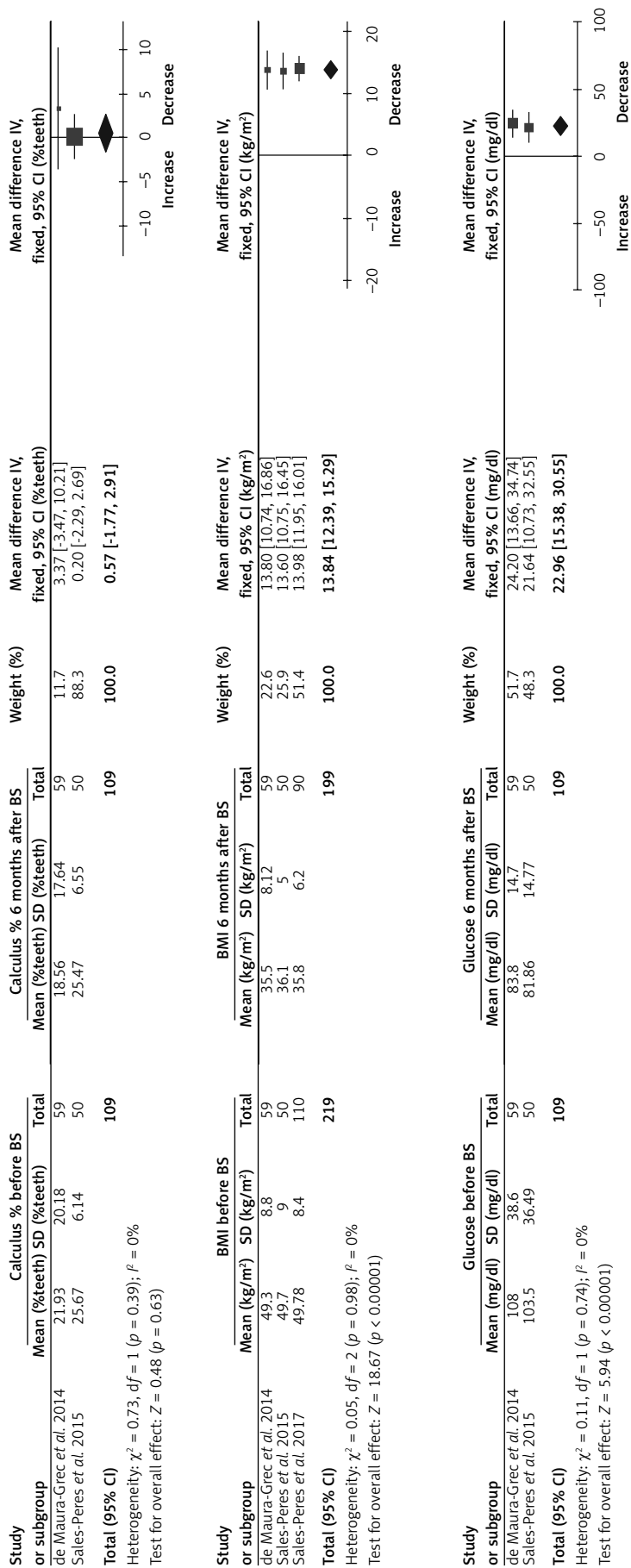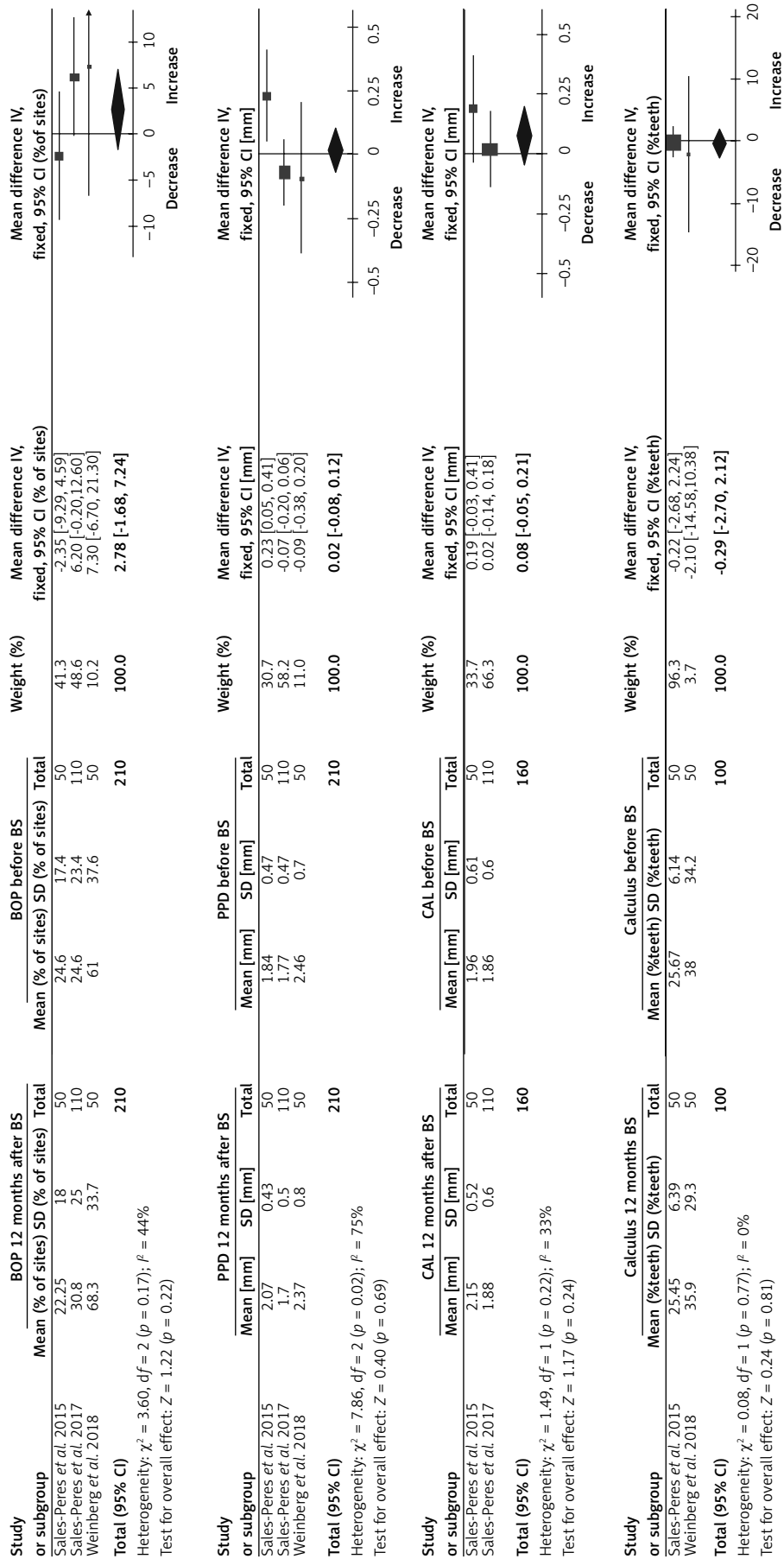