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# Peri-implant health, peri-implant mucositis, and peri-implantitis: Case definitions and diagnostic considerations

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## Abstract

The objective of this review is to identify case definitions and clinical criteria of peri-implant healthy tissues, peri-implant mucositis, and peri-implantitis. The case definitions were constructed based on a review of the evidence applicable for diagnostic considerations. In summary, the diagnostic definition of peri-implant health is based on the following criteria: 1) absence of peri-implant signs of soft tissue inflammation (redness, swelling, profuse bleeding on probing), and 2) the absence of further additional bone loss following initial healing. The diagnostic definition of peri-implant mucositis is based on following criteria: 1) presence of peri-implant signs of inflammation (redness, swelling, line or drop of bleeding within 30 seconds following probing), combined with 2) no additional bone loss following initial healing. The clinical definition of peri-implantitis is based on following criteria: 1) presence of peri-implant signs of inflammation, 2) radiographic evidence of bone loss following initial healing, and 3) increasing probing depth as compared to probing depth values collected after placement of the prosthetic reconstruction. In the absence of previous radiographs, radiographic bone level ≥3 mm in combination with BOP and probing depths ≥6 mm is indicative of peri-implantitis.

KEYWORDS

diagnosis, peri-implant health, peri-implant mucositis, peri-implantitis

## INTRODUCTION

Osseointegrated dental implants have become an increasingly popular modality of treatment for the replacement of absent or lost teeth. Dental implants have high rates of long-term survival (≥10 years) when used to support various types of dental prostheses. However, the long-term success of dental implants is not the same or as high as their survival, as functional implants and their restorations may be subject to mechanical and biological complications.[1]

It is recognized that there are also unusual peri-implant problems (e.g., peri-implant peripheral giant-cell granuloma, pyogenic granuloma, squamous cell carcinoma, metastatic carcinomas, malignant melanoma) or other conditions such as implant fractures that may mimic or share certain clinical features with biofilm-associated peri-implant diseases. With such context in mind, the reader is to be reminded that this manuscript focuses solely on biofilm-induced inflammatory lesions around dental implants.

Biological complications associated with dental implants are mostly inflammatory conditions of the soft tissues and bone surrounding implants and their restorative components, which are induced by the accumulation of bacterial biofilm. Such conditions, which have been named peri-implant mucositis and peri-implantitis, need to be clearly defined and differentiated from a state of peri-implant health, so that the clinician may assign a proper diagnosis and select a proper treatment modality in cases where disease is present.

In a survey of registered specialists in periodontology in Australia and the United Kingdom about the etiology, prevalence, diagnosis and management of peri-implant mucositis and peri-implantitis,

there appears to be no consensus on treatment standards for the management of peri-implant diseases.[2] An American survey that examined the practitioners' understanding of the etiology of peri-implant diseases and the management of peri-implant mucositis and peri-implantitis by periodontists in the United States revealed the absence of a standard therapeutic protocol to treat these conditions and a significant variation in the empirical use of therapeutic modalities that result in moderately effective treatment outcome.[3] Accordingly, there is a need to establish applicable clinical guidelines for the diagnosis of peri-implant mucositis, and peri-implantitis. Additionally, there is a need to develop criteria for peri-implant mucositis and peri-implantitis applicable in not only in for clinical practice but also for clinical and epidemiological research studies.

The objective of this manuscript is to define peri-implant health, peri-implant mucositis and peri-implantitis based on their clinical and radiographic parameters. The case definitions herein described were constructed based on a systematic review of the scientific evidence that currently correlates clinical and radiographic findings with the three diagnostic entities. The scientific evidence for peri-implant health, peri-implant mucositis and peri-implantitis has been summarized in other manuscripts in this volume.[4–6] The case definitions proposed in this paper are intended to apply to situations in which there are reasons to believe that the presence of biofilm on implant surfaces is the main etiological factor associated with the development of peri-implant mucositis and peri-implantitis. It is obvious from previous manuscripts in this volume that there are major patient-specific differences in inflammatory responses to the microbial challenge of bacterial communities that reside on implants and its restorations.[5,6]

