Peri-Implant Mucositis and Peri-Implantitis: A Current Understanding of Their Diagnoses and Clinical Implications*

The American Academy of Periodontology (AAP) periodically publishes reports, statements, and guidelines on a variety of topics relevant to periodontics. These papers are developed by an appointed committee of experts, and the documents are reviewed and approved by the AAP Board of Trustees.

I. INTRODUCTION – PURPOSE

The use of dental implants has revolutionized the treatment of partially and fully edentulous patients today. Implants have become a treatment approach for managing a broad range of clinical dilemmas due to their high level of predictability and their ability to be used for a wide variety of treatment options. While in many cases dental implants have been reported to achieve long-term success, they are not immune from complications associated with improper treatment planning, surgical and prosthetic execution, material failure, and maintenance. Included in the latter are the biologic complications of peri-implant mucositis and peri-implantitis, inflammatory conditions in the soft and hard tissues at dental implants. It is the purpose of this paper to review the current knowledge concerning peri-implant mucositis and peri-implantitis to aid clinicians in their diagnoses and prevention. It is recognized that new information will continue to emerge, and as such, this document represents a dynamic endeavor that will evolve and require further expansion and reevaluation.

II. BACKGROUND – DIAGNOSES, PREVALENCE, AND INCIDENCE

Peri-implant diseases present in two forms – peri-implant mucositis and peri-implantitis. Both of these are characterized by an inflammatory reaction in the tissues surrounding an implant.[1,2] Peri-implant mucositis has been described as a disease in which the presence of inflammation is confined to the soft tissues surrounding a dental implant with no signs of loss of supporting bone following initial bone remodeling during healing. Peri-implantitis has been characterized by an inflammatory process around an implant, which includes both soft tissue inflammation and progressive loss of supporting bone beyond biological bone remodeling.[3] While there may be some disagreement whether the soft tissues surrounding an implant are histologically consistent with mucosa or gingiva, this paper for the sake of consistency will retain the term mucositis as it has been historically used in the literature to describe this particular disease entity.

From a clinical standpoint, signs that determine the presence of peri-implant mucositis include bleeding on probing and/or suppuration, which are usually associated with probing depths ≥4 mm and no evidence of radiographic loss of bone beyond bone remodeling. Outcomes from reports[4,5] assessing the prevalence of peri-implant diseases revealed that peri-implant mucositis was present in 48% of implants followed from 9 to 14 years affected with this problem.[5] Since peri-implant mucositis is reversible with early intervention and removal of etiology,[6,7] it is quite possible that its prevalence could be underreported. However, when these same parameters are present with any degree of detectable bone loss following the initial bone remodeling after implant placement, a diagnosis of peri-implantitis is made.[8] This can only be applied for cases where there has been a baseline radiograph obtained at the time of suprastructure placement. It has been recommended in those cases where this baseline radiograph is absent to use a threshold vertical distance of 2 mm from the expected marginal bone level following remodeling post-implant placement as the threshold for diagnosing peri-implantitis.[3]

Distinct differences in the incidence and prevalence of peri-implantitis have been reported by a number of authors. Most recently, a publication discussed this problem and noted that a literature search of 12 studies in which bleeding on probing and/or purulence were detected with concomitant radiographic bone loss, revealed eight different thresholds of

* This paper was developed under the direction of the Task Force on Peri-Implantitis and approved by the Board of Trustees of the American Academy of Periodontology in January 2013. Task Force members: Dr. Paul Rosen, chair; Drs. Donald Clem, David Cochran, Stuart Froum, Bradley McAllister, Stefan Renvert, Hom-Lay Wang.

DISCLAIMER: This paper represents the views of the Academy regarding periodontal therapy and related procedures. It must be recognized, however, that decisions with respect to the treatment of patients must be made by the individual practitioner in light of the condition and needs of each specific patient. Such decisions should be made in the best judgment of the practitioner, taking into account all relevant circumstances.

doi: 10.1902/jop.2013.134001

Table 1.