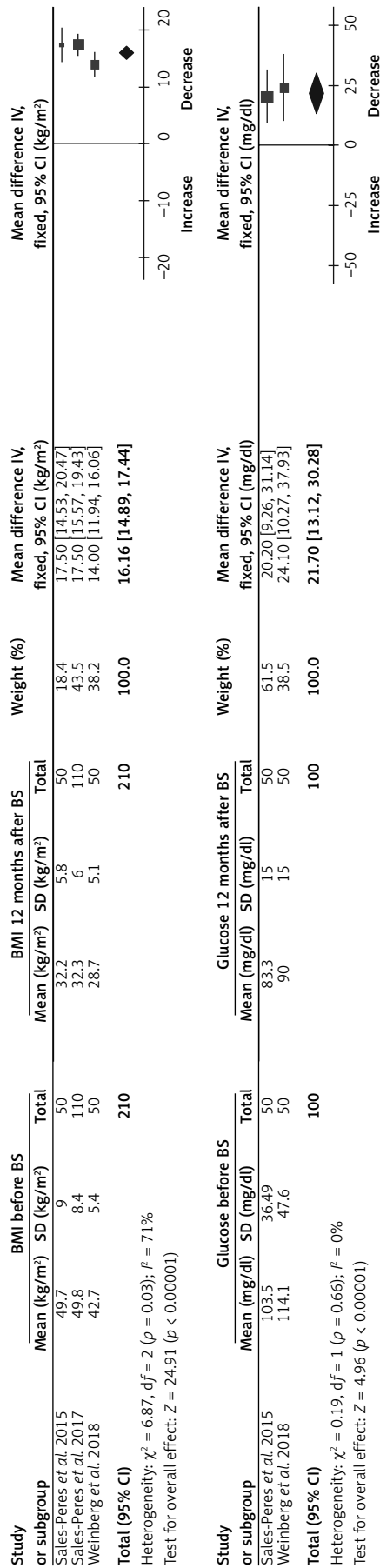
Dejana Čolak, Rok Gašperšič, Alja Cmok Kučič, Tadeja Pintar, Boris Gašpirc

