Systematic Review
Implantodontology

# Prevalence of peri-implant diseases – a critical review on the current evidence

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**Abstract:** The objective of this paper was to evaluate the current evidence reporting on the prevalence of peri-implantitis and to determine the influencing factors. An electronic search for articles published until February 2019 reporting on the prevalence of peri-implantitis was performed in MEDLINE. Included criteria were published in international peer-reviewed journals, written in English language, reported on the prevalence of peri-implantitis, included implants with a minimum follow-up of one year after functional loading and used a clear definition for peri-implantitis and/or peri-implant mucositis with a clear cutoff for bone level changes according to the case definitions of Sanz and Chapple and Berglundh et al. 2018. Included papers were anaylized for factors affecting the reported prevalences for peri-implantitis. Twenty-five papers were included in the present review and a wide range for the reported prevalence of peri-implantitis was seen. Case definitions for peri-implantitis with various thresholds for bone loss together with the type of reporting on patient- or implant-level were the most significant factors that lead to a large variety of the occurrence of the disease. Additionally, follow-up time and the evaluation in a certain "convenience" population may have influenced the prevalence values. In conclusion, it can be stated that a wide range for reporting the prevalence of peri-implantitis can be found and no real estimation of the global burden of the disease can be made. Applying accurate case definitions for peri-implantitis is the most important factor for reporting the prevalence and should be strictly followed in future reports.

**Keywords:** Dental Implants; Peri-Implantitis; Prevalence; Mucositis.

## Introduction

In the past two decades, dental implants have become a widely accepted and implemented therapeutical method to replace missing teeth and support fixed and partially removable prostheses. High long-term survival rates have been reported both for systemically healthy (cumulative survival rates of 83.8% after 25 years, 96.1% after 10 years)[1,2] as well as for medically compromised patients (i.e. oral cancer: cumulative survival rate after 20 years 90.8%).[3] Despite the high survival rates and intensive periodontal and prosthetical maintenance over time, implant failures may occur.[4,5,6] In the last decades, evidence on the presence of

peri-implant inflammations affecting both soft and hard tissues that may eventually lead to implant failure (loss) has substantially increased. These are seen as biological complications related to inflammatory conditions of the surrounding soft and bone tissues, which are induced by bacterial biofilm and are distinguished as peri-implant mucositis and peri-implantitis.[7,8,9]

Peri-implantitis was firstly described in 1987 by Mombelli et al.[10] as an infectious disease with many common features to periodontitis. Considering the multiple etiological factors and clinical characteristics, many definitions arose and, from the clinical perspective, no consensus for a clear definition for peri-implantitis was settled. Peri-implantitis was mainly defined as an inflammatory response of the peri-implant mucosa with marginal bone loss, while peri-implant mucositis resumed to soft-tissues inflammation.[11,12] Discrepancies in case definitions and disease estimations on various convenience samples led to controversial reports on the prevalence of peri-implant diseases.[13,14] The lack of clear clinical parameters in these definitions led to a large range in the reported prevalence/incidence of peri-implant diseases making thus difficult to estimate the real burden of these pathologies. Considering the definitions for incidence ("the number of new cases of a specific disease occurring during a certain period") and prevalence of a disease ("the number of cases of a disease in existence at a certain time point"),[15] the use of longitudinal studies has been proposed for assessing the incidence while that of cross-sectional studies for determining the prevalence of peri-implant diseases.[11] Nonetheless, in november 2017 in the World Workshop on Periodontolgy (WWP), the European Federation of Periodontology (EFP) and the American Academy of Periodontology (AAP) reached a consensus and set clear a definition with clear clinical cutoff points for peri-implant pathologies both for the day-to day clinical practice as well as for epidemiological studies.[16,17,18,19]

Therefore, the aim of the present review, was to critically analyze the available evidence for the prevalence of peri-implantitis in the light of the current definition of peri-implant diseases.

