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BEST-EVIDENCE CONSENSUS

Prevalence, incidence, systemic, behavioral, and patient-related risk factors and indicators for peri-implant diseases: An AO/AAP systematic review and meta-analysis

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Abstract

Background: A profound understanding of the epidemiology of peri-implant diseases (PIDs) is essential for the development of preventive approaches to mitigate the occurrence and progression of peri-implant biological complications. The present systematic review and meta-analysis aimed to assess the incidence, prevalence, systemic, behavioral, and patient-related risk indicators and factors for PIDs in adult patients with dental implants.

Methods: Clinical studies assessing the prevalence, incidence, systemic risk indicators, and risk factors for PIDs were considered eligible for inclusion. MEDLINE–PubMed, EMBASE, Cochrane Central Library, and ClinicalTrials.gov electronic databases were searched for published articles. Pooled data analyses were performed using random-effects models to identify risk indicators and factors for PIDs.

Results: Of 1120 potentially eligible records, 102 studies met the eligibility criteria and were included in this systematic review. Prevalence rates at the patient level for peri-implant mucositis and peri-implantitis were 46% (95% confidence interval [CI], 41–51) and 21% (95% CI, 17–24), respectively. Weighted mean incidence rates at the patient level for peri-implant mucositis and peri-implantitis were 53% and 22%, respectively, within 20 years of function. Pooled estimates identified periodontitis, obesity, and smoking habits as significant systemic risk indicators for mucositis. For peri-implantitis, the significant risk indicators were periodontitis, diabetes mellitus, smoking habits, and alcohol consumption. Only risk indicators could be identified in the selected evidence.

Conclusion: More than half of the patients treated with dental implants were affected by PIDs over a 10-year follow-up period, with peri-implant mucositis being the most prevalent condition. Periodontitis and smoking were identified as risk indicators for the development of both PIDs. Obesity was identified as

[Correction added on June 21, 2025 after first online publication: Figure 1 has been updated in this version.]

a potential risk indicator for mucositis, while diabetes mellitus and alcohol consumption were recognized as potential risk indicators for peri-implantitis.

KEYWORDS
dental implants, epidemiology, peri-implantitis, risk factors

Plain Language Summary

This systematic review looked at the causes and frequency of problems around dental implants, known as PIDs, which include conditions like peri-implant mucositis (inflammation around the implant) and peri-implantitis (more serious infection around the implant). Understanding these conditions and their etiology is important for finding ways to prevent them. This research reviewed 102 studies (including 13,030 patients) to gather data on how often these problems occur and what factors might increase the risk of developing them. The meta-analyses revealed that nearly half of people with dental implants had peri-implant mucositis, and about one in five had peri-implantitis. Over a period of 20 years, the incidence rates for developing these conditions were about 53% for mucositis and 22% for peri-implantitis. The study identified certain health and lifestyle factors that could increase the risk of these conditions. For mucositis, risk factors included having gum disease (periodontitis), obesity, and smoking. For peri-implantitis, the risks were similar, with periodontitis, smoking, and diabetes and alcohol use being important factors.

1 | INTRODUCTION

Contemporary clinical studies have evidenced that peri-implant diseases (PIDs) are common biological complications among the adult population subjected to dental implant therapy.[1–3] The scientific community has determined that the occurrence of peri-implant biological complications is a main outcome domain when evaluating implant therapy success and survival rates[4,5] and that it is imperative to comprehend the epidemiology of PIDs to formulate preventive strategies that mitigate the occurrence of peri-implant mucositis and peri-implantitis.[3]

PIDs result from biofilm-induced pathological inflammatory processes that affect the integrity of peri-implant soft and hard tissues.[6,7] Peri-implant mucositis is generally acknowledged as a disease that precedes peri-implantitis, where the lesion is contained within the soft tissue compartment.[8] When inflammation extends into the osseous compartment and progressive marginal bone loss (MBL) is identified, the pathological entity is defined as peri-implantitis, being the more advanced stage of the disease.[7,9] Peri-implantitis might progress in a nonlinear accelerated pattern and affect the underlying osseointegration.[7]

Scientific evidence has established that certain systemic factors such as smoking, diabetes mellitus, metabolic syndrome (MTS), cardiovascular diseases, obesity, and alcohol consumption, among others, play an important role in modulating bone physiology and wound healing.[10–14] Therefore, these conditions might be significant risk indicators or factors for the prevalence and incidence of PIDs.[15–18] Risk indicators may determine associations and are identified in observational studies, while risk factors are known as characteristics that increase the chance of developing a disease and are confirmed by a temporal sequence in longitudinal interventional studies.[7]

Evidence derived from longitudinal studies has confirmed that certain systemic diseases, behavioral conditions, and genetic factors are putative risk factors for periodontitis.[19,20] As follows, the current classification system of periodontitis considers the recognized risk factors (i.e., smoking and diabetes mellitus) to determine both the risk of disease progression and their potential impact on the patient's periodontal health.[20] However, existing evidence is inconclusive to determine risk factors for PIDs.[7] Currently, only periodontitis has been confirmed to be a risk indicator and possible risk factor for peri-implant mucositis and peri-implantitis.[7,21,22] Smoking and diabetes mellitus still have limited evidence as risk indicators for PIDs.[7]

As periodontitis may not have a unique pathophysiology, PIDs may also progress following a multifactorial

disease model with a complex interaction of risk factors.[20] In this context, gaining understanding of the influence of these factors on PIDs may lead to the development of strategies and therapeutics aimed at preventing and counteracting peri-implant pathology.

Consequently, the present systematic review and meta-analysis aimed to assess the incidence, prevalence, systemic, behavioral, and patient-related risk indicators and factors for PIDs in adult patients with dental implants.

The following focused questions were addressed: "What are the prevalence and incidence rates of peri-implant diseases in partially and completely edentulous adult patients with implant-supported prostheses? What are the patient-related risk factors and indicators including systemic diseases and conditions (i.e., diabetes mellitus, cardiovascular diseases and associated conditions, obesity, osteoporosis), behavioral factors (i.e., smoking habits and alcohol consumption), patient-related characteristics (i.e., sex and age), and patient-related oral conditions (i.e., complete edentulism and periodontitis) for peri-implant mucositis and peri-implantitis in partially and completely edentulous adult patients with implant-supported prostheses?"

2 | MATERIALS AND METHODS

The present systematic review was performed in accordance with the criteria of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[23] and registered in the Prospective Register of Systematic Reviews (PROSPERO) under registration number CRD4202346657800. The specific PECOS (Population, Exposure, Comparator, and Outcomes)[24] framework used to devise the focused questions is described in the following sections.

2.1 | Eligibility criteria

Observational and interventional studies evaluating the prevalence or incidence of peri-implant mucositis and peri-implantitis were considered for this systematic review. Studies were considered for inclusion if they met the following criteria:

1. Enrolled partially or fully edentulous adult patients (≥18 years) treated with titanium dental implant-supported prostheses that had been in function for ≥12 months.
2. Reported on the incidence and/or prevalence of peri-implant mucositis and/or peri-implantitis.
3. Peri-implant examination was conducted on the basis of a clear case definition for peri-implant mucositis and peri-implantitis considering both clinical signs of inflammation (i.e., bleeding on probing [BOP], suppuration, edema) and radiographic parameters (i.e., detecting absence or presence of MBL).[4]
4. Reported on patients' systemic and related conditions (i.e., data on potential risk factors and indicators influencing peri-implant outcomes).
5. Contained a minimum of 10 participants per study arm in interventional studies.

Studies reporting on nonhuman data, case series, reviews, retrospective data collections, as well as on retrograde peri-implantitis, zygomatic, zirconia, and short implants (<8 mm long) were excluded.

2.2 | Outcome measures

The primary outcome was to assess the prevalence and incidence of PIDs at both the patient and implant level. The secondary outcome was to determine the systemic, behavioral, and patient-related risk indicators and risk factors associated with the prevalence and incidence of PIDs.

2.3 | Information sources and search strategy

The literature search (electronic and manual) was executed by two independent reviewers (M.E.G. and T.S.). The electronic search was performed for publications written in English language, with no publication date limit, from September 1, 2023 to October 20, 2023. The following electronic databases were used using specific search strategies: MED-LINE (through PubMed), EMBASE, Cochrane Central Library, and ClinicalTrials.gov. Reference lists from eligible studies and previously published review articles were cross-checked to identify additional pertinent studies. A reference manager software (EndNote, 2020) was used to organize and screen the literature. Detailed search strategies were formulated for each database using specific keywords and Medical Subject Headings (MeSH) terms as presented in the supplementary material (see Tables S1 and S2 in the online *Journal of Periodontology*).

2.4 | Article selection process and data extraction

The studies were selected by two independent reviewers using a software for systematic reviews (Rayyan software). Discrepancies between the reviewers on the studies' eligibility were resolved by consulting a third reviewer

(L.C.). The reviewers (M.E.G.) and (T.S.) extracted the data in duplicate from full texts in a standardized electronic data extraction table using Microsoft Excel 2010 software. A third reviewer (L.C.) verified the correctness of the extracted data.

The following data were extracted: citation (author/year), publication type, study design, type of participants, indicator/exposure, comparator, study objectives, study duration, duration of participation, population description, number of participants at start of study, missing/dropouts, number of included implants, time in function of implants, age, sex, follow-up time, oral/dental status reported, comorbidities, timing of implant placement, PIDs definition used, clinical and radiographic mean values at implant level (i.e., probing depth [PD] in millimeter, BOP in percent, and MBL in millimeter), prevalence and incidence rates, risk factors and risk indicators of PIDs (diabetes mellitus, cardiovascular diseases and associated conditions, obesity, osteoporosis, smoking habits, alcohol consumption, sex, age, complete edentulism, and periodontitis, which were determined a priori), outcome, unit of measurement, conflict of interest, and conclusions of the study. Risk indicators could be identified in observational studies, while risks factors could be identified in longitudinal studies.

2.5 | Methodological quality and risk of bias assessment

The risk of bias was assessed using established tools according to the study design. The risk of bias 2 (ROB2) tool was used as the reference to assess the risk of bias of randomized clinical trials.[25] The risk of bias of nonrandomized interventional studies (ROBINS-I)[26] tool was employed to evaluate the methodological quality of interventional studies that were not randomized. The Newcastle-Ottawa Scale (NOS)[27] was used to evaluate the methodological quality of cohort studies, and an adapted version of NOS was used to assess the risk of bias of cross-sectional studies. A measurement tool to assess systematic reviews (AMSTAR 2)[28] was used to perform the critical appraisal of the evidence reported in the present review.

2.6 | Statistical analysis

Data were grouped into evidence tables and a descriptive summary was designed to assess individual study characteristics. Meta-analyses were performed to estimate the overall prevalence and incidence of PIDs at the patient level. Prevalence data were extracted from cross-sectional studies, and incidence data were extracted from prospective studies. When necessary, prevalence and incidence were derived from the reported data and included in the analyses, even when these outcomes were not reported explicitly. The effect size (ES) was assessed using the odds ratio (OR) values reported for risk indicators at the patient level. Studies reporting some risk indicators but not others were included in the analyses for the risk indicators they reported. A random-effects model was used in the meta-analyses. Subgroup analyses for prevalence and incidence were performed by stratifying the data by category of loading and follow-up time, respectively. The subanalysis on the prevalence of peri-implantitis was also conducted for the subgroup of fully edentulous subjects. Results were presented as forest plots with percentages or natural logarithm-transformed odds ratio (lnOR). Cochran's Q test, the T^2 statistic, and the I^2 statistic were used to assess heterogeneity. Egger's test and funnel plots were used to assess the potential for publication bias. Inter-rater reliability was assessed using the kappa statistic. Ninety-five percent confidence intervals (95% CI) were calculated, and the significance level was set at $\alpha = 0.05$. Stata 18 (StataCorp LLC, College Station, Texas, USA) was used in the analysis.

3 | RESULTS

3.1 | Study selection

The electronic search identified 1320 relevant records and the additional hand search yielded 19 records, totaling to 1339 potential articles to be evaluated. After the screening of titles and abstracts, 282 studies were analyzed in full text by two independent calibrated reviewers (M.E.G. and T.S.) (kappa = 0.70). After full-text analysis, 102 studies were included in the present systematic review as depicted in the flow diagram (see Figure S1 in the online *Journal of Periodontology*). Reasons for exclusion are also described in the supplementary material (see Table S3 in the online *Journal of Periodontology*).

3.2 | Study characteristics

The present systematic review included 102 clinical studies that encompassed 69 cross-sectional studies,[1,2,17,18,29–93] 28 prospective cohorts,[94–121] and 5 interventional studies.[122–126] The geographic segmentation of the included studies corresponded to 67.6% from Europe, 11.8% from Asia, 16.6% from South America, 3% from the United States, and 0.98% from Africa (Figure 1A). The setting of the included studies was 70% at university clinics, 26% at private practices, 2% at public centers, and 2% at hospitals; 9.8% of the studies were multicentered.