BOP

Study or subgroup	BOP 12 months after BS			BOP before BS			Weight (%)	Mean difference IV, fixed, 95% CI (% of sites)
	Mean (% of sites)	SD (% of sites)	Total	Mean (% of sites)	SD (% of sites)	Total		
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: $Z = 1.22$ ($p = 0.22$)

PPD

Study or subgroup	PPD 12 months after BS			PPD before BS			Weight (%)	Mean difference IV, fixed, 95% CI [mm]
	Mean [mm]	SD [mm]	Total	Mean [mm]	SD [mm]	Total		
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: $Z = 0.40$ ($p = 0.69$)

CAL

Study or subgroup	CAL 12 months after BS			CAL before BS			Weight (%)	Mean difference IV, fixed, 95% CI [mm]
	Mean [mm]	SD [mm]	Total	Mean [mm]	SD [mm]	Total		
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: $Z = 1.17$ ($p = 0.24$)

Calculus

Study or subgroup	Calculus 12 months BS			Calculus before BS			Weight (%)	Mean difference IV, fixed, 95% CI (%teeth)
	Mean (%teeth)	SD (%teeth)	Total	Mean (%teeth)	SD (%teeth)	Total		
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			BMI 12 months after BS			Weight (%)	Mean difference IV, fixed, 95% CI (kg/m²)
	Mean (kg/m²)	SD (kg/m²)	Total	Mean (kg/m²)	SD (kg/m²)	Total		
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			Glucose 12 months after BS			Weight (%)	Mean difference IV, fixed, 95% CI (mg/dl)
	Mean (mg/dl)	SD (mg/dl)	Total	Mean (mg/dl)	SD (mg/dl)	Total		
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.

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

Dejana Čolak, Rok Gašperšič, Alja Cmok Kučič, Tadeja Pintar, Boris Gašpirc

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.