## Methodology

A literature search for articles published until February 2019 reporting on the prevalence and/or incidence of peri-implantitis and peri-implant mucositis was performed in MEDLINE via PubMed database. Included studies had to be: published in international peer-reviewed journals, written in English language, report on the prevalence and/or incidence of peri-implantitis and/or mucositis, include implants with a minimum follow-up of one year after functional loading and a clear definition for peri-implantitis and/or peri-implant mucositis with a clear cutoff for bone level changes (≥2/≥3 mm apical of the coronal part of the implant, in the absence of previous radiographic measurements, or bone loss beyond crestal bone level changes after initial bone remodeling after the first year of loading).[9,16]

## Results

The initial electronic search revealed 248 publications; after abstract screening of the abstracts based on the inclusion criteria, 35 papers were selected for full-paper analysis. Included studies can be found in Table. Most of the papers considered in the definition for peri-implantitis a cutoff for bone loss of 2mm or calculated the bone loss from a level of 2–3 implant threads. Applying strictly all recommended definition criteria for peri-implantitis of the WWP 2017 (BOP/SUP, pocket depths ≥6mm, bone level ≥3mm of the most coronal portion of the intraosseous part of the implant) no single study can be taken into consideration.[16]

## Discussion

A wide range of prevalences for peri-implant biological complications has been reported in the literature so far. Reviews and meta-analyses from the past three years mention prevalences for peri-implant mucositis of 42.9%,[13] of 29.48% (implant level) or 46.83% (patient-based);[20] for peri-implantitis

**Table.** Included studies reporting on the prevalence of peri-implant mucositis and peri-implantitis.

| No. | Study | Country | Study type / Patients / Setting: University/ private practice / Evaluation period | Case definitions for mucositis / Peri-implantitis | Prevalence of mucositis | Prevalence of Peri-implantitis (PI) | Possible associated risk factors (implant type/surface, keratinized mucosa, history of periodontitis, diabetes, smoking, prosthetics) |
|---|---|---|---|---|---|---|---|
| 1 | Aguirre-Zorzano et al. 2015 [37] | Spain | Cross-sectional<br>Retrospective<br>239 patients/786 implants<br>university<br>6–17y (mean 5.3 y) functional loading | Mucositis:<br>BOP, clinical signs of inflammation, no BL (< 1.5 mm)<br>PI: BOP, clinical signs of inflammation, BL (≥ 1.5 mm) | Patient level: 24.7%<br>Implant level: 12.8% | Patient level: 15.1%<br>Implant level: 9.8% | Stat. sign. association for plaque index, periodontitis and implant location with mucositis.<br>Stat. sign. association for plaque index and implant location with PI. |
| 2 | Canullo et al. 2016 [63] | Spain | Cross-sectional<br>588 patients/1507 implants<br>university<br>5.1 y | Mucositis: n.r.<br>PI: PD≥4mm, BOP/ SUP, BL>3mm | n.r. | Patient level: 10.3%<br>Implant level: 7.3% | Peri-implantitis implants showed higher % of plaque, of BOP, < 2mm attached gingiva, more cemented crowns, more bone-augmented sites. |
| 3 | Cecchinato et al. 2014 [31] | Italy | Cross-sectional<br>100 patients/ 291 implants analysed<br>Private practice<br>≥ 8 y (mean 10.7 y) functional loading | Mucositis: BOP, BL≤0.5 mm<br>PI: PD≥4mm, BOP, BL>0.5mm from >1 year after loading | Patient level: 65%<br>Implant level: 69.8% | Patient level: 12% (within 10 y)<br>Implant level: 5% (within 10 y) | n.r. |
| 4 | Daubert et al. 2015 [34] | USA | Cross-sectional<br>96 patients/ 225 implants<br>university<br>9–15 y (mean 10.9 y) | Mucositis: BOP, gingival inflammation, no BL<br>PI: BOP/SUP, BL≥2mm after initial remodeling, PD≥4mm | Patient level: 48%<br>Implant level: 33% | Patient level: 26%<br>Implant level: 16% | Association betw. PI and diabetes and younger age at implant insertion, periodontal status at follow-up.<br>No association with smoking |