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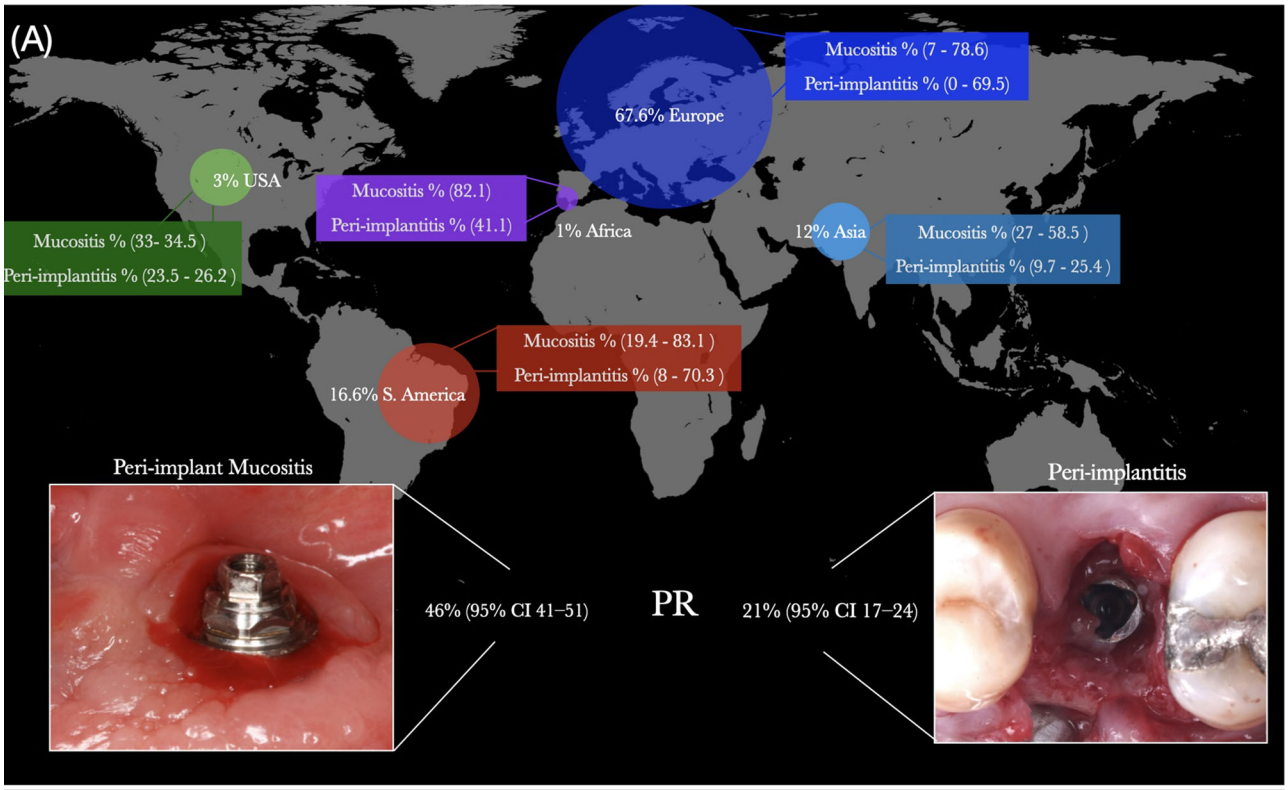

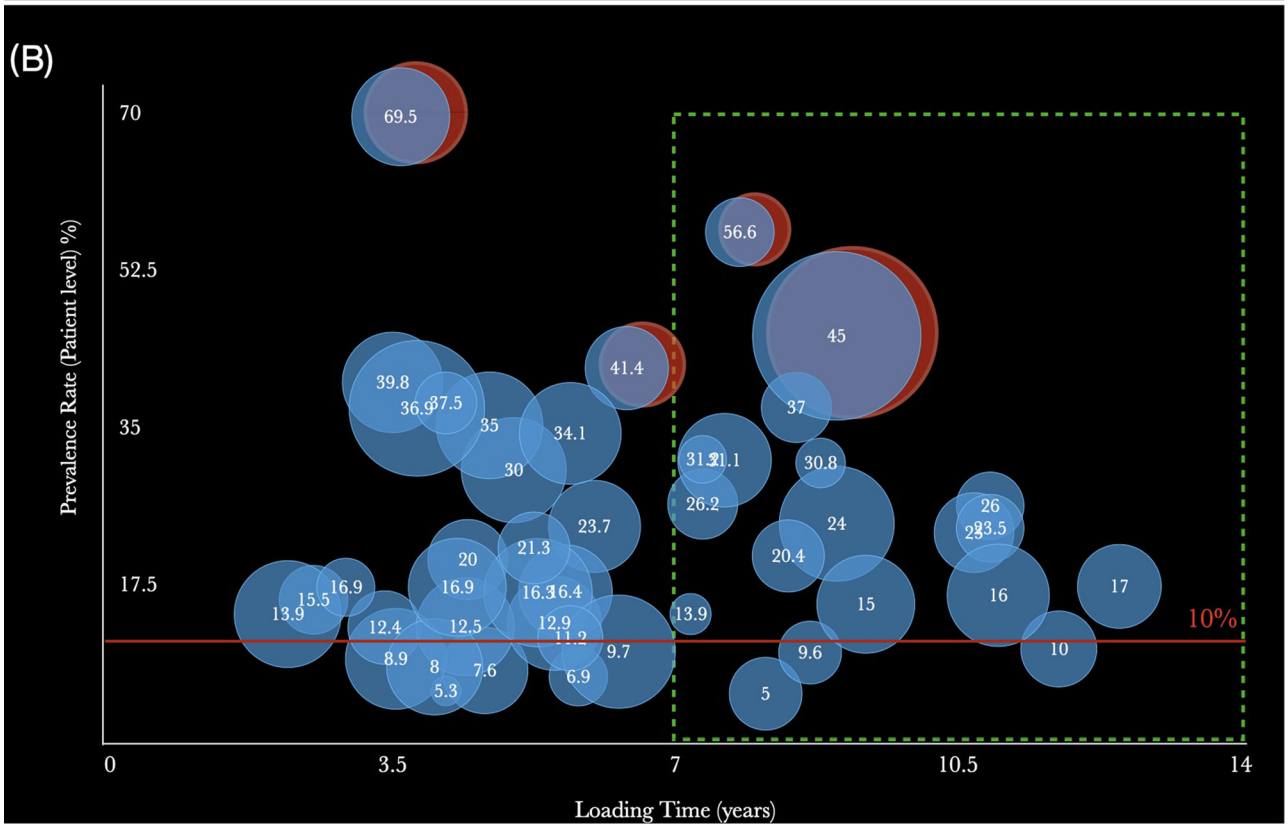

FIGURE 1 (A) Schematic world map depicting percentage of included studies per region, overall PR at patient level (meta-analyses weighted mean values), and mucositis and peri-implantitis PR ranges per region at patient level (Africa shows a single value rather than a range because only one study is available for this category). (B) Bubble chart depicting peri-implantitis PR (patient level) in relation to loading time; each bubble corresponds to one study (reporting on prevalence at patient level), and its diameter is proportional to the sample size of the respective study. PR over 40% are highlighted in red; loading time (7–14 years) encompassed in green framed region exhibits that with over 7 years of loading time, the majority of studies reported peri-implantitis PR over 10%. PR, prevalence rate.

Of these 102, 9.8% (n = 10)[75,85,86,94,95,97,98,100,116,122] reported outcomes on fully edentulous patients rehabilitated with overdentures and full-arch implant-supported prostheses. Among the included studies, three prospective longitudinal studies compared PIDs occurrence among patients with and without history of periodontitis.[102,109,111] One prospective study considered a controlled HIV population,[121] two studies considered individuals with liver disease (i.e., cirrhosis and liver transplantation),[126,127] one study considered postmenopausal women,[54] and two studies included patients with MTS.[36,65]

For case definition, 19 studies considered the World Workshop 2017 (WW 2017)[4] classification for peri-implant mucositis diagnosis[1,15,30–34,36,37,39,41,48,53,87,93,109,120,127,128] and 21 studies for peri-implantitis.[1,15,30–34,36,37,39,41,48,51,53,88,94,111,117,122,129,130] The remaining studies considered other case criteria evaluating both clinical and radiographic parameters for diagnosis, as described in detail in Tables 1 and 2.

In total, 13,030 patients (47.1% men and 52.3% women) ranging in age between 39 and 71 years were assessed in the present systematic review. The qualitative analyses included 39,991 implants, with a loading time ranging from 1 to 23.3 years. The overall median and range values for PD, BOP, and MBL were 3.03 mm (1.8–4.9), 45% (7–93.6), and −1.5 mm (−0.2 to 3), respectively. A complete description of the studies' data is presented in the supplementary material (see Tables S4-S7 in the online *Journal of Periodontology*).

3.3 | Risk of bias assessment

Based on the NOS, 6 observational studies[17,54,56,79,90,95] had an overall high risk of bias (6 stars) and 91 studies were judged to have a low risk of bias (7–8 stars). Based on the ROBINS-I tool, five interventional studies had an overall low risk of bias assessment. Two interventional studies[123,126] reported a moderate source of bias in the categories of missing data and bias in measurement of outcomes. The risk of bias for the included studies is presented in the supplementary data (see Tables S8–S10 in the online *Journal of Periodontology*).

3.4 | Synthesis of results

The results of individual study outcomes and meta-analyses pertaining to the prevalence, incidence, and the association of different risk indicators and factors to PIDs onset and progression are described below.

3.4.1 | Prevalence

Prevalence rates for peri-implant mucositis ranged from 7% to 83% at the patient level and from 7% to 85% at the implant level. Prevalence of peri-implantitis as a function of loading time can be observed in Figure 1B. Peri-implantitis prevalence ranged from 0% to 70.4% at the patient level and from 0% to 60% at the implant level. Meta-analyses for the prevalence of PIDs (patient level) revealed weighted mean values of 46% (95% CI, 41%–51%) and 21% (95% CI, 17%–24%) for peri-implant mucositis and peri-implantitis, respectively (Figure 2). Heterogeneity, expressed as I^2, was 94.3% and 94.0%, respectively. The majority of studies demonstrated the rate of prevalence to be over 10% after 7 years. Meta-analyses for the prevalence of PIDs (patient level), stratified at 5, 10, and 20 years (mean loading time), revealed weighted mean values of 44% (95% CI, 36%–53%) and 20% (95% CI, 14%–27%) after a mean loading time of 1–5 years for peri-implant mucositis and peri-implantitis, respectively. After 5–10 years of loading, the prevalence of peri-implant mucositis and peri-implantitis was 47% (95% CI, 40%–54%) and 22% (95% CI, 17%–28%), respectively, and between 10 and 20 years, 58% (95% CI, 51%–65%) and 19% (95% CI, 14%–24%), respectively (see Figures S2 and S3 in the online *Journal of Periodontology*).

The subanalysis on the prevalence of peri-implantitis considering only fully edentulous populations (at least one complete edentulous arch) revealed weighted mean values of 33% (95% CI, 3%–73%), I^2 = 95.8%. Egger test results and funnel plots are presented in the supplementary files (see Table S11 in the online *Journal of Periodontology*).

3.4.2 | Incidence

Patient level incidence rates for peri-implant mucositis ranged from 9% to 64% within 5 years, 48% to 77% within 10 years, and 57% to 68% within 20 years. Patient level peri-implantitis incidence rates ranged from 3% to 44% within 5 years, from 0% to 30% within 10 years, and from 14% to 40% within 20 years. Meta-analyses for the incidence of PIDs (patient level), stratified at 5, 10, and 20 years, revealed weighted mean values of 46% (95% CI, 25%–68%) and 12% (95% CI, 7%–19%) within 5 years for peri-implant mucositis and peri-implantitis, respectively. Within 10 years, the incidences of peri-implant mucositis and peri-implantitis were 61% (95% CI, 56%–65%) and 14% (95% CI, 9%–20%), respectively, and within 20 years, 53% (95% CI, 36%–65%) and 22% (95% CI, 11%–36%), respectively (Figure 3). The highest peri-implantitis incidence rates were reported in prospective studies assessing patient populations with a history

TABLE 1 Patient characteristics, peri-implant disease definitions, prevalence rates, clinical parameters, and associated risk indicators of cross-sectional studies.

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Ahn et al., 2019[84] >7 y	University, Asia Adult patients	BOP (+), PPD > 5 mm, MBL ≤ 2 mm	BOP (+), PPD > 5 mm, MBL > 2 mm	NR/39.7	NR/16.7	NR	NR	Female OR: 1.5 Smoking OR: 0.44	Female OR: 1.01 Smoker OR: 4.1
Aljalloud et al., 2023[44] >1 y	University, Asia Adult patients attending university setting	BOP without PD ≥ 6 mm and bone level ≥3 mm apical to most coronal portion of intraosseous part of implant	PD ≥6 mm with BOP or SUP and radiographic signs of bone level ≥3 mm apical to most coronal portion of intraosseous part of implant	58.5/NR	25.4/NR	4.43 ± 1.44	57.4 ± NR	Female OR: 0.27 Active periodontitis: OR: 2.4 Smoking OR: 1.521 Diabetes OR: 3.4 Age OR: 1.012	Female OR: 0.561 Active periodontitis: OR: 10.45 Smoker OR: 0.681 Age OR: 0.973 Diabetes OR: 2.64
Alves et al., 2020[17] 2.92 y	University, South America Patients treated at university setting	BOP in association with redness and swelling or SUP without BL	BL ≥ 3 mm and/or a PD ≥ 6 mm with BOP and/or SUP on probing	83.1/NR	16.9/NR	NR	NR	Female OR: 1.32 No osteoporosis OR: 0.67 Hypertension (no high systolic blood pressure) OR: 0.85 No obesity OR: 0.46 Age (<56 y) OR: 0.79	Female OR: 0.42 History of periodontal disease OR: 3.31 Hypertension (high systolic blood pressure) PR: 4.23 Obesity PR: 5.23 Age (<56 y) OR: 0.84
Apaza-Bedoya et al., 2023[1] 2.52 y	University, South America Multicenter Brazilian population patients with at least one dental implant with conical connection system	WW 2017 Classification	WW 2017 Classification	49.5/42.86	15.5/11.65	3.38 ± 1.66	53.38 ± NR	Male OR: 1.532 History of periodontal disease OR: 1.39 Diabetes (uncontrolled) OR: 3.087 Complete edentulism OR: 1.882 Osteoporosis OR: 6.086 No cardiovascular disease OR: 0.647 Age (older) OR: 0.966	Male OR: 2.39 History of periodontal disease OR: 2.74 Age (older) OR: 1.001 Nonsmoker OR: 0.608 Diabetes OR (uncontrolled): 1.046 Complete edentulism OR: 19.86 Osteoporosis OR: 7.74 No cardiovascular disease OR: 0.68

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Arunyanak et al., 2019[82] 4.3 y	University, South America Partially edentulous patients	BOP at at least one aspect of dental implant (recorded from mBLI) and no signs of supporting BL after initial bone remodeling	Soft tissue inflammation with BOP at at least one aspect of dental implant (recorded from mBLI) and BL beyond functional remodeling ≥2 mm from time of loading	NR/NR	16/NR	NR	NR	NR	History of periodontal disease OR: 2.55
Buonocunto et al., 2023[39] 2.5 y	University, Europe, multicenter Patients treated with implants inserted in sites treated with alveolar ridge preservation	WW 2017 Classification	WW 2017 Classification	45.1/37.7	5.9/8.2	NR	NR	Male OR: 0.56 History of periodontal disease OR: 2.81 Smoking OR: 1.81 Cardiovascular disease OR: 3 Age (older) OR: 1.04	Male OR: 4.57 History of periodontal disease OR: 5.55 Age (older) OR: 1.2 Smoker OR: 0.68 Cardiovascular disease OR: 0.6
Casado et al., 2013[78] NR	University, South America Adult nonsmoker patients attending university setting	BOP and absence of BL	BOP and BL from implant surgery, no threshold	19.4/24.7	30.1/4	2.6 ± NR	NR	NR	NR
Cecchinato et al., 2013[79] 10.7 y	Private practice, Europe Adult patients	NR	PPD ≥ 4 mm, BOP and BL > 0.5 mm from ≥1 y after loading	NR	23/11.3	NR	NR	NR	NR
Cetiner et al., 2021[66] 5.7 y	University, Europe Adult patients	BOP and/or SUP on gentle probing and MBL < 2 mm on baseline radiographs taken at delivery of prosthesis	BOP and/or SUP on gentle probing, and an MBL > 2 mm based on baseline radiographs taken at the delivery of the prosthesis	36.1/NR	34.1/NR	3.78 ± NR	48.7 ± NR	NR	NR