Prevalence of Peri-Implant Mucositis and Peri-Implantitis

Reference	Study Type; Implant System	N Subjects/Implants	Mean Function Time (range)	Peri-Implant Mucositis (% subjects/implants)	Peri-Implantitis (% subjects/implants)
Koldsland et al.[11] (*J Periodontol* 2010)	Cross-sectional; solid screw implants	109/351	8.4 years (1-16 years)	39.4% subjects 27.3% implants	47.1% subjects 36.6% implants
Roos- Jansåker et al.[5] (*J Clin Periodontol* 2006)	Cross-sectional; machined	218/999	9-14 years	—	16% subjects 6.6% implants (progressive bone loss = 7.7% implants)
Renvert et al.[13] (*Clin Oral Implants Res* 2007)	Cross-sectional	213/976	10.8 years (9-14 years)	59.6% subjects	14.9% subjects
Fransson et al.[4] (*Clin Oral Implants Res* 2005)	Cross-sectional; Brånemark	662/3,413	5-20 years	—	27.8% subjects 12.4% implants
Rinke et al.[12] (*Clin Oral Implants Res* 2011)	Cross-sectional;	89/– Avg 3.9 implants/ patient	5.7 years (2-11.3 years)	44.9% subjects	11.2% subjects; 53% smokers + perio history 3% non-smokers
Marrone et al.[10] (*Clin Oral Implants Res* 2012)	Cross-sectional	103/266	8.5 years (5-18 years)	31% subjects 38% implants	37% subjects 23% implants
Mir-Mari et al.[14] (*J Clin Periodontol* 2012)	Cross-sectional	245/964	6.3 years (1-18 years)	38.8% subjects 21.6% implants	16.3% subjects 9.1% implants
Roccuzzo et al.[15] (*Clin Oral Implants Res* 2010)	Longitudinal; TPS solid screw, TPS hollow screw, TPS cylinder	101/246	10 years	—	4.7% implants–perio healthy; 11.2% implants–moderate perio compromise; 15.1% implants–severe perio compromise

radiographic bone loss used as a disease criteria.[9] This has led to a variation in the reported prevalence of peri-implantitis around implants. For example, one study found the prevalence to be 6.61% over a 9- to 14-year period,[5] another 23% during 10 years of observation,[10] and a third reported a prevalence of 36.6% with a mean of 8.4 years of loading (Table 1).[11]

The problem with applying differing thresholds for probing depth and radiographic bone loss to define peri-implantitis has been discussed in explaining the variance in reporting the prevalence of peri-implantitis. In one study, the prevalence varied from approximately 11% to 47% of subjects depending on the threshold used.[11] Although it requires evidence-based studies for validation, a peri-implant disease classification has been proposed to aid in explaining disease severity and threshold.[16]

III. ETIOLOGIES AND PATHOGENESIS

The description of the inflammatory process of peri-implant mucositis around an implant is quite similar to gingivitis around natural teeth. Shortly after implants are placed, glycoproteins from saliva adhere to exposed titanium surfaces with concomitant microbiological colonization.[1,6,17-22] The formation of a biofilm plays a significant role in the initiation and progression of peri-implant diseases and is essential for the development of infections around dental implants.[1,6,7,19,21-23] Moreover, peri-implant diseases have been associated with Gram-negative anaerobic bacteria similar to those found around natural teeth in patients with severe chronic periodontitis.[1,6,7,23] It is generally accepted that peri-implant mucositis is the precursor of peri-implantitis as it is accepted that gingivitis is the precursor of periodontitis. However, similar to the causal relationship between gingivitis and periodontitis, peri-implant mucositis does not necessarily progress to peri-implantitis. The "epithelial sealing" around implants is similar in function to that around teeth.[24] Moreover, it is concluded that there is no evidence to suggest that any structural differences between natural teeth and implants would significantly alter the host response to bacterial challenge.[6,17,25,26] Furthermore, there is evidence to suggest that peri-implant mucositis, like gingivitis, is reversible when effectively treated.[6,7] Thus, elimination of the biofilm from the implant surface is the prime objective when treating peri-implant mucositis.