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| 5 | Derks et al. 2016 [24] | Sweden | Cross-sectional<br>Retrospective<br>588 patients/2277 implants<br>university, private practice<br>9 years functional loading | Mucositis: BOP/SUP, no BL<br>PI: BOP/SUP, BL (> 0.5 mm)<br>Moderate/severe PI: BOP/SUP, >2mm BL | Patient level: 32%<br>Implant level: 35.1% | Patient level: 45%<br>BL:<br>> 2 mm: 14.5%<br>> 3 mm: 10.1%<br>> 4 mm: 5.9%<br>Implant level: 24.9%<br>BL:<br>> 2 mm: 8.0%<br>> 3 mm: 4.3%<br>> 4 mm: 2.3% | Stat. sign. higher OR for moderate/severe PI for history of periodontitis (4.1), ≥4 implants (15.1), in the mandibular region (2.0), distance between prosthetic restauration margin and initial crestal bone level ≤ 1.5mm (2.3), for general practitioners as provider for prosthetics (4.3), certain brands of implants: Astra Tech (3.6, mostly TIOblast surface), Nobel Biocare (3.8, mostly TiUnite surface), Straumann (1, all SLA surface), remaining implant brands (5.56). |
| 6 | Fransson et al. 2005, 2008 [64,65] | Sweden | cross-sectional<br>662 patients /3413 implants-<br>82 patients with clinical assessment /482 implants<br>university<br>5–20 y (mean 9.4y) | Mucositis: BOP, BL≤0.6mm from 1 year after loading<br>PI: BOP, bone level ≥3 threads & BL≥0.6mm from 1 y after loading | Patient level: n.r.<br>Implant level: > 90% | Patient level: 27.8%<br>Implant level: 12.4% | Smokers had a higher number of affected implants than non-smokers.<br>A higher proportion of peri-implant clinical pathology (SUP& PD≥6mm) in smokers than in non-smokers.<br>Higher frequency of peri-implant clinical pathology (BOP, SUP, recession, PD≥6mm) at implants with progressive BL |
| 7 | Francetti et al. 2019 [53] | Italy | Cross-sectional<br>77 patients/384 implants<br>Private clinic<br>14.6% (after 5 y)13.7y (mean 8y) | Mucositis: n.r.<br>PI: BOP/SUP, BL>2mm | n.r. | Patient level: 12.7 % (after 5y)<br>Implant level: 4.6% (after 5 y) | No sign. Risk factors: smoking (p=0.755), periodontitis (p=0.399) |
| 8 | French et al. 2019 [54] | Canada | Retrospective cohort study<br>2060 patients/ 4591 implants<br>private practice<br>5 Mucositis+BL≥1 mm one y after installation10 y (mean 6.7y) | Mucositis: Implant mucosal Index (IMI)<br>Strict criteria:≥2<br>Relaxed criteria≥1<br>PI: Mucositis + B L≥ 1 mm one y after installation | Implant level: 38.6% (relaxed criteria)<br>14.2% (strict criteria)(6.7y) | Implant level:<br>4.7% (relaxed criteria)<br>3.6% (strict criteria)(6.7y) | Risk factors with effect on BL: autoimmune<br>disease, heavy smoking, bisphosphonate therapy, implant location, diameter and design, and BL |

