Limits and drawbacks of classification systems to identify peri-implant diseases.
A cross-sectional study with a novel proposal.

› **M. MERLI[1], E. GIULIANELLI[2], I. TOSELLI[2], G. MARIOTTI[3], U. PAGLIARO[4], M. NIERI[5]**

[1]MD, DDS, Visiting Professor, University Politecnica delle Marche, Ancona, Italy - Private practice, Rimini, Italy.
[2]RDH, Private practice, Rimini, Italy.
[3]DDS, Private practice, Rimini, Italy.
[4]MD DDS, Department of Experimental and Clinical Medicine, University of Florence, Italy.
[5]DDS, PhD, Department of Experimental and Clinical Medicine, University of Florence, Italy.

ABSTRACT

Aims Several peri-implant tissue conditions cannot be classified using the standard case definitions of the peri-implant diseases. The aim of this study was to estimate the prevalence of mucositis, peri-implantitis, healthy implants and unclassified peri-implant conditions using two principal standard case definitions and to compare their results.
Materials and methods Any adult patient with ≥1 dental implant was eligible. Two calibrated operators examined the patients' implants on the basis of pocket depth, bleeding on probing, suppuration and radiographic bone loss. Two different definitions of the peri-implant diseases proposed at the 7th European Workshop on Periodontology (EWPD) and at the 2017 World Workshop (WWD) were compared.
Results Fifty-two patients with 92 implants were included. Following the EWPD, 22 implants (24%) were affected by peri-implantitis, 60 implants (65%) were affected by mucositis, and 7 implants (8%) were healthy. The remaining 3 implants (3%) cannot be assigned to one definite peri-implant condition. Following the WWD, no implants (0%) were affected by peri-implantitis, 60 implants (65%) were affected by mucositis, and 4 implants (4%) were healthy. The remaining 28 implants (30%) cannot be assigned to one definite peri-implant condition. The difference in diagnosis between the two case definitions (EWPD, and WWD) was highly significant (P<0.0001).
Conclusions The estimates of the prevalence of the peri-implant diseases are different using the two standard case definitions. None of the classifications studied is exhaustive and both have limits and drawbacks. A simple exhaustive modification of EWPD was proposed.

INTRODUCTION

The Sixth European Workshop in Periodontics held in 2008 defined peri-implant diseases as follows: peri-implant mucositis is the presence of inflammation of the peri-implant mucosa without signs of loss of bone support, while peri-implantitis, in addition to inflammation of the mucosa, is characterized by a loss of bone support above 2 mm (1).
Previous studies reported a high prevalence of peri-implant disease. The prevalence of peri-implant mucositis and peri-implantitis ranged from 19 to 65% and from 1 to 47% respectively (2). The observed variability for reported prevalence of mucositis and peri-implantitis between different studies may be explained in part by the heterogeneous use of case definition (2-9).
Peri-implantitis is often defined by the incidence of peri-implant Pocket Depth (PD) ≥ 5 mm associated with Bleeding on Probing (BoP) and/or suppuration and radiographic images of Bone Loss (BL) (Classical definition – CD) (10,11). From a clinical standpoint, signs of peri-implant mucositis include BoP and/or suppuration and no evidence of radiographic BL (12). Mucositis is often defined by the presence of BoP without deep peri-implant probing and without radiographic images of BL (13).
The joint use of PD, BoP and radiographic BL is frequently implemented in the case definition of peri-implant diseases (6, 14-16). There are, however notable exceptions. For example, in the 7th European Workshop on Periodontology peri-implantitis is characterized by the change in the level of the crestal bone in conjunction with bleeding on probing with or without concomitant deepening of peri-implant pockets (European Workshop on Periodontology Definition - EWPD) (17,18). A new case