Peri-implantitis, like periodontitis, occurs primarily as a result of an overwhelming bacterial insult and subsequent host immune response. Outcomes from animal[27] and human cross-sectional studies[28] have found that the bacterial species associated with periodontitis and peri-implantitis are similar, mainly Gram-negative aerobes. Moreover, *Staphylococcus aureus* may also be an important pathogen in the initiation of peri-implantitis.[28,29] Studies have shown that peri-implantitis and periodontitis lesions from human biopsies have many features in common.[26,30] The connective tissue adjacent to the pocket epithelium is infiltrated by inflammatory cells, with B-lymphocytes and plasma cells being the most dominating cell types. Basically, similar markers are upregulated between peri-implantitis and periodontitis, including proinflammatory cytokines such as interleukin (IL)-1, IL-6, IL-8, IL-12, and tumor necrosis factor (TNF)-alpha.[31,32]

Although sharing similarities with periodontitis in both the bacterial initiators and key immune components to those insults, the rate of disease progression and the severity of inflammatory signs for peri-implantitis may be different. Experiments that allowed undisturbed dental plaque formation on implants and teeth in humans[33] and in dogs[34] demonstrated more advanced inflammatory cell infiltration in the peri-implant mucosa. Features of experimentally created peri-implantitis and periodontitis have been compared.[35,36] The results suggested that clinical and radiographic signs of tissue destruction were more pronounced and the size of inflammatory cell infiltrate in the connective tissue was larger, approaching the crestal bone in peri-implantitis. The increased susceptibility for bone loss around implants may be related to the absence of inserting collagen fibers into the implant as is the case with a tooth.[36] A recent comparison of periodontitis and peri-implantitis noted a "self-limiting" process existing in the tissues around-natural teeth that resulted in a protective connective tissue capsule of the supracrestal gingival fibers of the tooth that separated the lesion from the alveolar bone. These authors[37] went on to note that "such a self-limiting" did not occur in peri-implant tissues and that the lesion extended to the bony crest, which was different than the periodontitis lesions. Another distinct feature in studies on experimentally induced peri-implantitis was that following ligature removal, there was spontaneous continuous progression of the disease with additional bone loss.[33,38,39] All implants appear to be susceptible to peri-implantitis.[38,39] Hence, the primary objective for treating peri-implantitis is similar to that for treating peri-implant mucositis, which is the elimination of the biofilm from the implant surface.

IV. RISK FACTORS

A number of risk factors have been identified that may lead to the establishment and progression of peri-implant mucositis and peri-implantitis.[40] The following are some of those factors:

Previous Periodontal Disease

Systematic reviews[41-44] have indicated that although the implant survival rate may not be affected by the periodontal history, peri-implantitis was a more frequent finding in patients with a history of periodontitis. The results of these systematic reviews, although showing a positive correlation, might be influenced by heterogeneities in the patient profile and designs of the included studies. More well-designed cohort studies are required to strengthen the relationship between history of periodontal disease and peri-implantitis.

Poor Plaque Control/Inability to Clean

Implant prosthesis design can obviate the patient's ability to mechanically clean the site with brushes, interdental brush, and floss. This can be related to implant positioning and meeting patient expectations for esthetics, phonetics, and function. Moreover, prosthesis design can also preclude clinical evaluation with probing and adequate home-care procedures.[45] These concerns must be factored in the prosthetic decisions to facilitate daily oral hygiene. While the prosthesis suprastructure, if screw retained, can be removed to facilitate evaluation, the same cannot be said for patient home care. It is incumbent upon dental providers to educate the patient in proper plaque control and to ensure the establishment of regular periodontal maintenance. This will help to assess the adequacy of plaque removal efforts and to intervene as early as possible if problems are detected.

Residual Cement

A growing area of concern has been the incomplete removal of cement left in the subgingival space around dental implants.[46] The cementation of crowns on implants is a common practice. It is quite plausible for cement to be left behind because of implant positioning and the subsequent suprastructure design, which may hamper mechanical non-surgical therapy efforts to access the subgingival space.[47] Moreover, many of the commonly used cements are undetectable by radiographic survey.[48] How dental cement causes inflammation and disease may be related to its roughness which, unto itself, may cause inflammation; however, its surface topography may provide a positive environment for bacterial attachment.