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| 9 | Katafuchi et al. 2018 [55] | USA | Cross-sectional<br>83 patients/168 implants<br>mean 10.9 y | Mucositis: n.r.<br>PI: BOP/SUO, BL≥2mm after initial remodeling, PD≥4mm | n.r. | Implant level: 16.7%<br>bone level implant: 22.8%<br>tissue level implants: 7.5%<br>Petient level: 25.3%<br>Bone level implants: 28.9%<br>Tissue level implants: 14.8% | Emergence profile >30 degrees is a significant risk indicator for PI; convex profile additionally for bone-level implants. |
| 10 | Koldsland et al. 2010 & 2011 [32,66] | Norway | Cross-sectional<br>103 patients/374 implants<br>University<br>1-16 y (mean 8.4y) functional loading | Mucositis: inflammation (bleeding, BOP, SUP), no BL<br>PI: inflammation (bleeding, BOP, SUP), BL (≥2mm, or ≥3mm) | Patient level: 39.4%<br>Implant level: 27.3% | Patient level: 47.1%<br>Implant level: 36.6% | n.r. |
| 11 | Konstantinidis et al. 2015 [35] | Germany | Cross-sectional<br>186 patients/ 597 implants<br>university<br>1-16.5 y (mean 5.5y) | Mucositis: BOP, no BL (BL<2mm)<br>PI: BOP, PD ≥ 5 mm, B L > 2 mm | Patient level: 64.5%<br>Implant level: 57.0% | Patient level: 12.9%<br>Implant level: 6.2% | High plaque score (OR:1.36) was a risk indicator for mucositis, while soft- or hard-tissue augmentation had a protective effect.<br>Loss of the last tooth in the dentition (OR:1.06) and location in the maxilla (OR:1.05) were risk factors for peri-implantitis. |
| 12 | Marrone et al. 2013 [56] | Belgium | Cross-sectional<br>103 patoents/266 implants<br>private practice & university<br>5–18 y (mean 8.5y) | Mucositis: PD≤5mm, BOP, BL≤ 2mm<br>PI: PD>5mm, BOP, BL>2mm | Patient level: 31%<br>Implant level: 38% | Patient level: 37%<br>Implant level: 23% | Age over 65y (OR:1.39), active periodontitis (OR: 1.98), hepatitis (OR: 2.92) and edentulism (OR:5.56) were associated with peri-implantitis.<br>Sign. correlation between peri-implantitis and rough implant surfaces and overdentures. |
| 13 | Meijer et al. 2014 [25] | Netherlands | Prospective cohort study<br>150 patients/ 275 implants (5 y), 240 implants (10 y)<br>university<br>5 and 10 y functional loading | Mucositis: BOP/SUP, BL<2mm<br>PI: BOP/SUP, BL≥ 2mm | Incidence:<br>Patient level:<br>51.9% (5 y)<br>57.0% (10 y) | Incidence:<br>Patient level:<br>16.9% (5 y)<br>29.7% (10 y) | n.r. |