definition was proposed at the 2017 World Workshop on the Classification of Periodontal and Peri-implant Disease and Condition (WWD) (19,20). In this case definition (WWD) (19) the diagnosis of peri-implant health requires: absence of clinical sign of inflammation, absence of bleeding and/or suppuration on gentle probing, no increase in probing depth compared to previous examination, absence of bone loss beyond crestal bone level changes resulting from initial bone remodelling; the diagnosis of peri-implant mucositis requires: presence of bleeding and/or suppuration on gentle probing with or without increased probing depth compared to previous examinations, absence of bone loss beyond crestal bone level changes resulting from initial bone remodelling; diagnosis of peri-implantitis requires: presence of bleeding and/or suppuration on gentle probing, increased probing depth compared to previous examinations, presence of bone loss beyond crestal bone level changes resulting from initial bone remodelling. In the absence of previous examination data diagnosis of peri-implantitis can be based on the combination of: presence of bleeding and/or suppuration on gentle probing, probing depth ≥ 6 mm, bone levels ≥ 3 mm apical of the most coronal portion of the intraosseous part of the implant (19).

Clinical observations show that several combinations of the factors involved in the definitions of the peri-implant conditions (PD, BoP, and BL) are not contemplated in the current case definitions of these diseases. On the contrary, the classification of peri-implant conditions should be useful, exhaustive, pairwise disjoint and simple (21,22). In particular, an ideal classification should be exhaustive, that is, naturally accommodate every member of the group, and pairwise disjoint, that is, no particular case should fall into more than one class (21,22).

Following these principles, the current classifications of the peri-implant conditions are pairwise disjoint, but are not exhaustive. For example, the combination of the 3 factors used in the classical definition of peri-implant diseases (PD, BoP and BL) generates eight different clinical conditions (two to the power of three, 2^3). Only the condition with PD+, BoP+, BL+ implies peri-implantitis, only the condition with PD-BoP-,BL- implies healthy implant, and only the condition with PD-, BoP+, BL- implies mucositis. Five combinations, that may be frequently found in clinical observations, remain unmentioned and consequently unclassified:

• PD-, BoP+, BL+;
• PD+, BoP+, BL-;
• PD+, BoP-, BL-;
• PD+, BoP-, BL+;
• PD-, BoP-, BL+.

The combination PD-, BoP+, BL+ could be frequent in cases of recessions. This condition cannot be considered peri-implantitis because the variable PD is negative and cannot be considered mucositis because there is loss of supporting bone in the CD and WWD. Using the diagnostic criteria of the 7th European Workshop on Periodontology

(EWPD), this combination can be classified as peri-implantitis (17).

Using the CD, the combinations PD+, BoP+, BL- and PD+,BoP-,BL- cannot be classified because of the possible presence of a pseudo-pocket. In a previous study the condition PD+, BoP+, BL- was 3.7% of the examined cases (23). Using the diagnostic criteria of the EWPD, the combination PD+, BoP-, BL- can be classified as healthy implant and the combination PD+, BoP+, BL- can be considered a mucositis, while using the WWD the combination PD+, BoP-, BL- is unclassified and the combination PD+, BoP+, BL- is mucositis (17,19). The combinations PD+, BoP-, BL+, and PD-, BoP-, BL+ could be present in cases of previously healed peri-implantitis. Using the diagnostic criteria of the CD, EWPD, and WWD these conditions cannot be classified (17,19).

The prevalence of the unclassified conditions is not known and could contribute to increasing disagreement both in clinical and epidemiological research. Both reliability and accuracy in assigning case definitions to dental implant using WWD were mostly moderate in one recent research (8).

The objectives of this study were (i) to estimate the prevalence of mucositis, peri-implantitis, healthy implants, and possible unclassified peri-implant conditions using the two principal standard case definitions (EWPD, and WWD) and (ii) to compare the results between these two case definitions.

The manuscript was written following the guidelines for the reporting of observational studies in epidemiology (STROBE) (24).

MATERIALS AND METHODS

Study design and setting

This was a cross-sectional study. The patients were selected during the professional maintenance procedure in a private clinical centre specializing in implant therapy in Rimini (Italy) between September 2014 and December 2015. Data deriving from patients selected for this study were published previously in an observational cross-sectional study aiming to evaluate the association between peri-implant bleeding on probing and probing depth (25).