Smoking

Four systematic reviews have concluded that there is an increased risk for peri-implantitis in smokers, with odds ratios ranging from 3.6 to 4.6.[41,49-51] Moreover, cohort studies and cross-sectional studies frequently have linked smoking to higher implant failures. One study[41] reported that 78% of the implants in smokers had the diagnosis of peri-implantitis, while for non-smokers it was only 64%. More recently, a cross-sectional study demonstrated that smokers had an odds ratio of 3.8 of developing peri-implant mucositis and an odds ratio of 31.6 of developing peri-implantitis.[12]

Genetic Factors

Genetic variations have been cited as a risk factor for peri-implantitis. However, the association between IL-1 gene polymorphism and peri-implantitis remains to be determined since conflicting results exist. A systematic review[52] with 27 relevant articles found no consensus among the studies reviewed. If certain cofactors are present, IL-1 polymorphism alone cannot be considered a risk factor for bone loss. Another study[53] on IL-1RN gene polymorphism concluded that it is associated with peri-implantitis and may represent a risk factor. Future studies in this area are certainly needed to determine the role of genetic susceptibility and which genetic markers, if any, may provide a clue as to patient susceptibility.

Diabetes

The evidence regarding the association between diabetes and peri-implantitis is limited because of the small number of studies. Four systematic reviews[49,51,54,55] indicated that the current evidence does not allow a definitive conclusion that diabetic patients have a higher incidence of peri-implantitis. Those reviews also pointed out that diabetic control is an important factor when assessing the relationship. High blood glucose level can impact tissue repair and host defense mechanisms, as diabetic control affects neutrophil function.[56] As a result, diabetes can disrupt collagen homeostasis in the extracellular matrix and is associated with neutrophil dysfunction and imbalance of immune system. Thus, the tissue repair ability[57] and defensive mechanisms[58] of diabetic patients to the insult of dental plaque are impaired. Additional prospective cohort studies are needed to clarify the association between diabetes and peri-implantitis.

Occlusal Overload

One of the difficulties in conducting clinical studies on this topic rests on the definition of occlusal overload. Differences in the magnitude, duration, direction, and frequency of the applied occlusal load and the tolerance

threshold of the host are the underlying reasons of the observed conflicting reports. Possible mechanisms of why occlusal overload can lead to peri-implantitis are conceivable. Implants are considered less tolerable to non-axial occlusal load compared to teeth because of a lack of a periodontal ligament. Finite element studies[59,60] suggested that the occlusal load is concentrated at the implant marginal bone. Bone remodels in response to the strain. Excessive stress can cause microfracture within bone and eventual bone loss.[61] Moreover, a recent systematic review[62] suggested that occlusal overload was positively associated with peri-implant marginal bone loss. However, poor oral hygiene was still the key causative factor. Thus, the role of occlusal overload on peri-implantitis requires further investigation with more precise definition of occlusal overload.

Potential Emerging Risk Factors

Research endeavors continue to explore some additional areas that may impact the development and pathogenesis of peri-implantitis. These include rheumatoid arthritis with concomitant connective tissue disease,[63] increased time of loading,[64] and alcohol consumption.[65] Further study will determine the appropriateness of their inclusion.

V. STEPS TO FOLLOW IN OBTAINING A DIAGNOSIS

The early detection of these two diseases, peri-implant mucositis and peri-implantitis, is essential as the treatment of peri-implantitis is not predictable, at times complex, difficult to perform, and non-surgical therapy has proven to be ineffective. While both are inflammatory lesions around a dental implant, the latter, peri-implantitis, includes loss of bone. While probing a dental implant can certainly aid in detecting bleeding and determine changes in probing depth over time, it may not be able to establish bone loss without the use of periapical radiographs to establish the extent and pattern of bone loss. Moreover, it should be recognized that not all peri-implantitis lesions may be detectable or verified with radiographs. Unlike periodontitis, many peri-implantitis lesions can occur on the facial and lingual aspects of dental implants and may therefore be "masked" with routine periapical dental radiographs. More recently, cone beam computed tomography (CBCT) images have been utilized to aid in evaluating the extent of facial, lingual, and proximal bony lesions around implants.[66] Nevertheless, a baseline radiograph needs to be obtained at the time of both implant placement and prosthesis installation to facilitate comparison efforts.

