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REVIEW ARTICLE

Peri-implantitis: A Review to Simplify a Mystifying Disease

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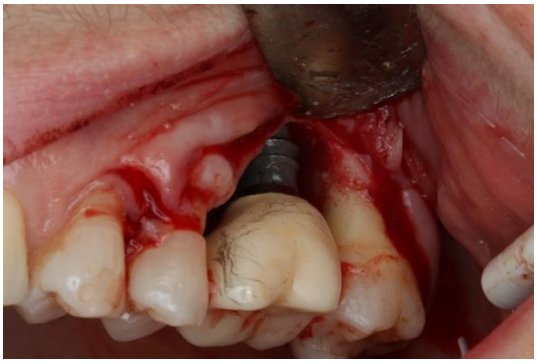
ABSTRACT

Dental implants have been recently used as a long-term treatment modality for replacing missing teeth. However, dental implants have been associated with complications such as peri-implant mucositis and peri-implantitis. Therefore, the aim of this manuscript is to provide current information on the definition, etiology, diagnosis, and treatment options for peri-implant diseases.

Peri-implant mucositis is an inflammation of the mucosa surrounding the implant and if left untreated, It may progress to peri-impantitis, which is characterized by bone loss. Peri-implantitis is a pathologic inflammatory condition that is caused by plaque accumulation on the implant surface. Many risk factors have been linked with peri-implant disease; therefore, a multifactorial disease etiology is judicious. It complicates the disease diagnosis and management. Several treatment approaches have been implemented to decrease the bacterial load within the peri-implant tissue, decontaminate the implant surface, or regenerating the lost tissue around dental implant. Treatment can be broadly divided into: Surgical and non-surgical treatment. Non-surgical treatment has a limited efficacy due to the restricted access to the implant surface. Whereas, surgical or flap surgery seem to improve the clinical outcome for the treatment of peri-implantitis either by utilizing a resective or regenerative approach. Patient compliance with supportive care and proper oral hygiene measures are of great importance to prevent the reformation of biofilm and calculus on teeth and implants and prevent both periodontitis and peri-implantitis. Preventive treatment is the best option to preclude advancement of peri-implant mucositis into peri-implantitis and therefore, careful diagnosis of peri-implant diseases are essential for successful treatment outcomes.

Introduction:

Dental implants are considered to be a viable option for the long-term replacement of missing teeth [1]. However, dental implants are associated with different types of complications, biological complications are considered the most common. This includes, peri-implant mucositis, periimplantitis, soft tissue dehiscence, and marginal bone loss [2]. Peri-implantitis is a chronic inflammatory process that causes the breakdown of the tissues surrounding the implant [3]. Clinical signs of peri-implant tissue inflammation, deep probing depth (PD), or bleeding on probing (BOP), along with progressive bone loss are typically observed in implants affected by this disease [4].Tissue inflammation including redness, edema, and mucosal enlargement are common features seen in both peri-implant mucositis and periimplantitis. However, radiographic bone loss is the main factor that distinguishes peri-implantitis [5] (Figure 1). Previous studies reported that peri-implant mucositis precedes peri-implantitis. As a result, management of peri-implant mucositis is considered as a preventive measure for the preventing peri-implantitis progression [4,6]. The aim of this review is to discuss the definition, etiology, diagnosis, and treatment options for peri-implant diseases.



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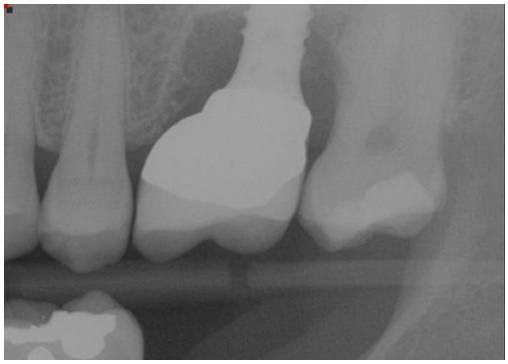