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Costa et al., 2022[53] >5 y	University, South America Adult patients attending university setting with >5 y of implant function with and without smoking habits	WW 2017 Classification	WW 2017 Classification	44/NR	21/NR	3.06 ± 1.5	47.5 ± NR	NR	Female OR: 1.16 Active periodontitis OR: 10.45 Smoker (former) OR: 1.31 Smoker (current) OR: 2.63 Alcohol consumption OR: 1.71 Age (>50 y) OR: 1.84
Costa, Cortelli, et al., 2022[127] >5 y	University, South America Adult patients attending university setting with and without liver cirrhosis	WW 2017 Classification	WW 2017 Classification	44.5/NR	23.85/NR	3.1 ± NR	48.15 ± NR	History of periodontal disease OR: 1.67 Smoking OR: 3.04	Male OR: 1.46 History of periodontal disease OR: 2.74 Smoker OR: 3.89 Cirrhosis (OR): 2.44 Alcohol consumption OR: 2.89 Age (>55 y) OR: 2.98
Dalago et al., 2017[2] 5.64 y	University, South America Multicenter patients treated with titanium implants (blasted with titanium particles)	NR	PD > 5 mm, at least one point with BOP/SUP on probing and BL > 2 mm	NR/NR	16.4/7.3	NR	NR	NR	History of periodontal disease OR: 2.2 Complete edentulism OR: 16.1
Daubert et al., 2015[46] 10.9 y	University, North America Adult patients	BOP and/or gingival inflammation with no evidence of radiographic BL beyond normal remodeling	BOP and/or SUP, with 2 mm of detectable BL after initial remodeling, and PD > 4 mm	48/33	26/16	NR	NR	NR	History of periodontal disease RR: 2.3 Active periodontitis (severe) RR: 7.3 Male RR: 1.4 Smoker RR: 1.5 Diabetes RR: 4.1 Complete edentulism RR: 1.2 Age (per 10 y) RR: 0.74

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Derks et al., 2016[52] 9 y	Dental clinic, Europe Adult patients who received implant-supported therapy for 9 y	BOP/SUP, but no detectable BL	BOP/SUP and detectable BL (>0.5 mm; exceeding measurement error)	32/35.1	45//54.2	NR	NR	NR	Active periodontitis OR: 4.08 Complete edentulism OR: 1.64
Di Murro et al., 2019[65] 7.87 y	University, Europe Adult patients attending university setting with >5 y of implant function	Peri-implant mucositis was characterized by presence of profuse (line or drop) BOP and/or SUP on gentle probing, without radiographic BL	BOP and/or SUP on gentle probing, with radiographic bone levels ≥3 mm	NR/46.2	NR/33.3	3.79 ± NR	NR	Obesity OR: 2.8	Obesity OR: 1.2
Dvorak et al., 2011[54] 6 y	University, Europe Female patients aged >45 y, postmenopausal, treated at university	NR	Patients with positive BOP and/or SUP, PD > 5 mm, and radiographic BL were diagnosed as having peri-implantitis	NR	23.7/13.3	NR	NR	NR	Active periodontitis OR: 0.57 Smoker OR: 4.17 Diabetes OR: 2.81 Osteoporosis OR: 2.07 Age OR: 0.99
Elemek et al., 2020[90] 3.6 y	University and practice based, Europe Adult patients	Presence of BOP and/or SUP and MBL < 2 mm	Presence of BOP and/or SUP and MBL ≥ 2 mm as proposed by 8th European Workshop on Periodontology	28/36	69.5/60.4	3.7 ± 1.6	93 ± NR	NR	NR

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Ferreira et al., 2006[18] 3.54 y	University, South America Multicenter partially edentulous adult dental implant patients	Presence of peri-implant BOP	PD 5 mm in association with peri-implant BOP and/or SUP and presence of vertical BL should be confirmed by radiographic exams for all different implant systems	64.6/62.6	8.9/7.44	NR	73.5 ± NR	Male OR: 1.7 Active periodontitis (periodontal BOP > 30% of sites) OR: 3.2 Diabetes (glucose >126 mg/dL or antidiabetic medicine over past 2 weeks) OR: 1.2 Age (>45 y) OR: 1.3	Male OR: 2.7 Age (>45 y) OR:1.7 Active periodontitis (periodontal BOP > 30% of sites) OR: 3.4 Diabetes (glucose >126 mg/dL or antidiabetic medicine over past 2 weeks) OR: 1.9
Ferreira et al., 2015[49] 4.02 y	University, South America Adult patients attending university setting	PD ≤ 4 mm with presence of BOP around implant presenting <2 mm of BL	PD ≥ 4 mm associated with BOP and/or SUP and BL ≥ 2 mm	23/23	8/9.4	NR	NR	Smoking OR: 1.17 Age (>57 y) OR: 0.65	NR
Grischke et al., 2019[92] 11.2 y	University, Europe Adult patients	Presence of BOP and/or SUP on gentle probing with or without increased PD compared with previous examinations and absence of BL beyond crestal bone level changes resulting from initial bone remodeling	NR	65.4/NR	NR/	2.8 ± 1.3	NR	NR	NR

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Grischke et al., 2021[69] 9.8 y	University, Europe Patients treated with fixed or removable dentures	defined by Group 4 of World Workshop on Periodontal and Peri-implant Disease Classification	defined by Group 4 of World Workshop on Periodontal and Peri-implant Disease Classification	NR/49.6	NR/16.4	3.96 ± 2.18	NR	NR	NR
Gündoğar et al., 2021[68] NR	University, Europe Geriatric patients treated at university	PPD ≤ 5 mm, BOP+ on at least one surface and ≤2 mm MBL	PPD > 5 mm, BOP+ on at least one surface and >2 mm MBL	24.7/NR	30.3/NR	NR	NR	NR	NR
Gunpinar et al., 2020[70] 3.8 y	University, Europe Patients treated at university	Diagnosed as tissue edema with BOP and absence of BL after initial crestal bone remodeling	BOP and/or SUP, PD > 5 mm, and MBL > 2 mm reference to most coronal part of implant	41.1/53.6	36.9/21.7	3.54 ± 1.53	50,49 ± NR	Active periodontitis OR: 3.342	Active periodontitis OR: 3.295
Jankovic et al., 2011[89] 4.16 y	University, Europe Healthy nonsmokers, partially edentulous patients	BOP, absence of radiographic BL or SUP	PD > 5 mm with BOP and/or SUP and concomitant radiographic BL (BL >3 threads)	31.2/31.3	37.5/37.6	3.55	NR	NR	NR
Jansson et al., 2022[129] 12.5 y	Public practice, Europe Adult patients attending public practice	BOP/SUP on pocket probing and radiographic BL 0.5 mm compared to baseline radiographs	BOP/SUP on probing, increased pocket depth compared to previous examinations and radiographic BL > 0.5 mm compared to baseline radiographs	NR/17.4	17/8.9	NR	NR	NR	Active periodontitis (general periodontitis stages III or IV at follow-up) OR: 5.9 Smoker (>5 cigarettes/day) OR: 3.9
Jervøe-Storm et al., 2023[41] 8.67 y	Private practice, Europe Patients with tissue-level implants treated at private practice	WW 2017 Classification	WW 2017 Classification	66.3/58.7	9.6/4.2	3.7	NR	NR	NR

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Kandasamy et al., 2018[83] >1 y	University, Asia Adult patients attending university setting, going through maintenance phase	NR	CAL ≥ 3 mm with BOP and evidence of bone resorption seen on radiograph	NR/NR	NR/15.3	3.34 ± NR	40.5 ± NR	NR	NR
Katafuchi et al., 2018[58] 10.9 y	University, North America Adult patients attending university setting	NR	BOP and/or SUP with 2 mm of detectable BL after initial remodeling and PD ≥ 4 mm	NR/NR	23.5/16.7	NR	NR	NR	NR
Kissa et al., 2021[33] 6.4 y	Private practice, Africa Adult patients attending a private dental clinic in Casablanca, Morocco	WW 2017 Classification	WW 2017 Classification	82.1/68.4	41.4/22.7	NR	NR	NR	NR
Koldsland et al., 2010[56] Part I	University, Europe Adult patients attending university setting	BOP/SUP without peri-implant BL	Peri-implant BL with inflammation	39.4/41	20.4/20.3	NR	NR	NR	NR
Koldsland et al., 2011[57] Part II 8.4 y	University, Europe Adult patients attending university setting	NR	Radiographic peri-implant BL > 2.0 mm and BOP/SUP at PPD > 4 mm	NR	20.4/20.3	NR	NR	NR	Male OR: 4.62 History of periodontal disease OR: 6.19 Smoker OR: 0.86
Konstantinidis et al., 2015[61] 5.5 y	University, Europe Partially edentulous adult patients attending university setting	BOP+	BOP, PPD > 4 mm, and radiographically detectable BL >2 mm	64.5/57	12.9/6.2	NR	NR	Female OR: 0.89 History of periodontal disease OR: 1.014 Smoking OR: 1.083 Diabetes OR: 1.025	History of periodontal disease OR: 1.063 Osteoporosis OR: 0.98

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TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Kungsadalpipob et al., 2020[80] 4.4 y	University, Europe Adult patients	Peri-implant soft tissue inflammation present with BOP at ≥1 aspect of implant (recorded from mSBI > 2) and no evidence of supporting BL after bone remodeling	BOP and/or SUP on probing at at least one aspect of dental implant (recorded from mSBI > 2) and BL around osseointegrated implant beyond functional remodeling ≥3 mm from time of loading	27.5/21.6	12.5/8.3	2.8 ± NR	NR ± NR	NR	NR
Latimer et al., 2021[48] >1 y	University, North America Partially edentulous adult patients attending university setting	WW 2017 Classification	WW 2017 Classification	54.1/34.5	26.2/19	3.8 ± 1.2	NR	NR	NR
Leone et al., 2023[47] Erratic complier group 9.5 y	University, Europe Adult patients attending university setting and erratic compliers	Presence of BOP/SUP after gentle probing (0.15 Ncm) Absence of BL beyond crestal bone level changes resulting from initial bone remodeling	With previous implant data: BOP/SUP after gentle probing (0.15 Ncm), increased PD compared with previous examinations, BL 1 mm beyond crestal bone level changes resulting from initial bone remodeling	NR/59.5	NR/36.5	4.77 ± 1.8	83 ± 26	NR	History of periodontal disease OR: 4.29

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Regular complier group 9.6 y	University, Europe Adult patients attending university setting and regular compliers	Presence of BOP/SUP after gentle probing (0.15 Ncm) Absence of BL beyond crestal bone level changes resulting from initial bone remodeling	In absence of previous implant data: BOP/SUP after gentle probing (0.15 Ncm), BL ≥3 mm from most coronal intraosseous portion of implant associated with PD ≥ 6 mm	NR/65.6	NR/8.8	3.62 ± 1.25	53 ± 36	NR	NR
Marrone et al., 2013[45] 8.5 y	University, Europe Adult patients with >5 y function	BOP, no radiological BL or BL 2 mm, absence of PPD > 5 mm	Radiological BL > 2 mm, BOP and PPD > 5 mm	31/38	37/23	NR	21 ± 8.5	NR	History of periodontal disease OR: 0.89 Active periodontitis OR: 1.988 Age (>65 y) OR: 1.39 Smoker (at least one cigarette per day) OR: 1.003 Diabetes OR: 0.914 Complete edentulism OR: 5.57
Matarazzo et al., 2018[64] 3.5 y	University, South America Adult patients	BOP/SUP and MBL < 2 mm	BOP/SUP, and MBL ≥2 mm	54.5/69.2	39.8/20.5	3 ± NR	71 ± NR	NR	Male OR: 1.954
Máximo et al., 2008[55] 3.4 y	University, South America Adult patients	BOP without radiographic BL or presence of radiographic BL, 3 threads	Presence of PD > 5 mm with BOP and/or SUP and radiographic BL > 3 threads	36.3/32	12.4/7.5	NR	NR	NR	NR

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Menini et al., 2018[85] 5.8 y	University, Europe Patients rehabilitated in maxilla and/or mandible with fixed full-arch prostheses supported by 4–6 immediately loaded implants, regular maintenance one time per y	BOP in mucosa at implant with no signs of loss of supporting bone	Loss of supporting bone in addition to inflammation in mucosa	20.8/10.57	6.9/1.51	1.8 ± NR	21.1 ± NR	NR	NR
Mir-Mari et al., 2012[60] 5.3 y	Private practice, Europe Patients enrolled in periodontal maintenance program (with follow-up visits every 3–6 months)	BL < 2 threads with BOP	BL > 2 threads with BOP or SUP	38.8/21.6	16.3/9.1	2.8 ± NR	NR	NR	Active periodontitis OR: 3.295
Monje and Blasi, 2019[87] 5.73 y	University, Europe Nonsmoking partially edentulous patients with gaps associated to at least one mesial and one distal adjacent tooth	WW 2017 Classification	WW 2017 Classification	NR/26	NR/14	4.13 ± NR	NR	NR	NR
Obreja et al., 2022[32] 3.8 y	University, Europe Patients who underwent immediate implant placement and immediate load, German population	WW 2017 Classification	WW 2017 Classification	45.5/45.6	0/0	2.52 ± 0.88	13.2 ± NR	NR	NR

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Obreja et al., 2021[131] 9.36 y	University, Europe Patients with attendance of yearly routine maintenance appointment, regular compliers, German population	WW 2017 Classification	WW 2017 Classification	62.6/66.5	15/7.5	2.87 ± 0.85	27.09 ± 31.26	NR	History of periodontal disease OR: 5.33
Obreja et al., 2021[128] No soft tissue graft at implant placement group 7.19 y	University, Europe Patients with at least one dental implant (conical connection) with attendance of yearly routine maintenance appointment, German population	WW 2017 Classification	WW 2017 Classification	52.8/52.7	13.9/9.1	2.99 ± 0.64	29.44 ± 30	NR	NR
Soft tissue graft at implant placement group 4.16 y	University, Europe Patients with at least one dental implant (conical connection) with attendance of yearly routine maintenance appointment, German population	WW 2017 Classification	WW 2017 Classification	42.1/44.8	5.3/3.4	2.4 ± 0.54	13.83 ± 19.4	NR	NR
Ogata et al., 2017[88] 6.3 y	Private practice, Asia Multicenter partially edentulous patients treated at private practice, regular compliers	Bleeding on gentle probing (<0.25 Ncm)	Changes on level of crestal bone in conjunction with BOP	33.3/33.3	9.7/9.7	3.4 ± 1.6	43.1 ± NR	NR	NR