References

1. Mazidi M, Banach M, Kengne AP. Prevalence of childhood and adolescent overweight and obesity in Asian countries: a systematic review and meta-analysis. Arch Med Sci 2018; 14: 1185-203.
2. Ellulu MS, Patimah I, Khaza'ai H, Rahmat A, Abed Y. Obesity and inflammation: the linking mechanism and the complications. Arch Med Sci 2017; 13: 851-63.
3. Cantero I, Abete I, Bullon-Vela V, et al. FGF-21 levels and liver inflammatory biomarkers in obese subjects after weight loss. Arch Med Sci 2021. DOI: https://doi.org/10.5114/aoms/98948.
4. Šoštarič A, Jenko B, Kozjek NR, et al. Detection of metabolic syndrome burden in healthy young adults may enable timely introduction of disease prevention. Arch Med Sci 2019; 15: 1184-94.
5. Fathy SM, Morshed G. Peripheral blood lymphocyte subsets (CD4+, CD8+ T cells), leptin level and weight loss after laparoscopic greater curvature plication in morbidly obese patients. Arch Med Sci 2014; 10: 886-90.
6. Ramos A, Kow L, Brown W, et al. The International Federation for the Surgery of Obesity and Metabolic Disorders Global Registry. Published online 2019: 1-100. https://www.ifso.com/ifso-registry.php
7. Porcelli ICS, Roma CC, Nunes MCP, Maciel SM, Pascotto RC. Effects of bariatric surgery on the oral health of patients. Int J Dent Oral Health 2016; 2(2). doi http://dx.doi. org/10.16966/2378-7090.181.
8. Salgado-Peralvo AO, Mateos-Moreno MV, Arriba-Fuente L, et al. Bariatric surgery as a risk factor in the development of dental caries: a systematic review. Public Health 2018; 155: 26-34.
9. Marsicano JA, Grec PG de M, Belarmino LB, et al. Interfaces between bariatric surgery and oral health: a longitudinal survey. Acta Cir Bras 2011; 26: 79-83.
10. Pataro AL, Costa FO, Cortelli SC, et al. Influence of obesity and bariatric surgery on the periodontal condition. J Periodontol 2012; 83: 257-66.
11. Keller A, Rohde JF, Raymond K, Heitmann BL. Association between periodontal disease and overweight and obesity: a systematic review. J Periodontol 2015; 86: 766-76.
12. Seymour GJ, Berglundh T, Trombelli L. Pathogenesis of periodontitis. In: Clinical Periodontology and Implant Dentistry. Sixth ed. Lang NP, Lindhe J (eds.). John Wiley & Sons, Ltd 2015; 256-70.
13. Nibali L, D'Aiuto F, Griffiths G, Patel K, Suvan J, Tonetti MS. Severe periodontitis is associated with systemic inflammation and a dysmetabolic status: a case-control study. J Clin Periodontol 2007; 34: 931-7.
14. Liu F, Wang Y, Xu J, Liu F, Hu R, Deng H. Effects of Porphyromonas gingivalis lipopolysaccharide on the expression of key genes involved in cholesterol metabolism in macrophages. Arch Med Sci 2016; 12: 959-67.
15. Pataro AL, Costa FO, Cortelli SC, et al. Influence of obesity and bariatric surgery on the periodontal condition. J Periodontol 2012; 83: 257-66.
16. de Carvalho Sales-Peres SH, de Moura-Grec PG, Yamashita JM, et al. Periodontal status and pathogenic bacteria after gastric bypass: a cohort study. J Clin Periodontol 2015; 42: 530-6.
17. de Moura-Grec PG, Ceneviva R, de Souza Leite CV, et al. Impact of bariatric surgery on oral health conditions: 6-months cohort study. Int Dent J 2014; 64: 144-9.
18. de Carvalho Sales-Peres SH, de Carvalho Sales-Peres M, Ceneviva R, Bernabé E. Weight loss after bariatric surgery and periodontal changes: a 12-month prospective study. Surg Obes Relat Dis 2017; 13: 637-42.
19. Balogh B, Somodi S, Tanyi M, Miszti C, Márton I, Kelentey B. Follow-up study of microflora changes in crevicular gingival fluid in obese subjects after bariatric surgery. Obes Surg 2020; 30: 5157-61.
20. Moher D, Shamseer L, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev 2015; 4: 1.
21. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol 2010; 25: 603-5.
22. Study Quality Assessment Tools. National Heart, Lung, and Blood Institute (NHLBI). Accessed May 7, 2020. https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools
23. Review Manager Web (RevMan Web). Published online 2019. revman.cochrane.org
24. Weinberg G, Bilder L, Horwitz J, et al. Oral health status of patients before and after bariatric surgery. Dent Oral Heal Care 2018; 1: 1-8.
25. dos Santos MCM, Pellizzer EP, SoutoMaior JR, et al. Clinical periodontal conditions in individuals after bariatric surgery: a systematic review and meta-analysis. Surg Obes Relat Dis 2019; 15: 1850-60.
26. Fontanille I, Boillot A, Rangé H, et al. Bariatric surgery and periodontal status: a systematic review with meta-analysis. Surg Obes Relat Dis 2018; 14: 1618-31.
27. Maria de Souza G, Willya Douglas de Oliveira D, Santos Lages F, et al. Relationship between bariatric surgery and periodontal status: a systematic review and meta-analysis. Surg Obes Relat Dis 2018; 14: 1205-16.
28. Nedeljkovic-Arsenovic O, Banovic M, Radenkovic D, et al. The amount of weight loss six months after bariatric surgery: it makes a difference. Obes Facts 2019; 12: 281-90.
29. Lager CJ, Esfandiari NH, Luo Y, et al. Metabolic parameters, weight loss, and comorbidities 4 years after Roux-en-Y gastric bypass and sleeve gastrectomy. Obes Surg 2018; 28: 3415-23.
30. van Dielen FM, Buurman WA, Hadfoune M, Nijhuis J, Greve JW. Macrophage inhibitory factor, plasminogen