There is no single diagnostic tool that can, with certainty, establish a diagnosis of peri-implantitis. Suppuration has been recognized as one of the diagnostic criteria for peri-implant diseases.[67] However, its presence or absence fails to distinguish between peri-implant mucositis and peri-implantitis without other more meaningful data. Similarly, while bacterial culturing has been reported,[24] how it relates to diagnosis as opposed to treatment remains unclear. Moreover, its use in targeting effective treatment to arrest peri-implantitis has also come into question.[24,68] The presence of bone loss and probing depth alone may not be enough to formulate a diagnosis of peri-implantitis. Bone loss can have a number of non-bacterial causes including surgical technique, implant design, implant position, crestal thickness of bone, loose prosthesis/abutment, and excessive occlusal force, to name a few. The clinician must use a combination of probing data over time, inflammatory status of the mucosa, "bleeding on light probing," radiographic changes in bone levels over time,[16] and possibly bacterial and/or PICF (peri-implant crevicular fluid) sample data to arrive at an accurate diagnosis of peri-implantitis.

While mobility of implants is found only in very advanced cases of bone loss primarily in situations where the integration has been completely lost, mobility of the restoration and/or abutment should be routinely checked as these can indicate loose or broken components and may affect the inflammatory status of soft tissue and bone due to the accumulation of plaque/biofilms in and around the mobile components.

A list of diagnostic considerations for the early detection of peri-implantitis is as follows:

Probing, Bleeding, Suppuration: Initial probing of the implant should be done once the final restoration has been installed. This can be done with a traditional periodontal probe using light force (0.25N)[69] because of the delicate and unique anatomy of the peri-implant mucosa. Probing depth should be recorded, and defined as the depth of probe penetration from the base of the implant sulcus to the crest of the mucosa. Similar to assessing natural teeth, the level of the crestal soft tissue can be measured using a fixed reference point on the restoration and should be noted as the clinical attachment level. A change in these parameters over time may be more important than the initial findings as implants may be placed more apically to achieve optimal esthetics, resulting in deeper soft tissue probing depths. It must also be remembered that probing may have to be done with the prosthesis removed as it may obviate probing along a parallel axis to the implant.[70]

Gentle probing resulting in bleeding suggests the presence of soft tissue inflammation. Increasing

probing depth and bleeding are indicators for the need to perform an additional radiographic examination.[2,71] The presence of suppuration/exudate indicates pathological changes and the necessity for further evaluation and treatment.

Radiographs: Periapical radiographs of the implant following placement and then following the prosthesis installation should function as the baseline by which all future radiographs are to be compared. These radiographs should be perpendicular to the implant body to show a clear demarcation between the threads of the implant. Other radiographs such as CBCT may be considered depending on the location of progressive attachment loss.

Mobility: Mobility is not a good diagnostic aid since a mobile implant is hopeless and should be removed, and thus a determination of etiology becomes moot. However, perceived implant mobility may be related to the restoration and/or abutment components that have loosened, which may or may not lead to crestal bone loss without loss of integration. A loose implant-supported prosthesis may contribute to the accumulation of plaque, which may lead to the development of peri-implant mucositis and/or peri-implantitis, and as such, this should be corrected.

Secondary Diagnostics: Bacterial culturing, inflammatory markers, and genetic diagnostics may be useful in the diagnosis of peri-implant diseases.

VI. CLINICAL IMPLICATIONS

Peri-implant mucositis and peri-implantitis differ with respect to treatment. To date, evidence suggests that peri-implant mucositis can be successfully treated if detected early and when combined with effective non-surgical efforts.[6,7] Non-surgical therapy has not been shown to be effective for the treatment of peri-implantitis.[2,68,72] Currently, different surgical treatment modalities have been proposed and have shown promising results.[16,73-77] However, long-term controlled studies are needed to validate which treatment modality may be optimal, given the different clinical scenarios. It has been suggested, as with many inflammatory diseases, that the earlier the diagnosis and intervention, the better the treatment outcome. To that end, routine monitoring of dental implants as a part of a comprehensive periodontal evaluation and maintenance is essential.

To conclude, it is suggested to:

- Identify risk factors associated with developing peri-implant diseases
- Establish radiographic baseline at the time of implant placement
- Establish clinical and radiographic baseline at final prosthesis insertion
- Employ methods that monitor implant health and determine inflammatory complications as part of an ongoing periodontal maintenance program
- Establish an early diagnosis and intervention, which will contribute to more effective management of peri-implant diseases

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