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Figure 1:

a. Clinical presentation of peri-implantitis showing a circumferential bony defect around dental implant at site #14

b. Radiographic appearance of bone loss around dental implant

Prevalence, etiology and contributing Factors

The prevalence of peri-implantitis ranges between 2.7% and 47.1%. This varying range is due to plenty of etiologic factors and different disease definitions associated with the peri-implant disease [3]. According to the consensus report by the 2017 workshop, a peri-implantitis case can be diagnosis by the presence of BOP, with or without suppuration on gentle probing, increased probing depth, and crestal bone loss. In the absence of previous records, diagnosis can be based on the presence of BOP or suppuration with gentle probing, PD of ≥6 mm, and bone loss of ≥3 mm [7]. The microbiology nature of peri-implantitis is mainly linked to the Gram-negative anerobic microorganisms; *Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans, Prevotella intermedia, Treponema denticola, Bacterioides forsythus, Prevotella nigrescens, Fusobacterium nucleatum, and Peptostreptococcus micros* [8,9]. Other predisposing risk factors involved in its etiology, such as history of pre-existing periodontal disease, further described below.

Peri-implant disease is a multifactorial condition, with the bacterial biofilm being the most common contributing factor [3,10]. Other predisposing risk factors are involved in the initiation of the peri-implant disease. However, there is no consensus as to which factor is more significant in its etiology. These factors include, but are not limited to, poor oral hygiene, genetics, smoking, diabetes, width of keratinized tissue (KT), history of periodontal disease, implant malposition, restoration type, and residual cement [11]. In addition to the previous factors, history of cardiovascular diseases, history of osteopenia/osteoporosis, flossing and brushing on implants, presence of an adjacent tooth, clinical signs of occlusal overloading, and presence of platform switching have been related to peri-implant diseases either in a direct or an indirect manner [12]. According to Wilson et al 2009, one of the predisposing factors for delayed peri-implantitis is extra-coronal residual cement. In this study he suggested that about 81% of the implants restored with cement-retained restorations that

have signs of peri-implantitis had residual cement [13]. Another study supports the results of Wilson's study showing that the presence of extra-coronal residual cement in patients with a history of periodontal disease are more likely to develop peri-implantitis [11]. Smokers also exhibit substantially more crestal bone loss than non-smokers [14]. Karoussis et al. (year) showed that development of peri-implantitis in smokers versus non- smokers was 18% vs 6% respectively [15]. Additionally, for diabetic patients, there appears to be a 3-fold risk for peri-implantitis at the time of implant placement [16]. Nevertheless, there is no conclusive evidence as to whether diabetes is a true risk factor/indicator for peri-implantitis [4]. Previous systematic reviews also discussed the width of keratinized tissue (KT) as a factor that could affect peri-implant health, and it was indicated that a KT of <2 mm was associated with more plaque accumulation and soft tissue inflammation when compared with implants that were surrounded by a KT of ≥2 mm [17,18]. Though the evidence is still limited, there seems to be a plausible indication for the need to maintain ≥2 mm of keratinized tissue (KT) to ensure peri-implant health [19]. A meta-analysis by Sgolastra et al 2013, revealed that periodontitis is a risk factor for implant loss. A significant risk for implant loss is also seen in patients with a history of periodontitis. Peri-implant bone loss was significantly higher in patients with active history of periodontal disease, when compared with periodontally healthy patients [20].

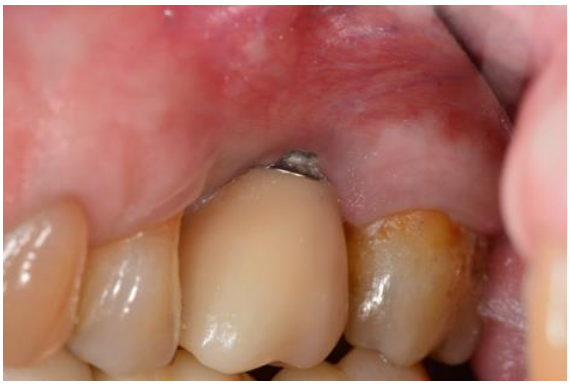


Figure 2: Dental implant at site #14 exhibits lack of keratinized around dental implant.