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TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Papi et al., 2019[36] 7.61 y	University, Europe Adult dental implant patients attending university setting with >5 y of implant function	WW 2017 Classification	WW 2017 Classification	57.9/NR	31.1/NR	3.71 ± 1.48	NR	Female OR: 2.572 Active periodontitis: OR: 4.31 Smoking OR: 0.723 Obesity OR: 10.07	Female OR: 1.59 Active periodontitis OR: 9.004 Smoker OR: 1.17 Obesity OR: 15.29
Papi, Pranno, Di Murro, et al., 2023[37] No subclinical atherosclerosis group 7.61 y	University, Europe Patients with hypertension	WW 2017 Classification	WW 2017 Classification	41.7/NR	31.2/NR	NR	NR	NR	NR
Subclinical atherosclerosis group 7.34 y	University, Europe Patients with hypertension	WW 2017 Classification	WW 2017 Classification	64.1/NR	26.2/NR	NR	NR	Cardiovascular disease (c-IMT > 0.9 mm and/or plaque presence) OR: 3.34	NR
Parvini et al., 2023[35] Tapered connection dental implant with a grit-blasted surface[a] group 5.24 y	University, Europe Partially edentulous patients with immediate implant placement and immediate restoration in the esthetic zone	WW 2017 Classification	WW 2017 Classification	10/10	0/0	2.31 ± 2.17	12 ± 22	NR	NR

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TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Self-tapping dental implant with a sandblasted, large grit, acid-etched surface[b] group 2.22 y	University, Europe Partially edentulous patients with immediate implant placement and immediate restoration in esthetic zone	WW 2017 Classification	WW 2017 Classification	7/7	0/0	2.23 ± 0.35	7 ± 13	NR	NR
Perussolo et al., 2022[67] 6.7 y	University, South America Patients treated at university	Presence of peri-implant visual signs of inflammation combined with profuse BOP and/or SUP and absence of BL beyond crestal bone level changes resulting from initial bone remodeling (<3 mm)	Presence of peri-implant visual signs of inflammation combined with profuse BOP and/or SUP, PD ≥ 6 mm, and radiographic evidence of bone level ≥3 mm apical to most coronal portion of intraosseous part of implant	NR/60.6	NR/7.7	2.90 ± 1.18	NR ±	NR	NR
Pimentel et al., 2018[72] >1 y	University, South America Multicenter partially edentulous patients with dental implants that had been rehabilitated with implant-supported fixed prostheses	Presence of BOP and/or SUP and radiographic BL < 2 mm	BOP and/or SUP, PD > 4 mm and radiographic BL ≥ 2 mm	80.9/85.3	19.1/9.2	NR	NR	NR	Smoker prevalence ratio: 6.59
Ramanauskaite et al., 2020[31] No bone grafting at implant placement group 11.75 y	University, Europe Patients with at least one dental implant (conical connection) and attendance of yearly routine maintenance appointment	WW 2017 Classification	WW 2017 Classification	61/64	10/8	3 ± 0.85	36.77 ± 32.33	NR	NR

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TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Bone grafting at implant placement group 8.12 y	University, Europe Patients with at least one dental implant (conical connection) and attendance of yearly routine maintenance appointment	WW 2017 Classification	WW 2017 Classification	68/66	5/5	2.78 ± 0.88	35.53 ± 32.67	NR	NR
Rinke et al., 2011[91] 5.7 y	Private practice, Europe Patients treated with dental implants	PPD > 4 mm and BOP	Peri-implantitis was diagnosed if progressive BL could be determined in addition to symptoms of peri-implant mucositis	44.9/NR	11.2/NR	NR	NR	Smoker OR: 3.77	Smoker OR: 31.58
Rodrigo et al., 2018[38] 9 y	Private practice, Europe Multicenter patients treated in Spain with 5 y of implant function	BOP and radiographic bone levels <2 or <3 mm	BOP and radiographic bone levels ≥2 mm	27/27	24/20	2.76 ± 1.33	46 ± NR	NR	Female OR: 0.5
Rokn et al., 2017[73] 4.43 y	University, Asia Partially edentulous patients with dental implants that had been rehabilitated with implant-supported fixed prostheses	Radiographic BL ≤ 2 mm and presence of BOP+ and/or SUP	BOP+ and/or SUP in combination with radiographic crestal BL > 2 mm	48.5/40	20/8.8	NR	NR	NR	Smoker (active) OR: 2.56
Romandini et al., 2019[86] 8.82 y	Hospital, Europe Edentulous patients rehabilitated with overdentures without supportive maintenance program	Presence of inflammation (BOP and/or SUP) with concomitant MBL < 2 mm	Presence of inflammation (BOP and/or SUP), PPD ≥ 4 mm ≤ 6 mm, and CBL ≥ 2 mm < 4 mm	NR/NR	30.8/19.4	NR	NR	NR	NR

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TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Romandini et al., 2021[15] 7.8 y	University, Europe Adult patients	WW 2017 Classification	WW 2017 Classification	42.4/63.6	56.6/27.9	NR	NR	NR	Active periodontitis OR: 2.77 Smoker (active) OR: 3.59 Smoker (former) OR: 1.89 Complete edentulism OR: 1.3
Roos-Jansåker, Lindahl, et al., 2006[76] Part II	Private practice, Europe Adult patients attending practice setting with 9–14 y of follow-up	PPD ≥4 mm, BOP, and bone level <1 thread	BOP/SUP and BL ≥1.8 mm from Year 1 after loading	48/16	16/6.6	NR ± NR	46.6 ± 27	NR	NR
Roos-Jansåker, Renvert, et al., 2006[77] Part III 11 y	Private practice, Europe Adult patients attending practice setting with 9–14 y of follow-up	PD > 4 mm and BOP	BL > 3 threads when comparing radiographs taken at final examination with radiograph taken 1 y after placement of superstructure, combined with BOP and/or pus	NR/NR	NR/NR	NR	46.6 ± 27	Smoking OR: 2.8	History of periodontal disease (30%–100% teeth with BL) OR: 4.7 Smoker OR: 4.6
Sánchez-Siles et al., 2015[81] 6.44 y	Private practice, Europe Adult patients using implant-supported fixed prostheses	NR	Changes on level of crestal bone in conjunction with BOP with or without concomitant deepening of peri-implant pockets and presence of pus	NR/NR	NR/9.6	NR	NR	NR	Age OR: 1.08 Smoker OR 1.54: Alcohol consumption OR: 2.04

(Continues)

TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Schuldt Filho et al., 2014[75] >1 y	University, South America Fully edentulous adult patients attending university setting that did not have any routine maintenance care	NR	PD > 4 mm, at least one point with BOP/SUP and BL > 2 mm	NR/NR	70.37/28	NR	NR	NR	Age (≤60 y) OR: 3.24
Schwarz et al., 2017[40] 2.2 y	University and private practice, Europe Patients with two-piece implant system with tube-in-tube internal connection	BOP at at least one aspect of implant, but no changes in radiographic bone level compared to baseline (i.e., radiograph taken at time of prosthesis installation)	BOP with or without pus and changes in radiographic bone level compared to baseline (i.e., radiograph taken at time of prosthesis installation)	41.6/35.6	13.9/7.6	NR	27.09 ± 31.26	Male OR: 2.003	Smoker OR: 2.68
Stacchi et al., 2021[43] 4.64 y	Private practice, Europe Multicenter patients treated with implants inserted in augmented maxillary sinuses	NR	Presence of BOP and/or SUP on gentle probing, increased PD compared with baseline examination, and presence of radiographic MBL	10.8/10.9	7.6/14	NR	NR	NR	Male OR: 0.74 History of periodontal disease OR: 13.46 Diabetes (controlled) OR: 9.9 Age (older) OR: 1.011 Smoker OR: 3.35
Strooker et al., 2022[63] 5 y	Private practice, Europe Patients treated in private practice	NR	Progressive radiographic BL ≥2 mm combined with presence of at least one bleeding pocket (bleeding index ≥2) of ≥4 mm and/or SUP	NR/NR	30/23	NR ± NR	NR ± NR	NR	Smoker OR: 2.245 Depression OR: 2.04

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TABLE 1 (Continued)

Authors, year, and mean loading time	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Prevalence mucositis, % (patient/implant level)	Prevalence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Tsaousoglou et al., 2023[34] 5.25 y	University, Europe Adult patients	WW 2017 Classification	WW 2017 Classification	NR/NR	21.3/NR	4.9 ± 1.71	63.4 ± NR	NR	History of periodontal disease OR: 3.11
Vignoletti et al., 2019[74] 4.7 y	University, Europe Adult patients	BOP and/or SUP and radiographic bone level <2 mm apical of reference landmark	BOP and/or SUP and radiographic bone level ≥2 mm apical of reference landmark	38.8/37.7	35/17.1	NR	NR	NR	Smoker OR: 1.8
Vilarrasa et al., 2021[71] >1 y	University, Europe Partially edentulous adult patients	BOP/SUP with or without increased PPD compared to previous examinations, without additional BL after initial marginal bone remodeling	BOP with or without concomitant PPD deepening, with progressive BL	NR/56.2	22.5/NR	NR	NR	Male OR: 0.31 History of periodontal disease OR: 1.12 Xerostomia OR: 1.99 Sugar-rich diet OR: 3.24	Male OR: 0.61 History of periodontal disease OR: 3.74 Xerostomia OR: 2.16 Sugar-rich diet OR: 5.38
Weinstein et al., 2020[42] NR	Private practice, Europe Multicenter patients treated in Italy	NR	BOP, exudate/SUP, BL > 0.2 mm/y and increased pocket depth	NR/NR	4.03/1.2	NR	NR	NR	History of periodontal disease OR: 2.42 Smoker (>10 cigarettes/day) OR: 0.53 Diabetes OR: 8.65
Yi et al., 2020[51] >5 y	University, Asia Adult patients	NR	WW 2017 Classification	NR/NR	NR/24.8	NR	NR	NR	History of periodontal disease OR: 2.34

Abbreviations: BL, bone loss; BOP, bleeding on probing; BOP+, BOP positive; CAL, clinical attachment level; CBL, crestal bone loss; c-IMT, carotid intima-media thickness; MBL, marginal bone loss; MBLi, implant marginal bone loss; NR, not reported; OR, odds ratio; PD, probing depth; PPD, probing pocket depth; PR, prevalence rate; RR, relative risk; SUP, suppuration; WW 2017, World Workshop 2017; y, years.

[a]Ankylos; Dentsply Sirona Implants, Hanau, Germany.

[b]BLX; Institute Straumann (AG), Basel, Switzerland.

TABLE 2 General characteristics, peri-implant disease definitions, incidence rates, clinical parameters, and associated risk indicators of the included prospective cohort and interventional studies.

Authors, year, and follow-up period	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Incidence mucositis, % (patient/implant level)	Incidence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Bergkvist et al., 2009 2.8 y	Private practice, Europe Maxillary edentulous population	Positive BOP	Bleeding after gentle probing together with increased PD, occasional SUP, and radiographic loss of crestal bone	NR	2.8 y: 3.8/2.8 y: 1.3	NR	NR	NR	NR
Costa et al., 2012[96] 5 y Irregular complier group	University, South America Adult patients attending university setting that had no maintenance	NR	PDi 5 mm associated with bleeding on peri-implant probing and/or SUP with peri-implant BL	NR	5 y: 43.9/NR	NR	40.4 ± 20.7	NR	NR
Regular complier group	Adult patients attending university setting that had maintenance	NR	PDi 5 mm associated with bleeding on peri-implant probing and/or SUP with peri-implant BL	NR	5 y:18/NR	NR	26.06 ± 19.6	NR	NR
Total sample	Adult patients attending university setting that had maintenance vs. no maintenance	NR	PDi 5 mm associated with bleeding on peri-implant probing and/or SUP with peri-implant BL	NR	5 y: 31.2/NR	NR	31.5 ± NR	NR	Active periodontitis OR: 9.29
Costa et al., 2023[120] Irregular complier group 17.9 y	University, South America Patients that are irregular compliers with dental implants	WW 2017 Classification	WW 2017 Classification	11 y: 70.8/NR	11 y: 37.5/NR	NR	39.9 ± 13.9	NR	Male OR: 3.23 Active periodontitis OR: 7.28
Regular complier group 18.16 y	Patients that are regular compliers with dental implants	WW 2017 Classification	WW 2017 Classification	11 y: 37/NR	11 y: 11.1/NR	NR	25.7 ± 11.1	NR	NR

(Continues)

TABLE 2 (Continued)

Authors, year, and follow-up period	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Incidence mucositis, % (patient/implant level)	Incidence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Degidi et al., 2013[98] 6 y	Private practice, Europe Fully edentulous patients	Inflammation of mucosal cuff around neck of implant associated with edema, rubor, and BOP	Purulence and peri-implant radiological translucency	NR/6 y: 11.85	NR/6 y: 3.31	NR	NR	NR	NR
Donati et al., 2016[99] 12 y	University, Europe Healthy patients treated in implant center	BOP+	(BOP+) in combination with radiologically assessed BL of ≥2 mm	NR/12 y: 25	12 y: 10/12 y: 8.6	NR	NR	NR	NR
Fischer and Stenberg, 2012[100] 10 y	Private practice, Europe Maxillary edentulous population	NR	Perfuse bleeding including SUP after probing in combination with BL exceeding 4 mm.	NR	5 y: 4.34/NR	NR	NR	NR	NR
Flores-Guillen et al., 2018[124] 5 y	University, Europe Adultpatients attending university setting that are regular compliers	Presence of BOP	Presence of changes in level of crestal bone (≥2 mm) and BOP	NR	5 y: 3.33/NR	3.08 ± NR	NR	NR	NR
Gherlone et al., 2016[121] 1 y	University, Europe Controlled HIV-positive patients requiring implant rehabilitation, with good oral hygiene	NR	Progressive BL with sign of infections around osseointegrated implant	NR	1 y: 10.6/1 y: 5.2	NR ± NR	NR	NR	NR
Karoussis et al., 2004[102] History of periodontitis group	University, Europe Adult patients attending university setting with history of periodontitis	NR	PD > 5 mm with BOP and radiographic signs of BL	NR	NR/10 y: 28.6	3.03 ± 1.58	29 ± 36	NR	NR