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| 14 | Mir-Mari et al. 2012 [48] | Spain | Cross-sectional<br>245 patients/ 964 implants<br>private practice<br>1–18 y (mean 6.3 y) | Mucositis: BOP, BL< 2 implant threads<br>PI: BOP/SUP, BL≥2 implant threads | Patient level: 38.8%<br>Implant level: 21.6% | Patient level: 16.3%<br>Implant level: 9.1% | n.r. |
| 15 | Monje et al. 2017 [67] | Spain | Cross-sectional<br>115 patients/ 206 implants<br>Private practice<br>3–4.6 y (mean 3.9y) | Mucositis: BOP/SUP, swelling, BL<2 mm<br>PI: BOP/SUP, redness, BL> 2mm | n.r. | Patient level:<br>RC (regular compliers 3-6m recall): 4.5%<br>EC (erratic compliers: 7-12m recall): 26.3%<br>NC (non-compliers, no recall): 14.3%<br>Implant level:<br>RC: 2.4%<br>EC: 19%<br>NC: 8.7% | Stat. sign. association (p=0.04) betw. compliance to maintenance therapy and peri-implantitis.<br>Compliance was associated with 86% fewer conditions of peri-implantitis. |
| 16 | Papaspyridakos et al. 2018 [68] | USA | Cross-sectional<br>52 patients/457 rough implants<br>university<br>1–12y (mean 5.2y) | Mucositis:<br>n.r.<br>PI:<br>BL>2mm after 1st y of function/ >0.2mm per y, BOP/SUP | Implant level:<br>31.5% (estim. 5 y)<br>63.0% (estim. 10y) | Implant level:<br>10% (estim. 5 y)<br>20% (estim 10 y) | High plaque index was associated stat. sign. with bone loss |
| 17 | Renvert et al. 2014 [58] | Sweden | Cross-sectional, retrospective<br>270 patients/n.r.<br>University<br>Mean 10.1 y functional loading | Mucositis: BOP/SUP, edema, BL<2mm<br>PI: PD≥4mm, BOP/SUP, BL>2mm | Patient level:<br>36.3% -Peri-implant health/ mucositis | Patient level: 63.7% (172 patients) | OR of having peri-implantitis was stat. sign for history of cardio-vascular disease (8.7) and of periodontitis (4.5). No association betw. PI and smoking or gender. |
| 18 | Renvert et al. 2018 [46] | Sweden | Cross-sectional<br>218 patients (9–14 y)<br>86 patients (20–26y)<br>university | Mucositis: BOP/SUP, no BL<br>PI: BOP/SUP, BL (3 imp. threads) | Implant level:<br>82.6% (10y)<br>91.1% (20y) | Implant level:<br>4.8% (10y)<br>10.8% (20y) | Patients with ≥3 implants at 10 years had a higher risk for PI at 20 y.<br>No predictive value for PI at 20y for radiographic evidence of periodontitis, mucositis, smoking. |

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| 19 | Rinke et al. 2011 [69] | Germany | Cross-sectional<br>89 patients/n.r.<br>private practice<br>2–11y (mean 5.7y) | Mucositis: PD ≥ 4 mm, BOP<br>PI: PD ≥ 5 mm, BOP/SUP, BL | Patient level: 44.9% | Patient level: 11.2% | Significant association betw. mucositis and smoking (OR: 3.77).<br>Significant association betw. peri-implantitis and smoking (OR:31.58) and compliance (OR:0.09). |
| 20 | Rokn et al. 2016 [36] | Iran | Cross-sectional<br>134 patients/478 implants (55% tissue level)<br>university<br>1–11 y (mean 4.4 y) | Mucositis: BOP/SUP, BL ≤ 2 mm<br>PI: BOP/SUP, BL> 2mm | Patient level: 48.5%<br>Implant level: | Patient level: 20%<br>Implant level: 8.8% | Smoking (OR: 2.57) and lack of keratinized mucosa (OR: 3.89) were associated with PI. |
| 21 | Roos-Jansaker et al. 2006 [45] | Sweden | Cross-sectional<br>216 patients/ 999 implants analysed<br>university<br>9–14y (mean 11y) | Mucositis: PD≥4 mm, BOP, BL<1 thread<br>PI: BOP/SUP, BL≥1.8 mm from 1 y after loading | Patient level: 48%<br>Implant level: 16% | Patient level: 16%<br>Implant level: 6.6% | n.r. |
| 22 | Schwarz et al. 2017 [47] | Germany | Cross-sectional<br>238 patients/ 512 implants<br>university<br>1–6.7y (mean 2.2 y) | Mucositis: BOP, no changes at bone level compared to baseline<br>PI: BOP/SUP, changes at bone level compared to baseline | Patient level: 41.6%<br>Implant level: 35.6% | Patient level: 13.9%<br>Implant level: 7.6% | Plaque (OR: 8.4) and male gender (OR: 2.0) were associated with mucositis.<br>Plaque (OR: 9.3) and smoking (OR: 2.7) were associated with peri-implantitis. |
| 23 | Simonis et al. 2010 [51] | France | Retrospective cohort study<br>55 patient/131 implants<br>university<br>10-16y | Mucositis: n.r.<br>PI: PD≥5mm, BOP/SUP, BL≥2.5mm or BL≥3 threads for at least 10y | n.r. | Patient level:<br>With periodontitis: 37.93%<br>Without periodontitis: 10.53%<br>Implant level: 16.94% | History of periodontitis increases the risk for peri-implantitis (OR:5.1). |
| 24 | Tenenbaum et al. 2017 [70] | France | Prospective cohort study<br>52 patients/108 implants<br>university<br>10.8y | Mucositis: BOP, no BL<br>PI: PD≥5mm, BOP, BL (Progressive BL: 4.5mm) | Patient level: 73.1%<br>Implant level: 60.2% | Patient level: 15.4%<br>Implant level: 12% | Some bacteria were associated with worsened clinical situation. |