Onset and pattern of progression

According to the 7th European Workshop on Periodontology, the onset and progression of periimplantitis may be influenced by iatrogenic factors. These factors include, micro gap between the crown and the abutment, implant mal-positioning, and over contouring of restorations [21]. Implant position and crown design should enable easy access for oral hygiene for both self and professional cleaning. However, there are limited studies investigating the role of iatrogenic factors in developing peri-implant diseases [6]. The pattern of peri-implant bone loss is non-linear, accelerating with progressive bone loss that increases with time [22,23]. A study by Derks et al 2016 showed that peri-implantitis may occur early after implant placement. Fifty-two percent of the implants revealed early signs of bone loss (>0.5 mm) after the second year of placement, whereas 66% of implants showed bone loss after the third year in function [23]. The analysis suggested that peri-implantitis appears to progress faster when compared to periodontitis [24,25]. A systematic review by Chrcanovic et al 2014 showed that an increased risk for periodontal disease may increase the probability for implant failure, peri-implant bone loss, and postoperative infection [26]. Similar to periodontitis, peri-implantitis manifests with an identical cellular response with plasma cells and lymphocytes being the predominant cells. However, peri-implantitis exhibits a larger proportion of neutrophils, leukocytes and macrophages are present [27,28]. It is also characterized by more dense vascular structures on the periphery of the cell infiltrate [29].

Classification of peri-implant bone defects:

Monje et al 2019, classified the peri-implant defects according to the morphology and severity of the bony defect [30]. (Table 1)

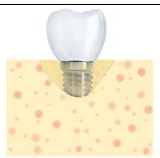
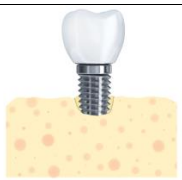
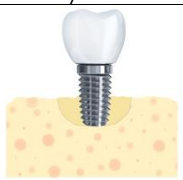
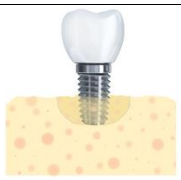
Class	A	B	C
I (Infra-osseous)	 Buccal Dehiscence	 2/3 wall defect	 Circumferential defect
II (Horizontal) Supra-crestal/horizontal defect	 Supra-crestal/horizontal defect		
III (Combined defect)	 Buccal Dehiscence and horizontal bone loss	 2/3 wall defect with horizontal bone loss	 Circumferential defect with horizontal bone loss

Table (1): Classification of peri-implant defect according to Monje et al 2019.

Severity of peri-implant disease:

According to Rosen et al, 2012, the peri-implantitis severity was classified according to the probing depth and the amount of bone loss into 3 main categories: early, moderate and advanced [31].

	Early	Moderate	Severe
Probing depth (PD)	≥ 4mm	≥ 6mm	≥ 8mm
Bleeding/exudate	Bleeding and/or suppuration on probing.	Bleeding and/or suppuration on probing.	Bleeding and/or suppuration on probing.
Percentage of bone loss	≤ 25% of implant length	25-50% of implant length.	≥ 50% of implant length.

Table (2): Classification of peri-implantitis severity according to Rosen et al 2012.

Implant risk assessment:

A study by Heitz-Mayfield et al 2020 introduced an implant disease risk assessment (IDRA) tool to estimate patients risks for developing peri-implantitis. This tool included has eight parameters that include: history of periodontitis, percentage of sites with BOP, number of teeth/implants with probing depths (PD) ≥5 mm, the ratio of periodontal bone loss (evaluated from a radiograph) divided by the patient's age, periodontitis disease stage and grade, compliance with supportive periodontal therapy, distance from the restorative margin to the marginal bone crest and prosthesis-related factors including prosthesis cleanability and fit. [32].

Parameter	Low risk	Moderate risk	High risk
Periodontal Disease History	No history	-	Positive History
Bleeding on Probing	≤10%	10-25%	≤10%
Presence of deep pockets	≤ 2 sites with ≥5mm	3-6 sites with ≥5mm	6 sites with ≥5mm
Bone Loss relative to patient age	<0.5	0.5 to <1	≥1
Periodontitis Susceptibility	Stage 1 grade A	Stage 2 or 3, grade A or B	Stage 4 grade C
Compliance with Supportive Therapy	Compliant	≤ 5 months recalls interval of supportive periodontal therapy	≥ 6 months recalls interval of supportive periodontal therapy.
Distance from the bone to the restorative margin of the prosthesis	Tissue level implant	1.5mm	<1.5mm
Prosthesis fit	Well-fitting and cleansable screw-retained prosthesis or no excess cement (if cement retained)	Poorly fitting prosthesis with subgingival margin	Poor fit with subgingival margin and not cleansable prosthesis