(Continues)

TABLE 2 (Continued)

Authors, year, and follow-up period	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Incidence mucositis, % (patient/implant level)	Incidence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Without history of periodontitis group 10 y	Adult patients attending university setting without history of periodontitis	NR	PD > 5 mm with BOP and radiographic signs of BL	NR	NR/10 y: 5.8	2.52 ± 0.64	40 ± 33	NR	NR
Karoussis et al., 2004[101] 10 y	University, Europe Patients with history of periodontitis with regular maintenance therapy	NR	PD > 5 mm with BOP and radiographic signs of BL	NR	NR/10 y: 15.4	2.36 ± NR	45 ± NR	NR	NR
Krennmair et al., 2019[103] 5 y	Private practice, Europe Patients treated in private practice with implants placed in staged maxillary augmented sinus, enrolled in regular hygiene program	Presence of at least one implant surface with BOP+	BOP and radiographically detectable MBL > 2.0 mm	1 y: 23.7, 3 y: 28.9, 5 y: 26.3/1 y: 16.7, 3 y: 17.5, 5 y: 20.8	1 y: 3.9, 3 y: 3.9, 5 y: 6.6/1 y: 2.2, 3 y: 2.9, 5 y: 3.3	2.59 ± 0.7	NR	NR	NR
Li et al., 2017[94] 5 y	Private practice, Europe Patients with advanced gap treated with immediate implant placement	NR	BL > 2 mm with BOP	NR	NR/5 y: 1.25	3 ± 0.5	NR	NR	NR
Mameno et al., 2019[104] 10 y	University, Asia Adult patients attending university setting with regular maintenance every 6 months	NR	BOP and/or SUP with bone resorption >1 mm, in accordance with previous studies	NR	10 y: 15.3/10 y: 9.15	NR	NR	NR	Age (per 10 y) HR: 0.94 Female HR: 0.82 Smoker HR: 3.03

(Continues)

TABLE 2 (Continued)

Authors, year, and follow-up period	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Incidence mucositis, % (patient/implant level)	Incidence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Mangano et al., 2014[119] 10 y	Private practice, Europe Adult patients treated with locking-taper implants	Not clear	PD > 6 mm with BOP/SUP and radiographic BL/DIB > 2.5 mm	NR/10 y: 0.9	NR	NR	NR	NR	NR
Mei et al., 2017[105] 5 y	Implant center, Asia Patients treated in implant center in need of one implant	Presence of plaque-related inflammatory soft tissue infiltration without concurrent loss of peri-implant bone tissue	MBL > 5 mm in combination with BOP, SUP, or both	5 y: 9.1/5 y: 9.2	NR	2.4 ± NR	NR	NR	NR
Meijer et al., 2014[97] 5–10 y	Private practice, Europe Fully edentulous patients with mandibular overdenture	Radiographic BL (<2 mm): BOP+ and/or SUP	BOP+ and/or SUP in combination with radiographic BL ≥2 mm	5 y: 51.9, 10 y: 57/5 y: 41.2, 10 y: 47	5 y: 16.9, 10 y: 29.7/5 y: 11.5, 10 y: 20.3	3.4 ± 1.1	NR	NR	NR
Meyle et al., 2014[106] 5–10 y	Private practice, Europe Nonsmoking patients with a previous history of chronic periodontitis	NR	Loss of radiographic bone (at mesial, distal, or both peri-implant sites) after 5 or 10 y compared to baseline, combined with BOP/SUP (at least at one peri-implant site)	NR	5 y: 18.2, 10 y: 30/5 y: 8.9, 10 y: 23.8	3.3 ± 1	27 ± 17	NR	NR
Onclin et al., 2022[122] 5–10 y	University, Europe Fully edentulous patients with maxillary overdenture	Bleeding and/or SUP on probing (BOP+) with radiographic MBL < 2 mm	Bleeding and/or SUP on probing (BOP+) and MBL ≥ 2 mm compared to baseline	5 y: 37.7, 10 y: 64.6/5 y: 17.1, 10 y: 35.2	5 y: 10.4, 10 y: 19.5/5 y: 3.2, 10 y: 8.5	4.3 ± 1.2	NR	NR	NR

(Continues)

TABLE 2 (Continued)

Authors, year, and follow-up period	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Incidence mucositis, % (patient/implant level)	Incidence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Paredes et al., 2018[126] Liver transplantation group 9.85 y	University, Europe Patients who received liver transplant more than 18 months and immunosuppressive treatment, nonsmokers, regular compliers	PD > 4 mm, BOP, and no BL	BOP or pus and BL > 3 threads	NR	NR	2.95 ± 0.66	35.42 ± NR	NR	NR
No liver transplantation group 9.5 y	University, Europe Patients treated at private practice, regular compliers	PD > 4 mm, BOP, and no BL	BOP or pus and BL > 3 threads	NR	NR	2.68 ± 3	43.40 ± NR	NR	NR
Raes et al., 2018[107] 8 y	Private practice, Europe Healthy, partially nonsmoking, edentulous patients	NR	Progressive BL (>2 mm) and deep pockets (>6 mm)	NR	8 y: 6.9/8 y: 6.9	3.05 ± NR	NR	NR	NR
Renvert et al., 2012[123] Medium rough implant surface TiOblast implant group (AT)[a] 7 y	Public dental health department, Europe Adult patients with dental implants	NA	BL after first year after implant installation, >1.0 mm in conjunction with BOP with or without SUP	NR	NR/7 y: 26.2	1.9 ± 2.2	93.6 ± NR	NR	NR
Medium rough implant surface TiOblast implant group (AT)[b] 13 y	Adult patients with dental implants	NA	BL after the first year after implant installation, >1.0 mm in conjunction with BOP with or without SUP	NR	NR/13 y: 32.1	2.6 ± 2.3	89.7 ± NR	NR	NR

(Continues)

TABLE 2 (Continued)

Authors, year, and follow-up period	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Incidence mucositis, % (patient/implant level)	Incidence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Smooth machine-etched surface implant group[c] (NB) 7 y	Adult patients with dental implants	NA	BL after first year after implant installation, >1.0 mm in conjunction with BOP with or without SUP	NR	NR/7 y: 30.4	2.4 ± 2.2	79.8 ± NR	NR	NR
Smooth machine-etched surface implant group (NB)[d] 13 y	Adult patients with dental implants	NA	BL after first year after implant installation, >1.0 mm in conjunction with BOP with or without SUP	NR	NR/13 y: 39.7	3.1 ± 2.2	82.1 ± NR	NR	NR
Renvert et al., 2018[108] 23.3 y	University, Europe Patients who had received dental implants between 1988 and 1993	BOP and/or SUP, but without any evidence of BL	Changes in level of crestal bone, presence of BOP and/or SUP, with or without concomitant deepening of peri-implant pocket	NR	NR	NR	63.8 ± 27.4	NR	History of periodontal disease OR: 2.8
Roccuzzo et al., 2023[109] 10 y	Private practice, Europe Patients with dental implants attending specialist periodontal practice run by senior investigator	WW 2017 Classification	WW 2017 Classification	NR	NR	4.5 ± NR	33.7 ± NR	History of periodontal disease OR: 1 Smoker OR: 1.5	History of periodontal disease OR: 2.9 Smoker OR: 1.6
20 y	Patients with dental implants attending specialist periodontal practice run by senior investigator	WW 2017 Classification	WW 2017 Classification	NR	NR	4.2 ± NR	27.5 ± NR	History of periodontal disease OR: 1.6 Smoker OR: 1.2	History of periodontal disease OR: 2.3 Smoker OR: 1.4
History of periodontitis group 10–20 y	Patients with history of periodontitis	WW 2017 Classification	WW 2017 Classification	10 y: 47.6, 20 y: 40.3/10 y: 56.4/20 y: 51.4	10 y: 14.3, 20 y: 40.3/10 y: 14.3, 20 y: 35.4	4.4 ± 1.4	30.1 ± 27.5	NR	NR

(Continues)

TABLE 2 (Continued)

Authors, year, and follow-up period	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Incidence mucositis, % (patient/implant level)	Incidence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Without history of periodontitis group 10–20 y	Patients without history of periodontitis	WW 2017 Classification	WW 2017 Classification	10 y: 77, 20 y: 68.2/10 y: 74.4, 20 y: 56.4	10 y: 0, 20 y: 13.6/10 y: 0, 20 y: 17.9	4 ± 1.3	25 ± 22	NR	NR
Rodrigo et al., 2012[110] 5 y	Private practice, Europe Patients that needed at least two implants for replacing hopeless teeth—one immediate and one delayed implant	PPD > 4 mm that bled on probing but without significant BL	PD > 4 mm plus BOP plus significant BL	NR/5 y: 20	NR/5 y: 5.8	NR	28.5 ± NR	NR	NR
Swierkot et al., 2012[111] 3–16 y Total sample	University, Europe Adult patients	PD > 5 mm with BOP and no BL	PD > 5 mm with or without BOP and annual BL of >0.2 mm	5 y: 64/5 y: 53	5 y: 32/5 y: 23	NR	NR	Age (>50 y) OR: 0.42 History of periodontal disease OR: 3.6 Smoker (former) OR: 6.45	Age (<50 y) OR: 0.119 Male OR: 0.135 History of periodontal disease (aggressive periodontitis) OR: 14.09
With history of periodontitis group	Adult patients attending university setting (aggressive periodontitis history)	PD > 5 mm with BOP and no BL	PD > 5 mm with or without BOP and annual BL of >0.2 mm	5 y: 74/5 y: 56	5 y: 43.9/5 y: 26	NR	NR	NR	NR
Without history of periodontitis group	Adult patients attending university setting without history of periodontitis	PD > 5 mm with BOP and no BL	PD > 5 mm with or without BOP and annual BL of >0.2 mm	5 y: 44/5 y: 40	5 y: 11.1/5 y: 10	NR	NR	NR	NR

(Continues)

TABLE 2 (Continued)

Authors, year, and follow-up period	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Incidence mucositis, % (patient/implant level)	Incidence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Thöne-Mühling et al., 2020[112] 10 y	University, Europe Adultpatients with history of periodontitis	PD ≥ 5 mm with BOP and annual BL ≤ 0.2 mm at 1 y after implant loading	Annual BL > 0.2 mm and PD > 5	NR/10 y: 21.4	NR/10 y: 13.5 NR/20 y: 21	NR	NR	NR	NR
20 y	University, Europe Adultpatients with history of periodontitis	PD ≥ 5 mm with BOP and annual BL ≤ 0.2 mm at 1 y after implant loading	Annual BL > 0.2 mm and PD > 5	NR/20 y: 27	NR/20 y: 21	NR	NR	Age (>50 y) OR: 0.727 Female OR: 0.688 History of periodontal disease (aggressive periodontitis) OR: 2.5	Age (>50 y) OR: 1.21 Female OR: 1.12 History of periodontal disease (aggressive periodontitis) OR: 2.4
Tormena et al., 2020[113] 4 y	University, South America Partially edentulousattending university setting	Signs of inflammation and no detectable BL	Detectable BL > 1 mm in combination with BOP/SUP	2 y: 92.7, 4 y: 85/2 y: 96, 4 y: 81.6	2 y: 0, 4 y: 9/2 y: 0/4 y: 5	2.6 ± NR	91 ± NR	NR	NR
van Velzen et al., 2015[114] 10 y	Private practice, Europe Partially and fully edentulous patients	BOP without BL	BOP and BL ≧1.5 mm	10 y: 59.8/10 y: 45.5	10 y: 14.8/10 y: 7	3.71 ± 1.12	52 ± NR	NR	NR

(Continues)

TABLE 2 (Continued)

Authors, year, and follow-up period	Setting and patient characteristics	Peri-implant mucositis definition	Peri-implantitis definition	Incidence mucositis, % (patient/implant level)	Incidence peri-implantitis, % (patient/implant level)	PD, mm (mean ± SD)	BOP, % (mean ± SD)	Mucositis systemic risk indicators	Peri-implantitis systemic risk indicators
Windael et al., 2018[118] 10 y	University, Europe Mandibular edentulous patients treated with fluoride-modified implants	NR	BOP in combination with MBL exceeding 2 mm	NR/10 y: 49.5	10 y: 10/10 y: 4.8	3.73 ± 0.73	NR	NR	NR
Windael et al., 2020[115] 11.38 y	Private practice, Europe Adult patients attending private practice	NR	WW 2017 Classification	NR	NR/10 y: 12.6	4.25 ± 1.26	30 ± 38	NR	NR
Zetterqvist et al., 2010[125] 5 y	University, Europe Multicenter nonsmoking healthy adult patients	NR	PPD > 5 mm, BOP/SUP, and BL > 5 mm from loading	NR	5 y: 1/NR	NR	NR	NR	NR
Zhang et al., 2016[116] 10 y	Hospital, Asia Edentulous adult patients that received dental implants with an early loading (6 weeks)	NR	MBL exceeding 3 mm in combination with BOP or SUP, or both	NR	10 y: 9/10 y: 1.2	2.78 ± 0.5	NR	NR	NR
Zhang et al., 2018[117] 1–5 y	University, Asia Patients with history of severe periodontitis	NR	Presence of bleeding and and/or SUP on gentle probing Increased PD compared to previous examinations Presence of BL beyond crestal bone level changes resulting from initial bone remodeling	NR	5 y: 16/5 y: 11.2	3.12 ± NR	NR	NR	NR

Abbreviations: BL, bone loss; BOP, bleeding on probing; BOP+, BOP positive; DIB, distance between implant shoulder and first visible bone–implant contact; HR, hazard ratio; MBL, marginal bone loss; NR, not reported; OR, odds ratio; PD, probing depth; PDi, implant probing depth; PPD, probing pocket depth; SUP, suppuration; WW 2017, World Workshop 2017; y, years.

[a]TioBlast AstraTech (AT).

[b]TioBlast AstraTech (AT).

[c]Branemark Nobel Biocare.

[d]Branemark Nobel Biocare.