Participants

Inclusion criteria were:
1. Patients participating in a professional maintenance therapy program.
2. Eighteen years or older.
3. Presence of ≥1 implants previously loaded for at least 1 year.
4. Implant supported fixed prosthesis.
5. Current radiographs of the implants.
Gender, age, diabetes and smoking status were recorded.

Exclusion criteria were:
1. Patients irradiated in the head and neck area.

2. Chemo- or immune-suppressive therapy in the previous 5 years.
3. Pregnancy or lactating period.
4. Implants with cemented restorations.
5. Drug abusers.

The investigators explained the nature of the trial, the aim and the methods to the patients, anticipating benefits, potential risks, as well as any form of discomfort that participation might entail. The patients read and asked questions inherent to the study prior to signing the informed consent. The informed consent was signed and dated by each patient before entering the study. Patients were aware of their right to decline to participate or to withdraw from the study at any time.

Variables and measurements

Two operators (EG, IT) with 7 and 6 years of experience respectively, in implant diagnosis and therapy, examined the patients. They were previously calibrated in a study on inter-rater agreement in implant diagnosis (7).

Recession, PD and BoP were measured at 6 sites per implant (mesio-vestibular, vestibular, disto-vestibular, disto-lingual, lingual, mesio-lingual). Gentle probing was applied using the PCPUNC15 probe (Hu-Friedy, Frankfurt, Germany). An air syringe was used to dry the tissue prior to probing (26). Peri-implant PD was dichotomized using the 5 mm threshold. Probing depth was considered positive when $\geq$ 5 mm (PD+) and negative when < 5 mm (PD-). Bleeding on probing was considered positive when BoP and/or suppuration occurs (BoP+) and negative when they do not occur (BoP-).

Peri-implant bone loss was assessed in a dichotomous mode (yes, BL+ or no, BL-). For EWPD, in the absence of previous radiographic records the criterion used for diagnosis of BL was based on a vertical distance threshold of 2 mm from the expected marginal bone level following remodelling post-implant placement in at least one site, mesial or distal (18). For WWD increasing of PD were considered if a previous observation was present (19). In the absence of previous examination data diagnosis of peri-implantitis was based on the combination of: presence of bleeding and/or suppuration on gentle probing, probing depth $\geq$ 6 mm, bone levels $\geq$ 3mm apical of the most coronal portion of the intraosseous part of the implant (19).

Bias

The two examiners (EG, IT) were previously aligned and calibrated in peri-implant measures and diagnosis (7). The agreement between the two examiners regarding the peri-implant diseases was 0.63 (kappa statistics) and regarding the peri-implant probing depth was 0.57 (intra-class correlation coefficient) (7).

Study size

The determination of sample size was based on another published study on this study sample, aimed at evaluating the association between peri-implant bleeding on probing and probing depth (25). The same patients were included in this study.

Classifications

The analysis was conducted at implant level. The most compromised sites for PD, BoP, and BL were considered. For example, if an implant showed PD = 6 mm in the mesio-vestibular site and PD < 5 mm in the other five sites, it was considered as PD+. If the same implant showed bleeding on probing at the disto-vestibular site and it did not bleed at the other five sites, it was considered BoP+. Similarly, if an implant showed BL at the mesial site and no BL at distal side, it was considered BL+ independently of the value of the other factors.

Eight categories of peri-implant conditions can be described based on combinations of PD, BoP and BL.
1) PD-, BoP-, BL-
2) PD+, BoP-, BL-
3) PD-, BoP-, BL+
4) PD+, BoP-, BL+
5) PD-, BoP+, BL-
6) PD+, BoP+, BL-
7) PD-, BoP+, BL+
8) PD+, BoP+, BL+

Examples of 8 different peri-implant conditions are illustrated in Table 1.