Table (3): IDRA tool parameters and respective risk categories (adapted from Heitz-Mayfield et al. 2020)

Prevention and maintenance:

It has been shown that regular recall visits of implant supportive care is crucial for peri-implant health and stability [32]. A previous study by Monje et al. 2016 revealed that peri-implant health was sustained when maintenance visits were completed within a period of five months or less [33]. The treatment of peri-implant mucositis is essential in preventing peri-implantitis as it always precedes peri-implantitis [34]. The long-term maintenance of implants is mainly based on routine and regimented dental visits. Patient compliance with six months or less maintenance visits is integral to the prevention of biological complications. It was shown that with compliant patients, bone fill of peri-implant defects after the treatment of peri-implant defect caused by peri-implantitis can be sustained for a longer period compared to non-compliant patients [35]. However, a cohort study by Mengel et al. 2007 reported that periodontally compromised patients lose their implants 2.3 times more often than those placed in patients with healthy periodontium [36]. Implant success depends mainly on the long-term maintenance of health around the peri-implant tissue. During maintenance visits, the patient's medical and dental history should be updated followed by reviewing oral hygiene measurements. In addition, a clinical and radiographic examination of the implant and surrounding tissue should be completed to evaluate the implant stability and to eliminate plaque or calculus that could possibly be retained in the tissues surrounding the implant [37].

Treatment:

The main goals of the treatment of peri-implantitis lesions are to restore bone support and peri-implant tissue integration and reduce the soft-tissue inflammation in order to suppress disease progression. Implant surface decontamination is essential to attain such goal. Several treatment modalities have been recommended for the treatment of peri-implant infections. These treatments can be divided into non-surgical and surgical therapy. Surgical treatment can be either resective or regenerative surgery, depending on the anatomy of the bony defect and the peri-implant mucosa condition [38,39].

Non-surgical therapy:

Peri-implant debridement is one of the non-surgical treatment therapies that is used to treat peri-implant infections. Such treatment will remove the causative factor, which is the adhered biofilm and hence, reduction of the bacterial load can be achieved. Furthermore, local, or systemic antibiotics, and antiseptics can be used as an adjunctive treatment. This adjunctive therapy has been recommended to enhance treatment outcomes [40,41].

Also, patient compliance and proper oral hygiene measures are of great importance to prevent the reformation of biofilm and calculus. [42]. Different instruments can be used around implants, including materials that are not as rigid as titanium. The purpose of this is to avoid scratching and roughening the implant surface, which may result in more bacterial accumulation [43,44]. Moreover, a study by Renvert et al 2006, revealed that the use of local antibiotics as an adjunct to debridement in early peri-implantitis resulted in less probing depths compared to debridement alone [45]. Different methodologies of mechanical debridement of implant surfaces have been evaluated for the treatment of peri-implantitis, with the main difference being that they are aimed more sub gingivally to decontaminate the exposed implant surfaces [46]. Abrasion with sodium bicarbonate has been used as a treatment approach for polishing and removing stains from natural teeth. Due to its high abrasiveness, it cannot be used around dental implants. Lately, a low abrasive amino-acid glycine powder has been introduced to effectively remove the biofilm from the root surfaces. It is exclusively useful for removing biofilm off the implant surfaces, without damaging the implant surface itself [46]. Another treatment modality for peri-implantitis is laser treatment. It has been shown to be a promising and predictable treatment approach. It allows the clinician to effectively ablate the tissue and detoxify the implant surface [47-49]. In the non-surgical management of peri-implantitis, subgingival mechanical debridement is a necessity just like periodontitis. This reduces bleeding tendency to (20-50%) and results in pocket depth reduction. However non-surgical treatment of peri-implantitis has its limitations depending on the disease severity, in which case surgical intervention is necessary [35]. Currently, there are no clear clinical information that supports a single technique to treat peri-implantitis, further studies are needed.
[34]

Surgical therapy:

Non-surgical therapy has a minor effect in treating majority of peri-implantitis cases due to limited access, therefore, surgical treatment is recommended in most of the cases [50].