## PERI-IMPLANT HEALTH

While peri-implant health shares many common clinical features with periodontal health around natural teeth, it is clear that there are major structural differences between the two scenarios, particularly with respect to their relationship with surrounding tissues and biological attachment. The review by Araujo and Lindhe[4] describes the different anatomical and histological characteristics associated with the soft and hard tissues around natural teeth and dental implants and the authors further described how such differences may be responsible for the distinct biological mechanisms involved in host response and tissue homeostasis observed between the two entities.

Araujo and Lindhe[4] also concluded that peri-implant health requires the absence of clinical signs of inflammation (i.e. erythema and swelling) including no bleeding on probing. This determination is true to evidence from the periodontal literature that the absence of bleeding on probing is consistent with periodontal health.[4,7] In clinical health, the peri-implant mucosa forms a tight seal around the trans-mucosal component of the implant itself, the abutment or the restoration. The height of the soft tissue around the implant following placement influences the initial probing depth. In general, however, the probing depth associated with peri-implant health should be ≤5.0 mm.[4] It should also be noted that peri-implant tissue health can exist following treatment of peri-implantitis with variable levels of bone support.

It has been proposed that the soft tissue cuff around implants exhibits less resistance to probing than the gingiva at adjacent teeth sites.[8,9] This property of the implant mucosal seal may lead to mechanically induced bleeding on probing on dental implants that are clinically healthy.[9] The clinical relevance of such phenomenon is that the presence of a local bleeding dot may, therefore, represent a traumatic episode rather than a sign of biofilm-induced inflammation. Such trauma-induced bleeding on probing may not only be the result of excessive probing forces, but can also be the consequence of clinical difficulties in aiming the dental probe at the sulcus/pocket around the implant, which can occur because of the implant-restoration spatial relationship and contours. It has been suggested that the absence of a periodontal ligament around implants and the prosthetic design makes assessments of pocket probing depth measurements at dental implants difficult to perform and interpret.[10] Recognizing the above described issue, a modified bleeding index has been proposed using a grading scale of the extent of bleeding at dental implants,[11] where a score of "0" represents healthy conditions, and a score of "1" representing an isolated dot of bleeding.

### What clinical and radiographic findings and what clinical examination steps are necessary to detect the presence of peri-implant health?

1. Clinical evaluation of the soft tissue conditions around implants should include registration of oral hygiene in general, with specific focus on the presence of biofilm on implants and their restorations;
2. Dental implants should be visually evaluated and probed routinely and periodically (at least once per year) as part of comprehensive oral exams, similar to natural teeth;
3. Pocket probing on dental implants should be conducted with a light force (approximately 0.25 N); peri-implant pocket depths should in general be ≤5 mm;
4. Bleeding on probing should not occur at implant sites defined as being healthy. Bleeding on probing should be assessed carefully using light forces (0.25 N) to avoid possible effects of trauma caused by the process. It is difficult to differentiate between biofilm-induced peri-implant inflammation and mechanically-induced trauma; bleeding "dots" should be interpreted carefully as this may represent bleeding due to tissue trauma and not bleeding associated with tissue inflammation;
5. Intra-oral radiographic evaluation of changes in bone levels around implants (preferably using a standardized film holder) is necessary to discriminate between health and disease states. A prerequisite for the radiographic evaluation should be an image taken at baseline (supra-structure in place) that clearly allows for identification of an implant reference point and distinct visualization of implant threads, for future reference as well as assessment

of mesial and distal bone levels in relation to such reference points; and

6. Absence of bone loss beyond bone level changes resulting from initial bone remodeling. Alveolar bone remodeling following the first year in function may be dependent on the type and position of the implant, but change (loss) of alveolar bone starting after the implant was placed in function should not exceed 2 mm.[12–14] Changes ≥2 mm at any time point during or after the first year should be considered as pathologic.