The prevalence of the eight combinations was calculated. The prevalence was also calculated considering only BoP and BL, irrespectively of the value of PD (7th European Workshop on Periodontology Definition - EWPD) (17,18). In this case 4 categories of peri-implants conditions were constructed based on the two levels combinations of BoP and BL (Table 1). They were: BoP- BL- healthy implant; BoP- BL+ unclassified; BoP+ BL- mucositis; BoP+ BL+ peri-implantitis (Table 1).

Considering the WWD (19), only the condition with PD- BoP- BL- implies healthy implants, the conditions PD- BoP+ BL- and PD+ BoP+ BL- imply mucositis and only the condition PD+ BoP+ BL+ implies peri-implantitis. In this case, in absence of a previous examination, the PD should be $\geq$ 6 mm and BL should be $\geq$ 3 mm.

Three combinations (PD+ BoP- BL-, PD- BoP- BL+ and PD+ BoP- BL+) remain unmentioned and consequently unclassified (Table 1).

Statistical analysis

Descriptive statistics were calculated considering mean and standard deviation for quantitative variables and frequency, as well as a percentage for qualitative variables. Binomial exact confidence limits at 95% of the proportion for each peri-implant condition of the EWPD, and WWD were calculated.

The difference in diagnosis of peri-implant diseases between EWPD and WWD was tested as an overall test of marginal homogeneity (across all the four categories: healthy implants, mucositis, peri-implantitis, and unclassified) using the Bhapkar test.
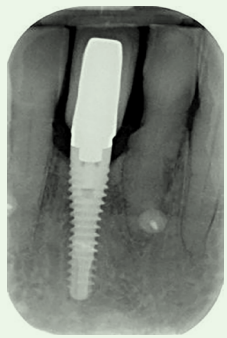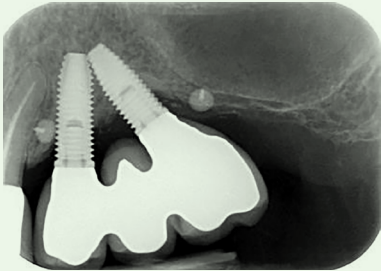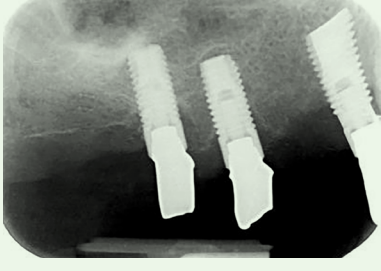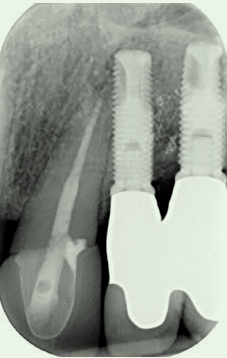
Condition	Diagnosis	Clinical image	Radiographic image
1) PD– BoP– BL–	EWPD: Healthy implant WWD: Healthy implant		
2) PD+ BoP– BL–	EWPD: Healthy implant WWD: Unclassified		
3) PD– BoP– BL+	EWPD: Unclassified WWD: Unclassified		
4) PD+ BoP– BL+	EWPD: Unclassified WWD: Unclassified		
5) PD– BoP+ BL–	EWPD: Mucositis WWD: Mucositis		

TABLE 1 Examples of the eight different peri-implant conditions based on the combinations of PD, BoP and BL

6) PD+ BoP+ BL-	EWPD: Mucositis WWD: Mucositis	
7) PD- BoP+ BL+	EWPD: Peri-implantitis WWD: Unclassified	
8) PD+ BoP+ BL+	EWPD: Peri-implantitis WWD: Peri-implantitis†	

EWPD: Definition of the 7th European Workshop on Periodontology (18); WWD: Definition of the 2017 World Workshop (19); PD: Pocket Depth (+ if PD ≥ 5 mm, else -); BoP: Bleeding on Probing (+ if bleeding, else -); BL: Bone Loss (+ if ≥ 2 mm; else -). † In case of WWD in the absence of a previous examination data, diagnosis of peri-implantitis is based on the combination of PD ≥ 6 mm, BoP+ and BL ≥ 3mm.