Surgical treatment of peri-implantitis should enhance the cleanability of the implant surface and obtain re-osseointegration [42]. Several surgical approaches have been utilized for the treatment of peri-implantitis with overall great outcomes. These include open flap debridement, resective therapy, regenerative therapy, and combined therapy [50]. A previous case series by Leonhardt et al. has shown that open flap debridement successfully resolved the peri-implant infection in 58% of the cases [51].

Resective surgery aims to reduce the peri-implant pockets by apically positioning the flap. It is mainly indicated when there is horizontal bone loss that led to exposure of the implant threads in non-esthetic areas [52]. Implantoplasty or implant surface modification can positively affect the treatment outcomes when it is implemented as an adjunctive treatment with resective surgery [53]. This procedure is based on smoothing the rough implant surface creating a surface that is less prone to bacterial accumulation [54]. Implant surface decontamination has been utilized with resective surgeries before debriding the implant. Surface contamination can be done by the use of chemical, biological and antibacterial agents such as chlorhexidine gluconate (CHX), sterile saline, and hydrogen peroxide (H202), antibiotics, or laser therapy [50]. A factor that may complicate decontamination is the geometry of the implant threads. Rough implant surfaces are more susceptible to bacterial colonization [55]. Another treatment modality is regenerative surgery. Bone augmentation has been used to regenerate the bony defect that is caused by peri-implant disease, to re-establish the structural and functional connection between the bone and implant, and to stop the soft tissue recession [56]. Peri-implant defects can be augmented by using autogenous, allogenic, xenogeneic, or alloplastic bone grafts [50]. Although historically autogenous bone grafting has been considered the gold standard. More recent research has demonstrated that xenograft materials have a superior clinical and radiographic outcome over autogenous bone grafts [57]. Both resective and regenerative approaches can be implemented together in cases of combined bony defects. There is inconclusive evidence to support regenerative treatment approach over resective treatment [50]. However, these techniques do not treat the disease but rather fill the osseous defect to prevent disease progression [58]. Therefore, further long-term studies in humans involving sufficient numbers of subjects are needed to provide a solid basis for recommendations regarding the surgical treatment of peri-implantitis [59].

Conclusions:

- Biological complications around implants, such as mucositis and peri-implantitis are very prevalent.
- Several factors have been linked with peri-implant disease; therefore, a multifactorial disease etiology is judicious. It complicates the disease diagnosis and management [60].

- The treatment of peri-implant mucositis is essential in preventing peri-implantitis as it always precedes peri-implantitis[34].
- Treatment approach of peri-implant disease should be based on disease type and severity and defect morphology [50].
- Screw-retained restorations of dental implant is preferred option whenever possible, given the association of excess cement and peri-implantitis [11].
- Patient compliance with supportive care and proper oral hygiene measures are of great importance to prevent the reformation of biofilm and calculus on teeth and implants and prevent both periodontitis and peri-implantitis [42].

Author's recommendations:

- Non-surgical treatment of peri-implant disease can be initiated. If the condition did not improve, surgical intervention is implemented.
- Open flap debridement will provide better access to the implant surface and therefore, more favorable outcome compared to non-surgical treatment is expected, therefore, more favorable outcome compared to non-surgical treatment.
- Implant surface decontamination can be performed mechanically with friction of a sterile gaze/cotton ball wetted in an adjunct agent. Hydrogen peroxide, Chlorhexidine or saline can be performed.
- Laser treatment can also be used for implant surface decontamination.
- The adjunct use of local or systemic antibiotic may have an additional benefit in the resolution of infection around dental implant
- Resective surgery can be used in peri-implantitis cases with horizontal bone loss to reduce the pocket around dental implant. This can be achieved with apically flap positioning that could include osseous removal or not.
- Regenerative therapy is the treatment of choice in contained bony defect.

Conflict of interest:

The authors declare no conflicts of interest related to this case report.

All authors have made substantial contributions to the manuscript and revised it critically and have given final approval of the version to be published.

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