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| 25 | Zetterqvist et al. 2010 [28] | Multicenter (Europe: Sweden, Italy, USA) | RCT<br>112 patients/ 304 implants<br>after 5 y: 96 patients<br>university<br>5 y | Mucositis: n.r.<br>PI: PD > 5 mm, BOP, SUP, BL > 5 mm from loading | n.r. | Patient level: 1%<br>Implant level: 0.4% | After 5 y no increased risk of peri-implantitis for fully etched implants compared to hybrid-designed implants. |

PD: pocket depth; BOP: bleeding on probing; SUP: suppuration; BL: bone loss; n.r.: not reported; stat. sign.: statistiscally significant; PU: peri-implantitis; KMW: keratinized mucosa width; OR: odds ratio; RCT: randomized controlled trial; y: years

values vary significantly between those reported on implant level (21.7%,[13] 9.25%,[20] 1.1–85%,[21] 12.8%[22]) and those on patient level (19.83%,[20] 0–39.7%,[23] 18.5%[22]). For longer evaluation periods (over 9 years of functional loading) data from a retrospective and cross-sectional analysis show a prevalence for peri-implantitis of 45% (patient level, 14.5% of these patients with moderate to severe disease[24] and 57% after 10 years of function.[25]

Methodological inconsistencies and shortcomings of the reporting studies[9,14,26] led to these significant variations of the prevalence for peri-implant diseases making thus difficult to globally estimate the real impact of peri-implant biological complications. Despite the recommendations for quality improvement in peri-implant disease research of the VIII-th EWP,[9] only few study protocols have applied these. Since 2018, according to the new classification of periodontal diseases of the WWP 2017[16] clear definitions for peri-implant health, mucositis and peri-implantitis were made and these should ease and assure a more reliable evaluation of the prevalence, extent and severity of peri-implant diseases in epidemiological studies. Nonetheless, after the search of the current review, no single study applied entirely the newly proposed definition criteria for peri-implantitis (BOP/SUP, pocket depths ≥6mm, bone level ≥3mm of the most coronal portion of the intraosseous part of the implant) [16]. Either bone loss thresholds were unclearly defined, or related to 2 mm bone los or to implant threads, and/or lower values for included peri-implant pocket depths (*i.e.*, 4 or 5 mm) were used (Table).

Analyzing closer the current evidence, following factors may affect the reported prevalence of peri-implant diseases.

## Definition of peri-implantitis

More than two decades ago, peri-implantitis has been defined as an infectious pathological condition of the peri-implant tissues.[10,27] Following the 1st European Workshop on Periodontology (EWP) in 1993 described the term peri-implantitis in relation to inflammatory processes at osseointegrated dental implants with the clinical signs of pocket formation and bone resorption following the anticipated initial bone remodeling.[12] This definition is nowadays still correct and applicable. Nonetheless, the lack of clear thresholds to define pathological values for peri-implant pocket depths and loss of the supporting bone after functional loading led to various applications of this definition in clinical studies assessing the prevalence, incidence and extent of peri-implantitis. Therefore, in the VIIIth EWP in 2012 it was agreed that the presence of clinical inflammation together with a peri-implant bone level of 2mm from the expected level after bone remodeling should be considered as criteria for defining peri-implantitis in clinical studies.[9] When reporting incidence and baseline radiographs are available, the bone loss cutoff is set at 1–1.5mm.[9]