activator inhibitor-1, other acute phase proteins, and inflammatory mediators normalize as a result of weight loss in morbidly obese subjects treated with gastric restrictive surgery. J Clin Endocrinol Metab 2004; 89: 4062-8.

31. Ulker I, Yildiran H. The effects of bariatric surgery on gut microbiota in patients with obesity: a review of the literature. Biosci Microbiota Food Health 2019; 38: 3-9.

32. Hubber N, Singhal R, Super P, Roberts HM, Grant MM, Chapple ILC. Impact of bariatric surgical intervention on peripheral blood neutrophil (PBN) function in obesity. Obes Surg 2017; 28: 1611-21.

33. Sanz M, Marco del Castillo A, Jepsen S, et al. Periodontitis and cardiovascular diseases: consensus report. J Clin Periodontol 2020; 47: 268-88.

34. Bui FQ, Almeida-da-Silva CLC, Huynh B, et al. Association between periodontal pathogens and systemic disease. Biomed J 2019; 42: 27-35.

35. Gurav AN. Periodontitis and insulin resistance: casual or causal relationship? Diabetes Metab J 2012; 36: 404-11.

36. Czesnikiewicz-Guzik M, Osmenda G, Siedlinski M, et al. Causal association between periodontitis and hypertension: evidence from Mendelian randomization and a randomized controlled trial of non-surgical periodontal therapy. Eur Heart J 2019; 40: 3459-70.

37. Cao R, Li Q, Wu Q, Yao M, Chen Y, Zhou H. Effect of non-surgical periodontal therapy on glycemic control of type 2 diabetes mellitus: a systematic review and Bayesian network meta-analysis. BMC Oral Health 2019; 19: 176.

38. Montero E, López M, Vidal H, et al. Impact of periodontal therapy on systemic markers of inflammation in patients with metabolic syndrome: a randomized clinical trial. Diabetes Obes Metab 2020; 22: 2120-32.

39. Osmenda G, Maclag J, Wilk G, et al. Treatment of denture-related stomatitis improves endothelial function assessed by flow-mediated vascular dilation. Arch Med Sci 2017; 13: 66-74.

40. de Souza Porcelli IC, Corsi NM, de Lourdes Calvo Fracasso M, et al. Oral health promotion in patients with morbid obesity after gastroplasty: a randomized clinical trial. Arq Bras Cir Dig 2019; 32: e1437.

41. Korac A, Srdic-Galic B, Stancic A, Otasevic V, Korac B, Jankovic A. Adipokine signatures of subcutaneous and visceral abdominal fat in normal-weight and obese women with different metabolic profiles. Arch Med Sci 2021; 17: 323-36.