TABLE 1 Examples of the eight different peri-implant conditions based on the combinations of PD, BoP and BL

RESULTS

Participants and descriptive data

Fifty-two consecutive patients for a total of 92 implants and 552 sites were included in the study. The mean age was 51.6 years (standard deviation 14.6, range 23 to 79 years). Thirty-six patients (69%) were female, only 1 (2%) patient was diabetic and 8 (15%) were smokers. The patients had 24.3 (sd 4.8) natural teeth and 1.7 (sd 1.0) implants. Thirty-seven (71%) patients were assessed by examiner 1 (EG) and 15 (29%) patients were assessed by examiner 2 (IT). Seventy-seven (84%) of the implants were situated in posterior areas and had been inserted 4.3 (sd 3.6) years before examination. Fifty-one (55%) of the implants were Thommen Medical implants (Grenchen, Switzerland), 23 (25%) were Nobel Biocare implants (Zurich, Switzerland) and 18 (20%) were other brands of implants. Mean keratinized tissue was 2.2 (sd 1.5) mm. Bleeding on probing was observed in 217 sites (39%), mean probing depth was 3.1 (sd 1.1) mm, mean recession depth was 0.1 (sd 0.5) mm and mean radiographic bone level was 1.27 (sd 0.94) mm.

Main results

The prevalence of the 8 combinations of the factors PD, BoP and BL are reported in Table 2. The prevalence was very different in the various conditions. The peri-implant condition with maximum prevalence was PD- BoP+ BL- (41%) and the peri-implant condition with minimum prevalence was PD+ BoP- BL+ (0%).

Following the EWPD, 22 implants (24%; 95%CI from 16% to 34%) were affected by peri-implantitis (BoP+ BL+), 60 implants (65%; 95%CI from 55% to 75%) were affected by mucositis (BoP+ BL-), and 7 implants (8%; 95%CI from 3% to 15%) were healthy (BoP- BL-). Three implants (3%; 95%CI from 1% to 9%) could not be placed in one definite condition and were unclassified (BoP- BL+).

Following the WWD, 0 implants were affected by peri-

	Diagnosis EWPD	Diagnosis WWD	PD	BoP	BL	Fr	%	95%CI
1	Healthy	Healthy	-	-	-	4	4	1; 11
2	Healthy	Unclassified	+	-	-	3	3	1; 9
3	Unclassified	Unclassified	-	-	+	3	3	1; 9
4	Unclassified	Unclassified	+	-	+	0	0	0; 4
5	Mucositis	Mucositis	-	+	-	38	41	31; 52
6	Mucositis	Mucositis	+	+	-	22	24	16; 34
7	Peri-implantitis	Unclassified	-	+	+	16	17	10; 27
8	Peri-implantitis	-	+	+	+	6	7	2; 14
8†	-	Peri-implantitis†	+	+	+	0	0	0; n/a

EWPD: Definition of the 7th European Workshop on Periodontology (18); WWD: Definition of the 2017 World Workshop (19); PD: Pocket Depth (+ if PD ≥ 5 mm, else -); BoP: Bleeding on Probing (+ if bleeding, else -); BL: Bone Loss (+ if ≥ 2 mm; else -). Fr: Frequency; %: Percentage; 95%CI: 95% Confidence interval of the Percentage. † In case of WWD in the absence of a previous examination data diagnosis of peri-implantitis is based on the combination of PD ≥ 6 mm, BoP+ and BL ≥ 3 mm (19).

TABLE 2 Prevalence of the combinations of the eight conditions based on the combinations of PD, BoP and BL

implantitis (PD ≥ 6mm BoP+ BL ≥ 3mm), 60 implants (65%; 95%CI from 55% to 75%) were affected by mucositis (BoP+ BL-), and 4 implants (4%; 95%CI from 1% to 11%) were healthy (PD- BoP- BL-). The remaining 28 implants (30%; 95% from 21% to 41%) could not be accommodated in one definite condition and were unclassified.