Despite these guidelines, the definitions used in clinical studies were inconsistent: most studies used the same threshold for peri-implant pocket depths (>5mm), but the various levels for bone loss resulted in a large range of disease occurrence. Studies reporting low prevalences for peri-implantitis (implant level) used a high bone loss thresholds: for bone loss of 5 mm 1%,[28] 8.80–22.20%;[29] for bone loss ≥3mm: 9%,[30] 0.37%.[28] On the other side, high prevalences were obtained when bone loss was set at low values (< 1.5mm) or was not mentioned: 77% (0.5 mm),[31] 47% (0.4mm).[32] Logically, different bone loss

thresholds reflect various degrees of disease severity and if these define the disease, then consecutively its prevalence is miscalculated. Thus, uniformity in the reported prevalence can be seen when studies used the same bone loss levels: for bone loss 1.5–3mm 14.5%,[24] 12.9%,[25,33,34,35,36,37], 8.8%,[36] 7.3%,[33] 6.2%,[35] 14.3%. [29]

Considering the new Classification for peri-implant conditions of the WWP 2017, reporting the prevalence and incidence for plaque-induced peri-implant diseases should be more homogenous and shall provide a realistic view of the global burden of peri-implant diseases.[16,17,19]

## Timepoint of assessment

Both peri-implant mucositis and peri-implantitis have an infectious etiology based on the accumulation of a biofilm composed of periodontal pathogens on the implant surface.[17,38,39,40,41] It is believed that peri-implant mucositis is the precursor for peri-implantitis, however, the histopathological and clinical conditions initiating this conversion are still not elucidated.[19] Since peri-implantitis represents rather a chronic form of disease implying time for the osseous destruction, it seems appropriate to report on the prevelance of peri-implantitis after sufficient time in function. Analyzing the existing reports with respect to timepoint of evaluation, it seems that prevalences of peri-implantitis do not vary strongly.

Studies evaluating the prevalence of peri-implantitis after 5 years of function and for a bone-loss threshold over 2 mm report similar values (implant level) compared to those for longer observation periods (over 9 years): at 5 years 12.9%,[35] 16.9%,[25] 9.6%,[42] 8.80%,[36] 10.9%,[43] 1.80%;[44] at over 9 years: 9%,[30] 6.6%,[45] 16%– 26%,[34] 14.5%[24] and 29.7%.[25] The differences that can be seen in the above mentioned values relate to the different thresholds for bone loss that was included in the case definition (0.5 mm vs. > 2 mm), highlighting again the importance of a consensus in the establishing a clear cutoff for peri-implant bone loss. Renvert et al.[46] reported on the prevalence of peri-implant diseases with the longest follow-up of over 20 years in function and obtained similar values to those reported in the literature for 10 years: peri-implantitis 22.1%. Thus, the present data suggest that function time has only a limited effect on the development of peri-implantitis.[13,14,32] Nonetheless, it seems relevant that clinical studies assessing the prevalence of peri-implantitis include cases with similar periods of function. Several studies mixed shorter with longer loading periods: 6 months -17 years,[37] 10–46 months,[47] 1–14 years,[33] 1–11 years,[36] 1–18 years,[48] which may have lead to a possible underestimation of the reported prevalence/incidence of peri-implantitis.