### Peri-implant health: Case definitions for day-to-day clinical practice

The diagnosis of peri-implant health requires:

1. Visual inspection demonstrating the absence of peri-implant signs of inflammation: pink as opposed to red, no swelling as opposed to swollen tissues, firm as opposed to soft tissue consistency;
2. Lack of profuse (line or drop) bleeding on probing;
3. Probing pocket depths could differ depending on the height of the soft tissue at the implant location. An increase in probing depth over time, however, conflicts with peri-implant health; and
4. Absence of further bone loss following initial healing, which should not be ≥2 mm.

## PERI-IMPLANT DISEASES

The scientific literature has provided the evidence to define the diagnosis of peri-implant conditions and diseases, and the reviews by Heitz-Mayfield and Salvi,[5] and Schwarz et al.[6] were used as the basis for the present report. In addition, two recent systematic reviews reporting on the prevalence of peri-implant mucositis and peri-implantitis were also evaluated.[15,16] Through these reports, we identified 33 articles defining clinical and radiographic criteria for the diagnosis of peri-implant mucositis and peri-implantitis (Table 1).

The American Academy of Periodontology has defined peri-implant mucositis as a disease that includes inflammation of the soft tissues surrounding a dental implant, without additional bone loss after the initial bone remodeling that may occur during healing following the surgical placement of the implant.[17] The etiology of peri-implant mucositis is the accumulation of a bacterial biofilm around the implant.[5]

Peri-implantitis has been defined as an inflammatory lesion of the mucosa surrounding an endosseous implant and with progressive loss of supporting peri-implant bone.[6,17–20] It is generally perceived that following implant installation and initial loading, some crestal bone height is lost (between 0.5 and 2 mm) in the healing process.[12,13] Any additional radiographic evidence of bone loss suggests peri-implant disease.

The conversion from an inflammatory process identified as peri-implant mucositis (without evidence of bone loss) to peri-implantitis (with bone loss) remains an enigma. It is, however, generally agreed that both peri-implant mucositis and peri-implantitis have an infectious etiology through the development of biofilm composed of a plethora of bacteria with known pathogenicity.[21–24]

## PERI-IMPLANT MUCOSITIS

Case definitions of peri-implant mucositis were identified in 22 out of 33 articles listed in Table 1. Bleeding on probing without any other criteria was identified in three out of 22 articles. Bleeding on probing combined with no radiographic evidence of bone level changes could be identified in seven out of 22 articles as the definition of peri-implant mucositis. Three of these articles accounted for remodeling of the marginal alveolar bone adjacent to the implant as a result of the surgical procedure. The remaining reports also included probing pocket depths and/or bone loss assessments. In addition to bleeding on probing, one study allowed up to 3 mm of bone loss from the implant platform to define peri-implant mucositis.[25]

The diagnosis of peri-implant mucositis should be based on clinical signs of inflammatory disease. In routine clinical examinations, signs of inflammation should be screened for. In addition, radiographic images should be evaluated to exclude bone level changes consistent with the definition of peri-implantitis, as described later in the manuscript.

### What clinical and radiographic findings and what clinical examination steps are necessary to detect the presence of peri-implant mucositis?

1. Visually, local swelling, redness, and shininess of the soft tissue surface are classical signs of clinical inflammation. A common symptom reported by patients is soreness;
2. A local dot of bleeding resulting from probing may be the result of a traumatic (probing) injury that should not be considered, in the absence of other inflammatory changes, a definitive criterion to characterize a peri-implant soft tissue lesion;
3. Any bleeding on probing that is combined with visual inflammatory changes of the tissues at the site of probing;
4. Clear evidence of bleeding such as a line of bleeding or drop bleeding should be used as an indication of an inflammatory peri-implant soft tissue lesion;
5. Suppuration upon clinical examination (e.g., application of light pressure to the tissues or following probing); and
6. Intra-oral radiographic evaluation of bone levels around implants should always be included in the presence of clinical signs of inflammation. In addition, a pre-requisite for the evaluation is that a radiograph be taken at baseline (supra-structure in place) and used for future assessment of mesial and distal bone levels in relation to defined references. Accounting for the remodeling