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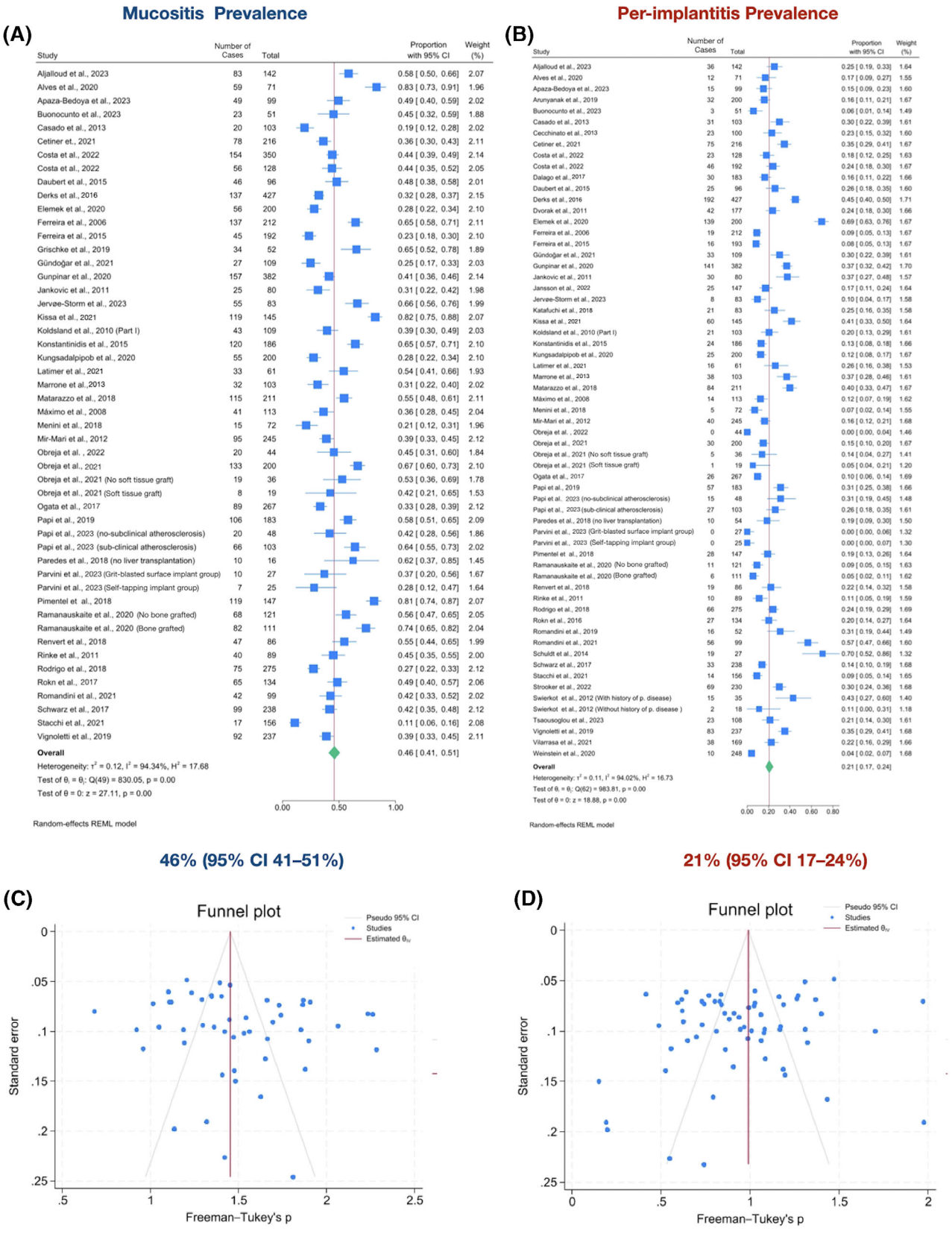

FIGURE 2 Forest plots (A, B) and corresponding funnel plots (C, D) for prevalence of peri-implant mucositis and peri-implantitis at patient level.

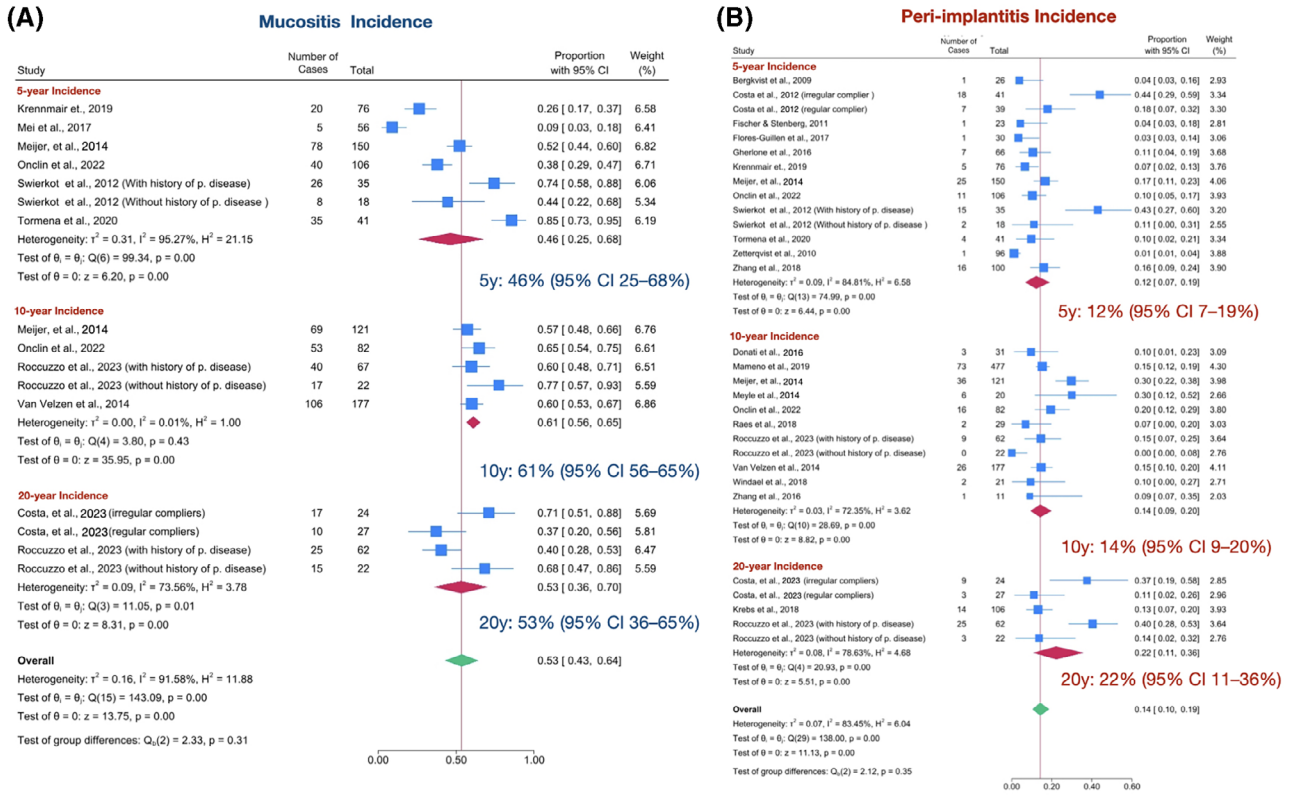

FIGURE 3 Forest plots for incidence of (A) peri-implant mucositis and (B) peri-implantitis at patient level stratified within 5, 10, and 20 years.

of periodontitis,[106, 109, 111] fully edentulous patients,[97] and erratic maintenance compliers.[96,120]

3.4.3 | Risk indicators and factors

Risk indicators and factors were reported using diverse measures of association such as OR, prevalence ratio, hazard ratio (HR), and relative risk (RR). Factors were classified into systemic diseases and conditions (diabetes mellitus; cardiovascular diseases and associated conditions, i.e., atherosclerosis and hypertension; obesity; and osteoporosis), behavioral factors (i.e., smoking habits and alcohol consumption) and patient-related characteristics (i.e., sex and age). Additionally, the impact of two oral conditions on the development and progression of PIDs was assessed: complete edentulism and periodontitis (i.e., history or active). The definitions and characteristics of the risk indicators are presented in Tables 1 and 2, and the most significant risk indicators for PIDs are illustrated in Figure 4.

Diabetes mellitus

Four studies[1,18,44,61] evaluating diabetes mellitus as a risk indicator for peri-implant mucositis were included. One of the studies defined diabetes as uncontrolled, and another diagnosed diabetes with glucose levels >126 mg/dL or consumption of hyperglycemic medicine during the past 2 weeks.[1,18] The highest OR was 3.4 and was reported in a cross-sectional study of Aljalloud et al. considering a Syrian population.[44] The effect summary contemplating OR values at the patient level for diabetes mellitus failed to identify a statistically significant association between peri-implant mucositis and diabetes (effect summary OR 1.54; 95% CI, 0.9–2.64; $I^2 = 82.3\%$; Egger test $p = 0.0040$) (Figure 5).

Ten studies[1,18,42–46,53,54,70] evaluated diabetes mellitus as a risk indicator for peri-implantitis. The studies defined diabetes as controlled, uncontrolled, or diagnosed with glucose levels >126 mg/dL or consumption of hyperglycemic medicine during the past 2 weeks. The highest OR was 9.9 and was reported by Stacchi et al. in a cross-sectional study evaluating implants inserted in augmented sinuses.[43] The effect summary contemplating OR values at patient level identified a statistically significant association between peri-implantitis and diabetes mellitus (effect summary OR 2.31; 95% CI, 1.59–3.32; $I^2 = 9.88\%$; Egger test $p = 0.2835$) (Figure 6).

Cardiovascular diseases and associated conditions

Four studies reported on certain cardiovascular conditions (i.e., atherosclerosis and hypertension) as possible risk

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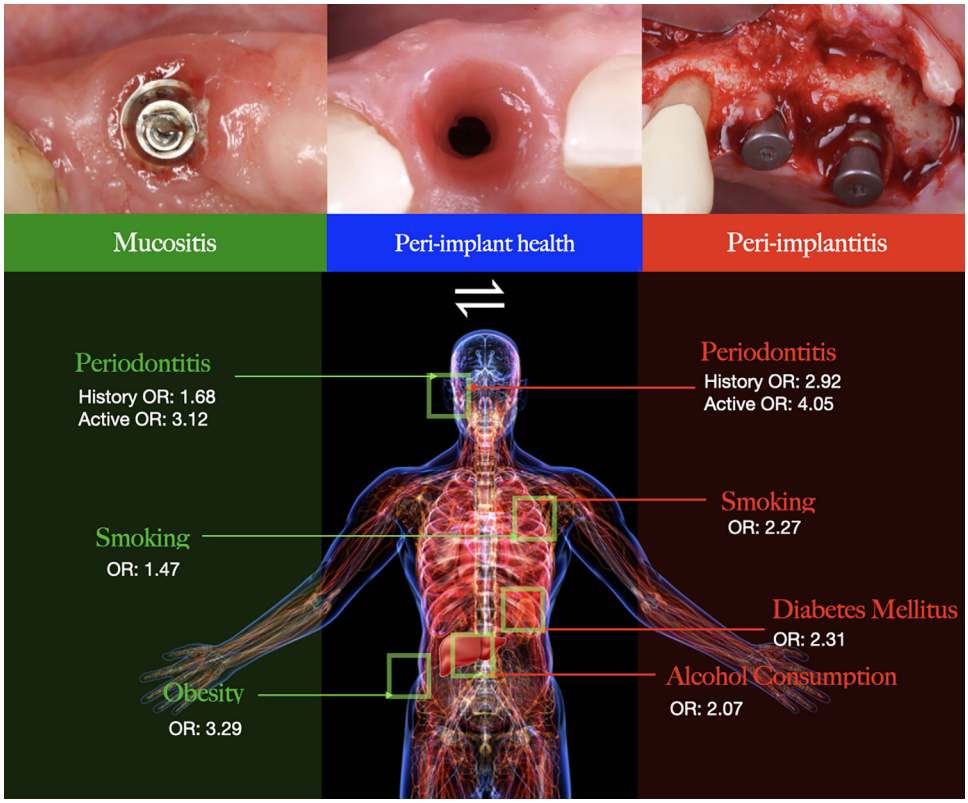

FIGURE 4 Schematic diagram depicting significant systemic risk indicators for peri-implant mucositis and peri-implantitis presenting OR overall size effects. OR, odds ratio.

indicators for peri-implant mucositis and three for peri-implantitis.[1,17,37,39] The reported definitions for cardiovascular conditions were heterogenous, and no meta-analyses could be performed. Papi et al. reported in a cross-sectional study that patients with subclinical atherosclerosis with a carotid intima-media thickness >0.9 mm and/or plaque presence presented an OR of 3.34 (95% CI, 1.13–9.85) for peri-implant mucositis.[36] Alves et al. described in a cross-sectional study that the presence of high systolic blood pressure (blood pressure ≥140 mm Hg) was a risk factor for peri-implantitis with a significant PR value of 4.23 (95% CI, 1.66–112.87; $p = 0.03$).[17] Apaza-Bedoya et al. reported in a cross-sectional study that the absence of cardiovascular disease had an OR of 0.647 (95% CI, 0.22–1.85) for peri-implant mucositis; however this association was not significant.[1] This cross-sectional study did not define cardiovascular disease with a specific diagnosis. Additionally, Buonocunto et al. reported an OR of 3 (95% CI, 0.21–42.63), associating cardiovascular disease and mucositis in a cross-sectional multicenter study.[39] The same study reported an OR value of 0.6 for cardiovascular disease and peri-implantitis. The reported definitions for cardiovascular diseases were not specific in the mentioned two studies.