The differences in diagnosis between the case definitions (EWPD, and WWD) were highly significant (P<0.0001; Bhapkar test). The WWD do not have any implants in the peri-implantitis group while they are 24% in EWPD. The cases of mucositis in the EWPD and in the WWD are the same. The use of EWPD compared to WWD increased the number of healthy implants from 4% to 8%. The difference between EWPD and WWD is represented by the implants with the condition PD+ BoP- BL-. They are 3 in this sample. The use of EWPD compared to WWD decreased the number of unclassified implants from 30% to 3%. The difference between EWPD and WWD is represented by the implants with the condition PD+ BoP- BL-, and PD-BoP+BL+. The implants with the condition PD+ BoP- BL- (3%) are healthy in EWPD case definition while they are unclassified in the WWD case definition. The implants with the condition PD- BoP+ BL+ (17%) are unclassified in the WWD but are peri-implantitis in the EWPD. Another difference is due to the implants with the condition PD+ BoP+ BL+. They are 7% (95%CI from 2% to 14%) and classified as peri-implantitis in the EWPD but not in the WWD. In fact, these 6 cases that are peri-implantitis in the EWPD are not peri-implantitis in the WWD. More specifically:

• In one implant PD was > 6 mm and BL was 2 mm; because the condition BL ≥ 3 mm is not satisfied, this situation cannot be considered peri-implantitis according to WWD.

• In two implants BL was > 3 mm and PD was 5 mm; because the condition PD ≥ 6 mm is not satisfied, these situations cannot be considered peri-implantitis according to WWD.

• In three implants PD was 5 mm and BL was 2 mm; because both the conditions PD ≥ 6 mm and BL ≥ 3 mm are not satisfied, these situations cannot be considered peri-implantitis according to WWD.

DISCUSSION

The objectives of this study were (i) to estimate the prevalence of mucositis, peri-implantitis, healthy implants, and to analyse the unclassified peri-implant conditions using the two principal standard case definitions (EWPD, and WWD) and (ii) to compare the results of utilizing each of the two considered classification.

The definitions of peri-implant disease should be simple to use, accurate, reproducible, quick and amenable to statistical analysis (25). In addition to that, a classification should be useful, exhaustive, pairwise disjoint and simple (21,22). Essentially, all members of the population should be classifiable (26,27). The classifications of peri-implant disease are pairwise disjoint, but not exhaustive. In fact, there are a considerable number of implants that cannot be considered affected by peri-implantitis, mucositis or healthy. Their prevalence is very high in the WWD (30%), and low in the EWPD, about 3%. This problem depends on the fact that traditionally only peri-implantitis and sometimes mucositis are defined, while the healthy implants are not defined. In the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Disease and Condition, the peri-implant health was clearly defined

but the problem of exhaustiveness was not resolved (19). At the moment, the diagnosis of peri-implant disease is based on these definitions and classifications. For this reason, their accuracy and agreement are of great relevance. Great consideration should be given to the fact that the two main classifications lead to a notable difference in terms of peri- implantitis. WWD case definition decreases the percentage of implant with peri-implantitis to 0% in this sample, while the percentage of mucositis is identical to EWPD.

Other authors have shown that different prevalence of mucositis and peri-implantitis between different studies may be explained in part by the heterogeneous use of case definition (2,4-8). In these studies, differences in peri-implantitis prevalence were considered in relation to the different criteria describing the severity of the disease (different thresholds of pocket depth or bone level). On the other hand, in the present study, the difference is also related to the use or not of the factor PD. What seems like a small change in the diagnosis of peri-implantitis, not taking the PD into consideration, leads to a great difference in prevalence of peri-implantitis. This depends on the fact that the peri-implant condition PD- BoP+ BL+ has a prevalence of 17% in this sample and it is unclassified in WWD and yet is peri-implantitis in EWPD. For the peri-implant condition PD- BoP- BL-, there is a perfect agreement between the two case definitions. The implant of the condition PD- BoP- BL- are considered healthy by EWPD and WWD.