**TABLE 1** Criteria used for the case definitions of peri-implantitis and peri-implant mucositis from studies selected in the review

| Study | Case definition of peri-implantitis | Case definition of peri-implant mucositis |
|---|---|---|
| Fransson et al. (2005)[29] | Bone level change > 3 threads after first year in function | ND |
| Roos-Jansåker et al. (2006)[31] | Bone level change > 1.8 mm after first year in function + BOP | BOP + PD > 4 mm + no bone loss after first year on function |
| Ferreira et al. (2006) [32] | PD > 5 mm + BOP and/or suppuration (SUP) | BOP |
| Gatti et al. (2008)[33] | Bone level change > 2 mm from last radiographic assessment + Pus/ BOP + PD > 5 mm | ND |
| Maximo et al. (2008)[34] | Bone level change ≥3 threads + BOP and/or SUP + PD ≥5 mm | BOP + absence of radiographic bone loss and no SUP |
| Koldsland et al. (2010)[35] | Bone level change ≥2 mm from platform + BOP + PD ≥4 mm | BOP + no bone loss from platform |
| Koldsland et al. (2010)[35] | Bone level change ≥2 mm from platform + BOP + PD ≥6 mm | BOP + no bone loss from platform |
| Koldsland et al. (2010)[35] | Bone level change ≥3 mm from platform + BOP + PD ≥4 mm | BOP + no bone loss from platform |
| Koldsland et al. (2010)[35] | Bone level change ≥3 mm from platform + BOP + PD ≥6 mm | BOP + no bone loss from platform |
| Simonis et al. (2010)[36] | Bone level change > 2.5 mm (or ≥3 threads) from platform + BOP and/or SUP + PD ≥5 mm | ND |
| Wahlström et al. (2010)[37] | Bone level change > 2 mm after first year in function + BOP and/or SUP + PD ≥4 mm | BOP + PD < 4 mm + no bone loss after first year on function |
| Zetterqvist et al. (2010)[38] | Bone level change > 5 mm from the platform + BOP/SUP + PD > 5mm | ND |
| Pjetursson et al. (2012)[39] | Bone level change ≥2 mm after bone remodeling equals marginal bone levels of ≥5 mm below the implant shoulder | Level 1: BOP + PD > 5 mm<br>Level 2: BOP + PD > 6 mm |
| Mir-Mari et al (2012)[40] | Bone level change > 2 threads from platform + BOP and or suppuration | BOP + bone level change < two threads from platform |
| Swierkot et al. (2012)[41] | Bone level change > 0.2 mm annually after first year in function, + PD ≥5 mm with or without BOP | BOP + PD > 5 mm + no bone level change |
| Fardal and Grytten (2013)[42] | Bone level change > 3 threads after bone remodeling + BOP or suppuration | ND |
| Marrone et al. (2013)[43] | Bone level change > 2 mm from the platform + BOP + PD > 5 mm | BOP + bone level change ≤2 mm from platform. PPD ≤5 mm |
| Cecchinato et al. (2014)[44] | Progressive bone loss > 0.5 mm +BOP + PD ≥4 mm | BOP |
| Martens et al. (2014)[45] | Bone level change > 2 mm from the platform + PD > 4 mm | ND |
| Meijer et al. (2014)[46] | Bone level change ≥2 mm from the platform + BOP | BOP + bone level change < 2 mm from platform |
| Passoni et al. (2014)[47] | Bone level change > 2 + BOP and/or SUP + PD ≥ 5 mm | BOP + no bone level change |
| Renvert et al. (2014)[48] | Bone level change ≥2 mm from the platform + PD ≥ 4 mm + BOP and or suppuration | BOP + bone level change < 2 mm from platform |
| Aguirre-Zorzano et al. (2015)[49] | Bone level change > 1.5 mm after 6 months in function + often associated with suppuration, increased probing depth and bleeding on probing | BOP + no bone loss |
| Canullo et al. (2015)[50] | Bone level change > 3 mm following implant integration | ND |
| Daubert et al. (2015)[51] | Bone level change > 2 mm after remodeling + BOP and or SUP + PD ≥4 mm | BOP and/or gingival inflammation + no bone level change after remodeling |
| Ferreira et al. (2015)[52] | Bone level change > 2 mm after remodeling + BOP and/or + PD ≥4 mm | BOP and no bone loss |
| Frisch et al. (2015)[53] | Bone level change ≥2 mm after remodeling + BOP +PD ≥5 mm | BOP |
| Konstantinidis et al. (2015)[54] | Bone level change > 2 mm from the platform (at tissue level implants > 2 mm from the polished collar+ BOP + PD > 4 mm | BOP |
| Rinke et al. (2015)[55] | Bone level change ≥ 3.5 mm from platform | ND |