Obesity

Three clinical studies defining obesity as a body mass index (BMI) of ≥30 kg/m or considering patients with abdominal obesity (defined as a waist circumference ≥102 cm [men] or ≥88 cm [women]) regarded it as a risk indicator for peri-implant mucositis and peri-implantitis.[17,36,65] The effect summary contemplating OR values at patient level identified a statistically significant association between mucositis and obesity (effect summary OR 3.29; 95% CI, 1.75–6.17; $I^2 = 1.93\%$; Egger test $p = 0.7166$) (Figure 5). The effect summary contemplating OR values at patient level for obesity did not identify a significant association between peri-implantitis and obesity (effect summary OR 3.89; 95% CI, 0.79–19.1; $I^2 = 73.5\%$; Egger test $p = 0.091$) (Figure 6). The highest significant OR values for mucositis and peri-implantitis were 10 ($p = 0.005$) and 15.29 ($p = 0.001$) reported by Papi et al. in a cross-sectional study.[36] This study considered patients with abdominal obesity who were concomitantly diagnosed with MTS. Patients' nutritional habits associated to obesity were presented by Vilarrasa et al. in a clinical study. They associated patients with a sugar-rich diet with OR values of 5.38 (95% CI, 1.39–20.87; $p = 0.01$) with the development of peri-implantitis.[71]

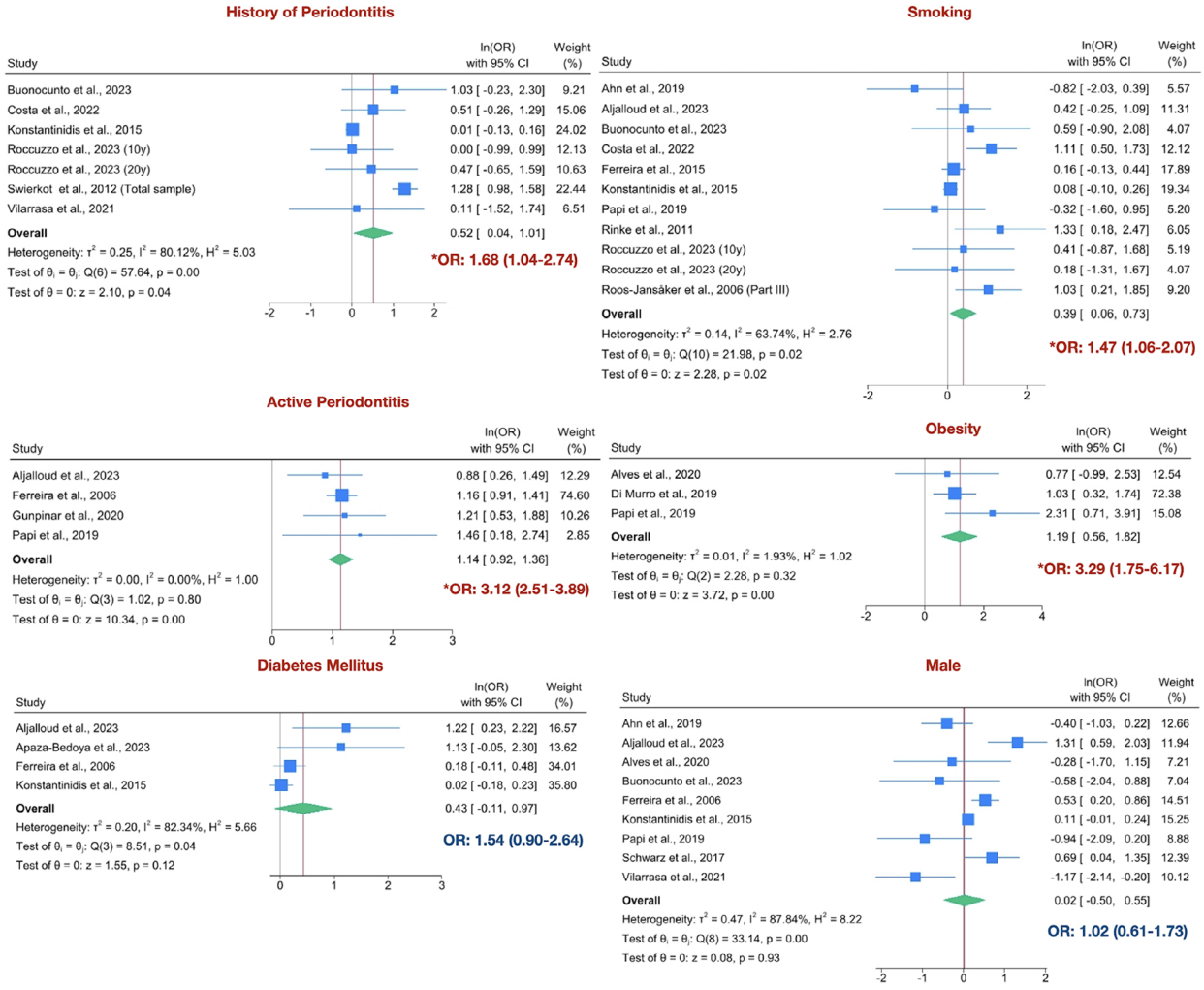

FIGURE 5 Forest plots corresponding to peri-implant mucositis risk indicators; meta-analyses considered lnOR values at patient level. Significant risk indicators are marked (*) with red. lnOR, natural logarithm-transformed odds ratio.

Osteoporosis

Two cross-sectional studies reported on osteoporosis OR values for peri-implant mucositis[1,17] and three studies for peri-implantitis.[1,54,61] Apaza et al. reported OR of 7.7 (95% CI, 1.33–27.72; $p = 0.020$) and 6.1 (95% CI, 1.39–43.15; $p = 0.02$) (implant level) associating osteoporosis with mucositis and peri-implantitis.[1] On the other hand, Konstantinidis et al. reported in a cross-sectional study a not significant OR of 0.98 (95% CI, 0.91–1.062; $p = 0.67$) for peri-implantitis.[61] No meta-analyses could be performed since only one study reported OR data at the patient level.

Smoking

Eleven studies[36,39,44,49,53,61,77,84,91,109,111] evaluating smoking and tobacco use as risk indicators for peri-implant mucositis were included. Studies reporting on active and former smokers were considered. The highest reported OR were 3.77 (95% CI, 1.20–11.86; $p = 0.023$) and 3.04 (95% CI, 1.16–3.98; $p = 0.001$), described in a cross-sectional study of Rinke et al. and in a clinical study by Costa and collaborators.[91,127] The effect summary considering OR values at patient level for smoking habits (active or former) identified a statistically significant association between peri-implant mucositis and smoking (effect summary OR 1.47; 95% CI, 1.06–2.07; $I^2 = 63.7\%$; Egger test $p = 0.8742$) (Figure 5).

Twenty-five studies[1,15,36,39,40,42–46,53,54,57,63,72–74,77,81,84,91,104,109,127,129] evaluating smoking and tobacco use as risk indicators for peri-implantitis were considered. Studies reporting on active smokers, patients consuming >10 cigarettes/day, and former smokers were evaluated. The highest reported OR was 31.58 (95% CI, 5.13–194.25; $p < 0.001$), corresponding to the aforementioned cross-sectional study of Rinke et al., where smoking was determined if patients had smoked at the time of the follow-up examination or had quit smoking for less than 5 years.[91] Of this smoker population, 88% also had a history of periodontitis. The effect summary considering OR values at patient

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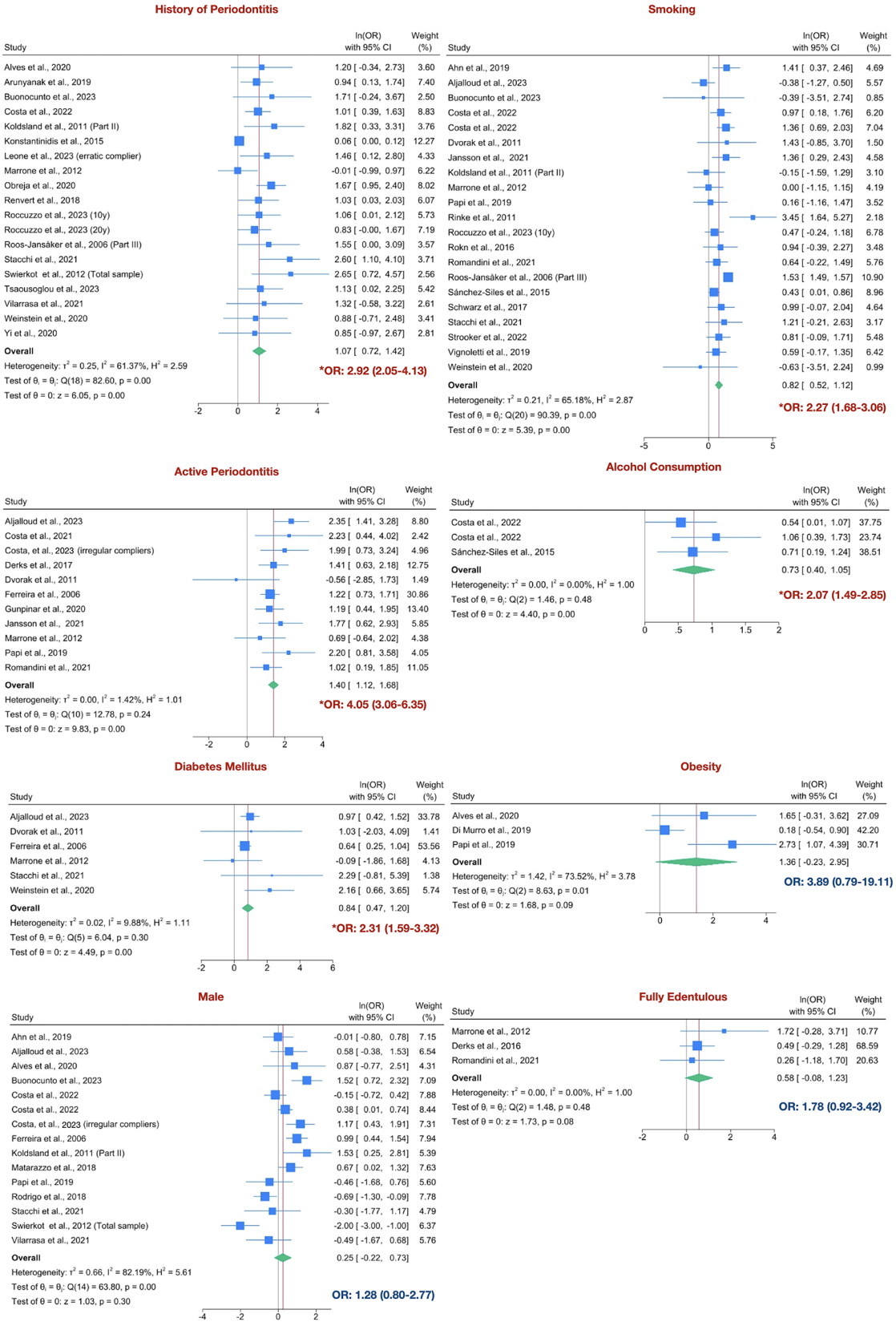

FIGURE 6 Forest plots corresponding to peri-implantitis risk indicators; meta-analyses considered lnOR values. Significant risk indicators are marked (*) with red. lnOR, natural logarithm-transformed odds ratio.

level for smoking habits identified a statistically significant association between peri-implantitis and smoking (effect summary OR 2.27; 95% CI, 1.68–3.06; $I^2 = 65.2\%$; Egger test $p = 0.4827$) (Figure 6).

Alcohol consumption

Three studies[53,81,127] evaluating alcohol consumption as a risk indicator for peri-implantitis were considered for the meta-analysis. The highest reported OR (patient level) value was 2.9 (95% CI, 1.09–4.14; $p = 0.01$), corresponding to the study of Costa et al., where alcohol use was determined to be a significant risk indicator for peri-implantitis.[127] The effect summary considering OR values at patient level identified a statistically significant association between peri-implantitis and alcohol consumption (effect summary OR 2.07; 95% CI, 1.49–2.85; $I^2 = 0.0\%$; Egger test $p = 0.271$) (Figure 6).

Sex

Nine studies[17,36,39,40,44,49,61,71,84] evaluating sex as a risk determinant for peri-implant mucositis were included. The effect summary contemplating OR values at patient level failed to identify a significant association between mucositis and male sex (effect summary OR 1.02; 95% CI, 0.64–1.73; $I^2 = 87.8\%$; Egger test $p = 0.7166$) (Figure 5). Fifteen studies[17,18,36,38,39,43,44,53,57,64,71,84,111,120,127] evaluating sex as a risk indicator for peri-implantitis were included. The effect summary contemplating OR values at patient level did not identify a significant association between peri-implantitis and male sex (effect summary OR 1.28; 95% CI, 0.80–2.77; $I^2 = 82.2\%$; Egger test $p = 0.7538$) (Figure 6).

Age

Seven studies[1,17,18,39,44,49,111] evaluating the patient's age as a risk determinant for peri-implant mucositis were included (Tables 1 and 2). OR values were reported at patient and implant levels. The majority of the studies did not define a specific age range as a risk indicator for mucositis. Fifteen studies[1,17,18,39,43–46,53,54,75,104,111,112,127] also evaluated the patient's age as a risk indicator for peri-implantitis (Tables 1 and 2). Studies defined age as risk indicator in heterogenous ways such as <56 years, >50 years, per 10 years, older, <50 years, <60 years, and >55 years. Some of the studies failed to mention any specific range. Following the heterogeneity of the reported data, age could not be identified as a risk indicator for mucositis or peri-implantitis.

Periodontitis

Eight studies[1,39,61,71,109,111,112,127] evaluating a history of periodontitis as a risk indicator for peri-implant mucositis were included. The highest OR value was 3.6 (95% CI, 1.09–1.98; $p = 0.036$), reported by Swierkot et al. in a 3- to 16-year long-term cohort study considering general aggressive periodontitis history as a risk indicator for mucositis.[111] The effect summary contemplating OR values at patient level identified a statistically significant association between peri-implant mucositis and history of periodontitis (effect summary OR 1.68; 95% CI, 1.04–2.74; $I^2 = 80.1\%$; Egger test $p = 0.5662$). Four studies[18,36,44,70] associating active periodontitis and mucositis were included in the meta-analyses. The effect summary considering OR values at patient level also presented a statistically significant association between peri-implant mucositis and active periodontitis (effect summary OR 3.12; 95% CI, 2.51–3.89; $I^2 = 0.0\%$; Egger test $p = 0.9895$) (Figure 5).

Twenty-two studies[1,2,17,30,34,42,43,45–47,51,57,61,71,77,82,109,111,112,123,127,130] evaluated history of periodontitis as a risk indicator for peri-implantitis. The highest OR was 14.09 (95% CI, 2.05–96.772; $p = 0.007$), again reported by Swierkot et al.[111] Stacchi and collaborators also reported in a multicentered cross-sectional study with a mean loading time of 4.64 years an OR of 13.46 (95% CI, 2.99–60.46; $p = 0.001$).[43] The effect summary with respect to OR values at patient level identified a statistically significant association between peri-implantitis and history of periodontitis (effect summary OR 2.92; 95% CI, 2.05–4.13; $I^2 = 61.4\%$; Egger test $p = 0.0001$). Eleven studies[15,18,36,44,45,50,52,54,70,96,120] associating active periodontitis and peri-implantitis were included in the meta-analysis. The effect summary contemplating OR values at patient level also presented a statistically significant association between peri-implantitis and active periodontitis (effect summary OR 4.05; 95% CI, 3.06–6.35; $I^2 = 1.4\%$; Egger test $p = 0.5805$) (Figure 6).

For risk factor analyses, three similar longitudinal studies comparing patient populations with or without history of periodontitis over 3–20 years, reported significantly higher mucositis and peri-implantitis incidence rates for a population diagnosed with periodontitis.[102,109,111] The included studies did not report on RR for other systemic conditions. Meta-analyses comparing the disease incidence rates for both patient populations or the RR could not be performed due to the heterogeneous follow-up periods and the fact that the incidence rates of comparable studies were not reported at the patient level.