The peri-implant condition PD+ BoP- BL- is poorly represented in our sample (3%) and it is unclassified in WWD while it is healthy implant in EWPD. This situation could be present in case of pseudo-pocket. Our recommendation is to consider this condition as healthy implants as in EWPD.

The peri-implant conditions PD- BoP- BL+ and PD+ BoP- BL+ are unclassified in EWPD, and WWD. They are poorly represented (3% and 0% respectively). The variables PD, BoP and BL are not independent measures. In two recent studies peri-implant bleeding was associated with site specific factor and the odds ratio of BoP increased by about 1.6-1.8 for each mm increment in PD (25,28). In our sample, no case was PD+ BoP- BL+. The conditions PD- BoP- BL+ and PD+ BoP- BL+ present sign of bone loss but were not inflamed. These conditions could be categorized as healthy but the rate of progression of the disease of these implants is not known. These situations could be present in cases of previously healed peri-implantitis (8). These conditions could also arise from the surgical or non-surgical treatment of peri-implant diseases (29). Our recommendation is to consider these situations tentatively as a healed peri-implantitis with recession or with residual PD. These situations may require a stringent follow-up examination to verify the diagnosis of healthy implants.

The peri-implant condition PD- BoP+ BL- is mucositis in EWPD and WWD. Recently, several authors proposed to change the definition of mucositis as follows: presence of bleeding (more than one spot at a location around the implant or presence of a line of bleeding or profuse bleeding at any location) and/or suppuration on gentle probing, in absence of bone loss beyond crestal bone level changes resulting from initial bone remodelling (30).

The peri-implant condition PD- BoP+ BL+ is unclassified in WWD and is peri-implantitis in EWPD. This condition is responsible for the difference in prevalence of peri-implantitis between EWPD and WWD. Our recommendation is to consider this condition as peri-implantitis as in EWPD. The peri-implant condition PD+ BoP+ BL- has a high prevalence in this sample (24%). It is mucositis in the EWPD and WWD. This condition deserves particular attention because the BL could be negative due to the presence of an intra-bony defect, the presence of a defect in the buccal and/or lingual side or the presence of a pseudo-pocket. Sometimes the bone defect could not be detected in the x-rays. This could be due to the presence of a buccal or lingual defect. A limitation of the periapical radiographs is the lack of information about the buccal and oral aspect. In addition, periapical radiographs are a suitable test for diagnosing advanced cases, but not for detecting initial inter-proximal bone loss and intra-bony defects. In a recent study, the intra-operatively measured peri-implant bone levels were more apical than the radiographic bone level: the difference was 1.3 mm on average (31). Limiting the diagnosis to BoP and BL (without considering PD), as in the EWPD, could consider as mucositis what is instead peri-implantitis, because the bone defect could be underestimated in the radiograph. This is especially relevant since better disease resolution after surgical treatment has been reported with initial bone defects ($\leq$ 3-4 mm) compared to more advanced lesions (32,33). Indeed, Serino et al. (2013) found a high correlation between peri-implant probing depth (measured without the prosthesis) and the bone level measured during surgery (34). For these reasons, the implants with PD+ BoP+ BL- should be investigated in detail to exclude or confirm the peri-implantitis diagnosis. We think that this peri-implant condition necessitates further investigations to adequately classify the implants. They could consist of bone probing, variations in PD over time, 3D CBCT, microbiological or biochemical indicators, etc. (35-37). A more accurate measure of PD could be obtained removing the prosthesis when it is possible (34). In addition, the variation in PD over time could be clinically relevant because some implants are associated with deep probing depth at the time of placement (19,20). An investigation revealed that bone probing without flap elevation was the best predictor of peri-implant bone level, whereas intraoral radiography was the most inferior (38). Consequently, peri-implantitis may be underdiagnosed if examination is only based on radiographs (38).