*(Continues)*

**TABLE 1** (Continued)

| Study | Case definition of peri-implantitis | Case definition of peri-implant mucositis |
|---|---|---|
| Papantonopoulos et al. (2015)[56] | Bone level change ≥3 mm from platform + BOP and/or SUP +PD ≥5 mm | ND |
| Trullenque-Eriksson et al. (2015)[25] | Bone level change ≥3 mm from the platform + BOP and/or SUP + PD ≥ 5 mm | BOP + bone level change < 3 mm from platform level |
| van Velzen et al. (2015)[57] | Bone level change > 1.5 mm after first year in function + BOP | ND |
| Derks et al. (2016)[1] | Bone loss > 0.5 mm after up to 24 months + BOP/ suppuration.<br>In addition, bone level change > 2 mm + BOP was considered moderate/severe peri-implantitis | BOP + no bone loss |
| Dalago et al. (2017)[58] | Bone level change > 2 mm from abutment installation + PD > 5 mm + BOP/SUP | ND |
| Rokn et al. (2017)[59] | Bone level change > 2 mm from platform level + BOP and/or SUP | BOP and/or SUP + bone level change ≤2 mm from platform level |
| Tenenbaum et al. (2017)[60] | Bone level change > 4.5 mm from platform + BOP + PD ≥5 mm | BOP + no bone level change from platform |

BOP = bleeding on probing, PD = probing depth, SUP = suppuration, ND = not defined.

process of alveolar bone during the first year after installation, the change in bone level since the placement of the prosthetic supra-structure should not be > 2.0 mm. Presence of bone loss beyond crestal bone level changes resulting from the intial remodeling process of alveolar bone after implant installation suggests either progressive peri-implant infection, or other local factors such as excess cement and looseness/fracture of implant components.

## Peri-implant mucositis: Case definitions for day-to-day clinical practice

The diagnosis of peri-implant mucositis requires:

1. Visual inspection demonstrating the presence of peri-implant signs of inflammation: red as opposed to pink, swollen tissues as opposed to no swelling, soft as opposed to firm tissue consistency;
2. Presence of profuse (line or drop) bleeding and/or suppuration on probing;
3. An increase in probing depths compared to baseline; and
4. Absence of bone loss beyond crestal bone level changes resulting from the intial remodeling.

## PERI-IMPLANTITIS

To assign a diagnosis of peri-implantitis, most reports listed in Table 1 (30 out of 33) require bleeding on probing in addition to bone loss. Following the initial healing, additional bone loss 0.5 mm to 5 mm – as assessed from radiographs – was a necessary criterion for the diagnosis of peri-implantitis in 13 reports.

Without accounting for the initial (remodeling-associated) bone loss, the remaining articles identified bone loss using the implant platform level as reference. Bone loss requirements varied between 1.8 to 4.5 mm to diagnose the implant as having peri-implantitis. Different cut-off levels for probing pocket depth around implants were also required in 20 of the articles to define a diagnosis of peri-implantitis. It is clear from the data summarized in Table 1 that there is a large variation in the requirements to define a case as having either peri-implant mucositis or peri-implantitis. Such variation in the application of individual clinical judgement is confirmed by Ramanauskaite et al.[26] who concluded that there is currently no single uniform definition of peri-implantitis, or parameters that could be used to define peri-implant disease entities.