Edentulism

One study reported an OR of 1.88 (95% CI, 0.78–4.54; $p = 0.16$), revealing a not significant association of complete edentulism and peri-implant mucositis.[1] Six studies[1,2,15,45,46,52] evaluating complete edentulism as a risk indicator for peri-implantitis were included. Only three

studies[15,45,52] reported OR values at the implant level. The effect summary contemplating OR values at patient level for edentulism was close to identifying a significant association between peri-implantitis and complete edentulism (effect summary OR 1.78; 95% CI, 0.92–3.42; $I^2 = 0.0\%$; Egger test $p = 0.4494$) (Figure 6).

Other patient-related conditions

Recent studies have reported on additional health conditions related to PIDs. Strooker et al. evaluated the psychological risk indicators and significantly associated depression with peri-implantitis (OR 2.04; 95% CI, 1.067–3.8; $p = 0.03$).[63] Costa and collaborators also associated liver cirrhosis with peri-implantitis (OR 2.44; 95% CI, 1.13–2.44; $p = 0.001$),[127] and Vilarrasa et al. reported in a cross-sectional study that xerostomia had an OR of 2.16 (95% CI, 0.69–6.82; $p = 0.18$) for peri-implantitis;[71] however this association was not significant.

4 | DISCUSSION

4.1 | Summary of main results

An analysis of the current evidence of PIDs demonstrated that case definitions for peri-implant mucositis and peri-implantitis fluctuate significantly among existing clinical studies.[7,132,133]

Weighted mean values calculated at the patient level demonstrated overall prevalence rates of 46% (95% CI, 41–51) and 21% (95% CI, 17–24) for peri-implant mucositis and peri-implantitis, respectively. Additionally, pooled estimates demonstrated that (1) more than half of the patients treated with dental implants were affected by PIDs over a 10-year follow-up period; (2) periodontitis and smoking acted as risk indicators for the development of PIDs; (3) obesity was identified as a potential risk indicator for peri-implant mucositis; (4) diabetes mellitus and alcohol consumption were identified as potential risk indicators for peri-implantitis; and (5) evidence from longitudinal studies exhibits periodontitis as a potential risk factor for PIDs.

4.2 | Agreements and disagreements with other studies

The present review estimated the prevalence at the patient level for peri-implant mucositis and peri-implantitis to be 46% (95% CI, 41%–51%) and 21% (95% CI, 17%–24%), respectively, which is comparable with the ones described by the previous systematic reviews of Derks and Tomasi[3] and Lee et al.[134]

The reported incidence for PIDs was determined in longitudinal prospective studies based on the number of new cases of disease in a population over a defined period of time. The present meta-analyses aimed to estimate the incidence for both peri-implant pathologies within 20 years of implant function. The stratified meta-analyses demonstrated that the weighted means for mucositis incidence increased from 46% to 61% between 5 and 10 years of follow-up. However, mucositis incidence decreased from 61% to 53% between 10 and 20 years of follow-up. It is possible to attribute this reduction in incidence to disease progression from mucositis to peri-implantitis over longer loading periods.[135–137] This inference is further corroborated by the forest plot of peri-implantitis, where its incidence increased 2% from 5 to 10 years and 8% from 10 to 20 years. Interestingly, the highest peri-implantitis incidence rates were reported in prospective studies considering patient populations with history of periodontitis.[106,109,111] The reported incidences must be interpreted with caution since the percentage of variability was high across the included studies in the meta-analyses. Future longitudinal studies are essential to determine the incidence rates for PIDs per patient-year in different populations.

Risk indicators for PIDs have been reported in several cross-sectional studies[2,30] and certain systematic reviews.[21,138–140] As the human body is an interconnected system, it is essential to comprehend that the systemic risk indicators are not independent from each other and they might also be affected by local and prosthetic factors.[51,58] The present systematic review established that the significant risk indicators for peri-implant mucositis and peri-implantitis were history or active periodontitis and smoking habits. Obesity was identified as a risk indicator for peri-implant mucositis, while diabetes mellitus was determined to be a risk indicator for peri-implantitis.

Periodontitis is a significant public health problem in the United States since it is a common disease among the population, presenting a total prevalence of 42.2%.[141] There is important evidence from longitudinal and cross-sectional studies establishing that active and history of periodontitis is a risk indicator for PIDs.[7,22] The present meta-analyses identified a statistically significant association between both diseases (i.e., mucositis and peri-implantitis) and periodontitis. The overall odds for mucositis and peri-implantitis were 1.68 and 2.92 times greater, respectively, if the patients had history of periodontitis. The mentioned OR were even higher for both diseases when considering active periodontitis. In line with this association, Ferreira et al. demonstrated in a systematic review that a diagnosis or history of periodontitis was associated with peri-implantitis, showing a significant association between peri-implantitis and chronic periodontitis (OR 2.9; 95% CI, 1.79–4.00).[22] This outcome is closely related to the overall

OR effect summary reported in the present meta-analyses. Moreover, three longitudinal studies comparing patient populations with or without history of periodontitis over 3–20 years have presented significantly higher mucositis and peri-implantitis incidence rates for the population exposed to periodontitis.[102,109,111] The mentioned longitudinal evidence supports that a history of periodontitis can be a potential risk factor for PIDs.

A systematic review reported on the potential association between smoking and peri-implant mucositis and established smoking as a risk indicator for the development of peri-implant mucositis.[142] Another systematic review by Dreyer et al. also identified smoking or tobacco consumption as a risk indicator of peri-implantitis (OR 2.0; 95% CI, 1.6–2.4),[21] which is an outcome comparable to the overall OR effect summary of the present systematic review. The reported overall OR effect summary indicated the odds of mucositis and peri-implantitis were 1.47 and 2.27 times greater, respectively, if the patients were exposed to cigarette consumption. In the present review, the highest reported smoking OR was 31.58, corresponding to a cross-sectional study of Rinke and colaborators.[91] The high OR value might be attributed to the fact that 88% of the referred smoker population had history of periodontitis. Therefore, the presented OR might consider a population with two potential risk indicators for PIDs.[91] The greatest difficulty faced in determining smoking being included as a risk factor or indicator for PIDs is the variability from study to study in including former or active smokers and in defining smoking habit. A cohort study by Costa et al. demonstrated that the longer the time since smoking cessation, the lower was the occurrence of peri-implantitis.[53] On the other hand, the systematic review of Carra et al. stated that there is limited evidence to determine whether smoking cessation is associated with a decreased risk for PIDs.[139]

Alcohol consumption has been associated with liver cirrhosis, high blood pressure, cardiovascular diseases, and other metabolic problems.[53,127] A relationship between alcohol consumption and periodontitis has been suggested by certain studies.[143,144] Currently, limited studies have studied the influence of alcohol consumption on the progression and prevalence of PIDs.[53,81,127] The present meta-analyses showed that patients consuming alcohol have a higher risk for peri-implantitis. The overall odds were two times greater for developing peri-implantitis in patients exposed to alcohol use. Physiologically, this association could be attributed to the fact that alcohol can affect the host's immunological response by decreasing neutrophil, macrophage, and T cell functions, increasing the patient's susceptibility to infections.[145] The mentioned aspects could potentially increase the inflammatory response and trigger PIDs progression. Nevertheless, scientific evidence regarding alcohol use including its frequency, dosage, and amount and its relationship with peri-implantitis is very limited. More studies are needed to further support alcohol use as risk indicator and factor for both PIDs.

The American Diabetes Association reported in 2021 that 38.4 million (11.6%) of the American population had diabetes. Diabetes mellitus global prevalence has been estimated at 8%.[146,147] This autoimmune metabolic disorder has been identified by various studies as a risk factor for periodontitis, and several studies have demonstrated that patients with controlled and uncontrolled diabetes are at higher risk for peri-implantitis.[138,148] The present meta-analyses showed that diabetic patients have an increased risk for peri-implantitis. The overall odds were 2.31 times greater for developing peri-implantitis in patients with diabetes mellitus. This finding is confirmed with the outcomes of a previous systematic review by Carra et al. that demonstrated a higher risk for developing peri-implantitis in patients with poor glycemic control (glycosylated hemoglobin [HbA1c] > 8%) when compared with patients with regular glycemic control.[139] Monje et al. also reported in a meta-analysis that diabetes overall OR was 1.89 (95% CI,1.31–2.46) for peri-implantitis and that there was no association between diabetes and peri-implant mucositis, which is likewise in line with the presented results.[138] Still, there are controversial results regarding the association of PIDs and diabetes, which could be due to the fact that different diabetic diagnostic criteria were used in the studies and it was not known whether the same patients had adequate glycemic control.

The Centers for Disease Control and Prevention (CDC) reported a 49% prevalence of obesity in the United States in 2017.[149,150] Obesity, along with related conditions like MTS, have reached epidemic proportions, resulting in over 4 million deaths annually as of 2017.[151] Obesity has been linked to periodontitis due to several shared risk determinants, and overweight individuals have a higher prevalence of periodontitis.[14] This systematic review confirmed obesity as a significant risk indicator for mucositis (effect summary OR 3.29; 95% CI, 1.75–6.17). Studies have established a connection between obesity and PIDs, with Papi et al. reporting the highest OR for mucositis and peri-implantitis. Notably, their study focused on patients with abdominal obesity and MTS.[36] Biologically, the association between obesity and PIDs may involve adiposity-related inflammation and microbial imbalance, potentially exacerbating inflammation and disease progression.[152] However, scientific evidence regarding the cause–effect relationship remains limited. Furthermore, the heterogeneity among studies warrants cautious interpretation of these associations.

The available evidence to consider other factors such as sex, aging, edentulism, osteoporosis, cardiovascular

diseases, and hypertension as risk factors/indicators for PIDs proved to be inconclusive and further studies will be needed for further clarification.

It is important to keep in mind that a risk factor is "an environmental, behavioral, or biologic factor confirmed by temporal sequence" that should be defined in longitudinal studies.[153] Still, there are limited controlled epidemiological studies that follow a cohort of subjects exposed to determined risk factors which could be compared to a sample of unexposed controls. There is contemporary longitudinal evidence demonstrating that a history of periodontitis can be a potential risk factor for PIDs, confirming the higher incidence rates for patient populations with a history of periodontitis. Nevertheless, more interventional studies of longitudinal design are required to identify true risk factors for PIDs.

4.3 | Limitations and potential biases in the review process

Among the limitations of the present systematic review, it is important to consider that the majority of the studies utilized convenience samples. Also, the studies assessed heterogenous populations, samples sizes, and follow-up periods. Studies employed significantly different methodologies and included patients with heterogenous maintenance programs (i.e., erratic and regular compliers), surgical and rehabilitation protocols, and settings (i.e., university, public center, hospital, private practice). The study setting is a crucial aspect in the interpretation of the results since implant therapy performed by highly trained clinicians or specialists might be particularly different from the one performed by university residents. Indeed, the rate of peri-implant biological complications might be influenced by the level of the experience of the clinician. As well, the studies that were multicentered might have additional bias in the interpretation of the results since the evaluators might not be calibrated among the different centers.

The present systematic review excluded studies reporting on data of implants with <8 mm of length. The mentioned exclusion criterion was supported on evidence that establishes that short implants have a higher variability and a decreased predictability in survival rates compared to longer implants.[154] As well, short implants might be placed in areas with reduced bone height, which might affect the subcrestal insertion of the implant and consequently the physiological bone remodeling following implant loading. Receptor areas with reduced bone height might also need extensive bone grafting procedures; this aspect could also be a bias in the interpretations of the results. However, a limitation of this systematic review is that it did not determine a cutoff value on a maximum implant length or thresholds for implant diameter.

Also, the meta-analyses of studies considering diverse study populations presented high heterogeneity indicated by I^2 values. Moreover, incidence definition for peri-implant mucositis and peri-implantitis was not clear in certain studies and the timepoints were not homogenous. It is also critical to consider that case definitions for PIDs varied significantly among the presented clinical studies.[7] In the present review, only 21% of the studies considered the standard WW 2017 case definition for peri-implantitis.[4] The heterogeneity in the current literature on PIDs epidemiology also highlights the importance of utilizing defined case definitions and threshold values to discriminate health from disease to facilitate merging concepts, outcome comparisons, and global epidemiological consensus related to PIDs. All the mentioned limitations should be taken into account when interpreting the outcomes of the present systematic review.

5 | CONCLUSIONS

Within the limits of this systematic review and meta-analysis, it can be concluded that:

1. More than half of the adult patients treated with titanium dental implants were affected by PIDs over a 10-year follow-up period.
2. It has been shown that one in five patients receiving dental implants will present peri-implantitis over a 20-year follow-up period.
3. Smoking and periodontitis were identified as risk indicators for the development of both PIDs.
4. Obesity was identified as potential risk indicator for mucositis.
5. Diabetes mellitus and alcohol consumption were identified as potential risk indicators for peri-implantitis. However, the association between alcohol consumption and peri-implantitis is supported by limited evidence.
6. There is a weak level of evidence that indicates hypertension, and other cardiovascular conditions can modulate the prevalence of PIDs; thus, further studies are needed to better determine this association.

5.1 | Implications for practice and future research

The current strategies to mitigate PIDs occurrence and progression should center on interventions that can target modifiable systemic risk factors and improve risk profiles for PIDs. Patients should be instructed about the

importance of controlling systemic conditions, periodontitis, and detrimental habits such as smoking and alcohol consumption that could influence disease progression. Future epidemiological longitudinal studies should explore the impact of these conditions as putative risk factors on the rate of disease onset and progression. The implementation of the standard WW 2017[4] classification, as well as the stratification of patients into subgroups according to the type of systemic condition or disease, might improve the report of peri-implant outcomes.

AUTHOR CONTRIBUTIONS

Maria Elisa Galarraga-Vinueza, Sarah Pagni, and Leandro Chambrone designed the study. Maria Elisa Galarraga-Vinueza and Todd Schoenbaum performed the literature search, initial screening, and article selection. Maria Elisa Galarraga-Vinueza and Todd Schoenbaum performed data extraction and risk of bias assessment. Maria Elisa Galarraga-Vinueza performed the qualitative analysis. Matthew Finkelman and Sarah Pagni contributed to the study methodology and conducted the statistical analysis. Leandro Chambrone and Matthew Finkelman contributed to data interpretation. Maria Elisa Galarraga-Vinueza led the writing. All authors critically revised the manuscript, gave their final approval, and agreed to be accountable for all aspects of the scientific work.

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CONFLICT OF INTEREST STATEMENT

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DATA AVAILABILITY STATEMENT

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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