The condition PD+ BoP+ BL+ is theoretically peri-implantitis in both case definitions. Nevertheless, the recent case definitions of WWD points out that in the absence of previous examination data diagnosis of peri-

implantitis can be based on the combination of: presence of bleeding and/or suppuration on gentle probing, probing depth ≥ 6 mm, bone levels ≥ 3mm apical of the most coronal portion of the intraosseous part of the implant (19). These thresholds appear very stringent and in our sample no implants could be diagnosed as affected by peri-implantitis following the WWD case definition. Perhaps, these new classifications could determine an underestimation of the peri- implantitis rate. Accuracy of classification was affected by the absence of longitudinal data in one recent research (8). In clinical reality, however, baseline readings may frequently not be available. According with other authors WWD peri-implantitis definition in absence of baseline recording showed low sensitivity specially for the early or incipient forms (8,39). For these reasons several authors proposed a modification of the WWD definition using bone levels ≥ 2mm apical of the most coronal portion of the intraosseous part of the implant (8,39).

The prognosis of the vast majority of the peri-implant condition is unknown. Therefore, the clinical implication is that optimal biofilm removal is a prerequisite for the prevention and management of all the peri-implant conditions and the great majority of implant patients require stringent ongoing assessment and supportive care. The agreement between the two examiners of this study was qualified as merely good (7). Nevertheless, inter-rater agreement on peri-implant variables has recently reported as moderate (8).

The sample size of this study was based on the relationship between probing depth and bleeding on probing. Therefore, the study did not have sufficient power to estimate the prevalence of several peri-implant conditions.

This study was limited to implant supporting screw retained fixed prostheses, while implants with cemented restorations were excluded. In addition, these case definitions regard only implants that are osteo-integrated. Hence, they should be applied only to implants previously loaded for at least one year. In addition, they do not apply to peri-apical implant lesions.

Proposal to modify the EPW definition

A modification of the EPWD is proposed in Table 3. This proposal is simple and exhaustive. It is an EWPD modification where the PD is taken into account. This does not require further manoeuvres because to measure the BoP in EWPD it is still necessary to probe. The asterisks indicate the need to undertake further examination to classify the clinical case. In case of BoP- BL+ the implant is considered healthy (or healed) but a stringent follow-up is scheduled. In case of PD+ BoP+ BL- the implant is initially diagnosed as affected by mucositis but further tests such as the bone probing are scheduled to perform a differential diagnosis between the pseudo-pocket with mucositis and the peri-implantitis. This proposal should be validated in a subsequent study.

CONCLUSION

In two prevailing classifications systems of peri-implant diseases, several peri-implants conditions are not represented. Consequently, these classifications are not exhaustive. In addition, the estimates of prevalence of peri-implantitis varies widely because of the different case-definitions. A simple modification of the EWPD classification is proposed. Further studies on the epidemiology of peri-implant diseases should consider the application of consistent and exhaustive case definitions.

	Diagnosis EWPD	Modified EWPD	PD	BoP	BL
1	Healthy	Healthy	-	-	-
2	Healthy	Healthy	+	-	-
3	Unclassified	Healthy*	-	-	+
4	Unclassified	Healthy*	+	-	+
5	Mucositis	Mucositis	-	+	-
6	Mucositis	Mucositis**	+	+	-
7	Peri-implantitis	Peri-implantitis	-	+	+
8	Peri-implantitis	Peri-implantitis	+	+	+

Further examination is required: for example, stringent follow-up.
**Further examination is required: for example, bone probing.*
EWPD: Definition of the 7th European Workshop on Periodontology (17,18); PD: Pocket Depth (+ if PD ≥ 5 mm, else -); BoP: Bleeding on Probing (+ if bleeding, else -); BL: Bone Loss (+ if ≥ 2 mm; else -).

TABLE 3 A novel proposal with a modification of the EPWD

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