Understanding the wide heterogeneity in defining peri-implantitis, the most uniform consensus in characterizing peri-implantitis is as follows; 1) peri–implantitis lesions present with the same clinical signs of inflammation as peri-implant mucositis and 2) the distinctive difference between a diagnosis of peri-implant mucositis and peri-implantitis is the presence of bone loss in peri-implantitis, as identified from dental radiographs.[6]

During the last 10 to 15 years, there has been a general agreement that following the first year in function, bone loss around dental implants ≥2 mm represents peri-implantitis.[14,27,28] Recent data suggest that the pattern of bone loss in general is not linear.[1,29] Typically, the development of peri-implantitis appears within the first few years after which the implant is in function. This suggests that it is important to carefully monitor changes that may occur around dental implants in the early post-restorative phase, with focus on bleeding on probing/suppuration and in combination with radiographic evidence of bone loss. From the clinical perspective, it is important to

recognize that there is no predictable model or algorithm to predict the progression of peri-implantitis based on diagnostic methodologies currently available in daily practice.

Furthermore, experiences from the knowledge about the progression of periodontitis can only be extrapolated to peri-implantitis with extreme care. For decades, it has been recognized that the progression of periodontitis is unpredictable, as lesions alternate phases of dormancy and bursts of disease activity, which may be slow or rapid.[30] Based on this knowledge and in attempting to extrapolate it to peri-implantitis, any bone loss greater than the measurement error (≥2 times its standard deviation) or approximately 2 mm is indicative of peri-implantitis.[28]

## What clinical and radiographic findings and what clinical examination steps are necessary to detect the presence of peri-implantitis?

1. The visual inspection with assessment of the presence of classical signs and symptoms of inflammation, i.e. redness, swelling, pain, and bleeding on probing (characteristics of the latter, described for peri-implant mucositis, also apply to the diagnosis of peri-implantitis);
2. The differential diagnosis between peri-implant mucositis and peri-implantitis is based on evidence that alveolar bone loss following initial healing and bone remodeling has occurred and requires a radiographic evaluation of the bone level around dental implants over time. This is in addition to the presence of inflammatory changes and bleeding on probing on a given site;
3. Presence of bone loss beyond crestal bone level changes resulting from the intial remodeling in conjunction with BOP after the implant has been placed in function should be considered as a marker for peri-implantitis; and
4. Radiographs should be taken based on clinical judgement after findings. Standardized radiographs should be taken and compared to reference radiographs when the implant(s) was placed in function.

## Peri-implantitis: Case definitions for day-to-day clinical practice

The diagnosis of peri-implantitis requires:

1. Evidence of visual inflammatory changes in the peri-implant soft tissues combined with bleeding on probing and/or suppuration;
2. Increasing probing pocket depths as compared to measurements obtained at placement of the supra-structure; and
3. Progressive bone loss in relation to the radiographic bone level assessment at 1 year following the delivery of the implant-supported prosthetics reconstruction; and
4. In the absence of initial radiographs and probing depths, radiographic evidence of bone level ≥3 mm and/or probing depths ≥6 mm in conjunction with profuse bleeding represents peri-implantitis.

For day to day clinical practice it may be valuable to assess the yearly rate of bone loss. This can be calculated if it is known when the implant was placed in function.

## CRITERIA TO BE USED IN EPIDEMIOLOGIC (SURVEILLANCE) STUDIES

The same criteria used to define peri-implant health and peri-implant mucositis in day-to-day practice should be applied in epidemiological studies. In epidemiological studies, radiographic and clinical information from the time point when the supra-structure was placed may not be available. Under such circumstances a distance from the implant platform to bone contact ≥3 mm, and in conjunction with bleeding on probing would be required for the diagnosis of peri-implantitis.

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