## Level of reporting: implant vs. subject level

Assessing the global burden of peri-implant diseases is a matter of patients/humans as in any other chronic systemical diseases. When prevalences of any type of disease are reported, these refer to the number of subjects affected by that disease at that moment. Therefore, it seems quite appropriate to similarly evaluate the prevalence of peri-implant pathologies at a subject level. This was also stressed out in 2012 at the VIII-th EWP consensus workshop where the impact of peri-implant diseases on individuals should be in the focus and not that on individual implants. Research assessing the prevalence of peri-implant diseases should be thus evaluated on subject-level analysis.[9]

Several previous clinical studies reported the prevalence only on implant-level making thus difficult to estimate the global impact of the disease.[28,49,50,51] Moreover, higher prevalences are reported on patient-level as opposed to implant-level: 14.5% vs. 8.0%,[24] 16.4 % vs. 7.3%,[33] 2.5 vs. 0.9,[52] 12.7% vs. 4.6,[53] 4.7 % vs. 3.6%,[54] 25.3% vs. 16.7%.[55] However, in the past 5 years, the majority of clinical studies reporting on the prevalence of peri-implantitis applied the recommendations of the VIII-th EWP and included patient-level analyses. [24,25,33,34,35,37,53,54,55]

## Evaluated population

The majority of the studies reported prevalences for peri-implant diseases investigating patients either from university or from private clinics.[28,31,48,56] These analyses rely however on "convenience samples" of various size bearing with it a high sensitivity for selection bias not representing the global/common implant population.[26,57] Only few studies reported the prevalence based on random patient selection[24] or

based on multicenter data from subjects in private and university clinics[24,47,58] or. The VIII[th] EWP from 2012 recommended for evaluations in clinical studies of the prevalence of peri-implant diseases random patient selection from multivariate treatment environments of adequate sample sizes.[9,26]

Various prevalences for peri-implantitis have been reported when populations with additional of conditions (*i.e.*, diabetes, rheumatoid arthritis, smokers, history of periodontitis, adherence to maintenance therapy) have been investigated to assess risk factors of developing peri-implantitis. Prevalence in patient with a *history of periodontitis* seem have a higher prevalence of the disease which remains stable over time; thus, studies evaluating the presence of peri-implantitis under 5 years of function report values of 14.3–26.1% (bone loss>2mm) or 8.9–17.4% (bone loss > 3 mm) as opposed to 6.1% or 3% in patients without residual periodontitis.[29] Similar values were observed also in more severe cases with bone loss > 5 mm (22.2%, after 7.9 years)[50] or > 0.2 mm annual bone loss at 8.25 y (26%).[59] Similarly, in non-smokers implant level based prevalence of peri-implantitis reached 7.44% for a functional loading period of 6 months–5 years[60] and 9% after 10 years.[30] Additionally, higher prevalences were reported for patients not attending a maintenance program (28.80%)[43] as opposed to those in regular prophylaxis (after 5 years: 10.8%, 1.8%; after 10 years: 9%).[30,43,44] Another type of population with various reports on the prevalence of peri-implantitis are diabetic patients. Ferreira et al.[60] reported a prevalence (patient-level) of 24% as opposed to 7% of non-diabetic patients. On the other side, Tawil et al.[61] reported occurrence (4.25%) of peri-implantitis only in poor controlled diabetes (HbA1c level 7-9%). Whether these patient conditions represent risk factors for developing peri-implantitis is to be discussed in a further paper of this issue.

### Implants placed in pristine vs. augmented sites

Outcome of a recent systematic review[62] indicated that implants placed in augmented sites performed slightly less effective after a mean observation period of at least 10 years compared with implants placed in pristine bone when assessing peri-implantitis (17.8% vs. 10.3%) and implant failure rates (3.6% vs. 2.5%), respectively. Patient samples included in that systematic review,[62] however, differed with respect to clinical characteristics such as history of treated periodontitis and materials used for augmentation procedures. Moreover, none of the studies including augmentation procedures adopted the same surgical protocol, thus enhancing heterogeneity due to sample selection. Hence, considering the lack of representation of various augmentation techniques used and of the variety of implant designs, the results of that systematic review [62] should be interpreted with caution.

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