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The Etiology and Causative Factors in Peri-Implant Disease: Mini Review

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Abstract

Aim: To detect the high and low risk factors behind the peri-implantitis disease that will provide evidence to clinician during diagnosis stage

Material and method: An online and hand-search of the published literature was conducted to identify studies that Examined peri-implantitis. The search terms that were used, alone or in combination, were peri-implant mucositis, peri-implantitis, implant complication and crestal bone resorption.

Results: Sixty-four studies were selected for comparison and to address the details emphasized in this study. Some of the articles were not directly related to peri-implant diseases but were reviewed for better understanding histology and examination of the tissue around implant.

Conclusion: Peri-implantitis disease is a multi-factorial disease that shared between the surgical, prosthodontic, tissue health and the patient care. plque retention around implant with weak soft tissue attachment in combined with poor hard and soft tissue thickness all work together to initiate per-implant disease.

Keywords: dental implant infection, bone resorption, bleeding on probing, gingival recession

Introduction

Dental implants are commonly used for the replacement of missing teeth in patients with partial or complete edentulism. Results of long-term follow-up studies **(Toy & Uslu, 2020; Chrcanovic et al., 2020; Kim et al., 2020)** have shown that dental implants can demonstrate success and survival rates of 100%. However, biological complications associated with dental implants (peri-implantdiseases, namely peri-implant mucositis and peri-implantitis) may jeopardize theintegrity of peri-implant mucosa and supporting alveolar bone **(Klinge et al., 2018).** Different methods have been used to assess peri-implant tissue health and to diagnose these disease entities. These methods include peri-implant probing, analyses of peri-implant crevicular fluid or saliva, evaluation of the peri-implantmicrobiota and radiographic evaluation of the peri-implant bone levels. The current consensus indicates that changes in probing depth, and the presence of bleeding on probing and suppuration, must be evaluated to assess the peri-implanttissues, whilst radiographs should be used to confirm peri-implant bone loss **(Serino et al., 2013).** The reported prevalence of peri-implantitis varies from less than 7% to 37% of implants **(Klinge, 2012)**. The variation can be attributed to differences instudied populations, length of follow-up time, implant variables, and the criteria used to define peri-implantitis **(Koldsland et al., 2010)**. Two systematic reviewsconcluded that peri-implantitis affected 10% of implants and 20% of patients during the 5 to 10 years after placement **(Mombelli et al., 2012; Atieh et al., 2013).**

Aims of the review

To focus on the role of plaque-biofilm to jeopardize the implant health.
And the importance role of the maintenance phase in prevention of implant failure, and increase the successful rate.

Materials and Methods

A search of the MEDLINE (PubMed) and Google scholar database was conducted, and the works published in the English language from 1990 until 2023 were included in the review. The search terms that were used, alone or in combination, were peri-implant mucositis, peri-implantitis, implant complication and crestal bone resorption. Titles and abstracts were screened, and a full-text analysis was performed for relevant publications. A manual search was conducted

for the following journals from 1990 until 2023: Clinical Implant Dentistry and Related Research; Clinical Oral Implants Research; International Journal of Oral & Maxillofacial Implants; Journal of Clinical Periodontology; Journal of Dental Research; International Journal of Periodontics and Restorative Dentistry; Journal of Periodontology; Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics; British Journal of Oral and Maxillofacial Surgery; and Journal of Prosthetic Dentistry.

Inclusion criteria including studies with the following designs were included

1-Randomized controlled clinical trials, controlled trials, and prospective and retrospective clinical studies
2- invitro studies
3-literature review

The following publications were excluded from our data

1-Case reports or a case series
2-Studies in a language other than English or without an English language abstract
The two authors independently reviewed the included studies to assess their conformity with the inclusion criteria.

Results

The combinations of search terms resulted in a list of 140 titles (PubMed until 2021and Google scholar). Following the screening of the titles and abstracts by applying the defined inclusion and exclusion criteria, 64 potentially relevant publications were identified in which a full-text analysis was performed. The number of articles that discuss the peri-implant disease were 19 articles. Some of the included articles were not directly related to per-implant disease but were reviewed to better understand the process of peri-implant healthy tissue structures and implant survival and success criteria. Relevant articles discussed the local and systemic etiological factors, bacterial types, crestal bone resorption, implant occlusion and prosthetic types.

Discussion

Peri-implant health: Peri-implant health requires the absence of clinical signs of inflammation,including no bleeding on probing. Around clinically healthy implants, the mucosa forms a tight seal around the trans-mucosal component of the implant itself, the abutment or the restoration. The soft tissue height around the implantfollowing placement determines the initial probing depth. In most cases, the probing depth associated with peri-implant health should be ≤5.0 mm. As part of the definition, there should be no bone loss greater than the bone level changeswhich occur after initial bone remodeling immediately following implant placement **(Renvert et al., 2018).** Healthy peri-implant tissue showed the mucosa covered by stratified squamous epithelium; in addition, a layer of vascular fibrous connective tissue was evident. A few stromal inflammatory cells and rarely some lymphoid cellsin the basal layer were observed **(Lucarini et al., 2019)**

Peri-implant mucositis

This inflammatory response is strictly limited to the soft tissue, with no evidence of progressive bone loss subsequent to the initial remodeling after implant placement, and is known to be reversible **(Ramanauskaite et al., 2016)**. The main clinical sign of this lesion is inflammation of the periimplant mucosa characterized by bleeding on gentle probing (<0.25 Ncm) **(Jepsen et al.,2015).** Peri-implant mucositis displayed an inflammatory infiltrate at the level ofthe connective tissue lateral to the barrier epithelium **(Lucarini et al., 2019)**

Peri-implantitis

Peri-implantitis was defined by the 2017 Proceedings of the World Workshop as "a plaque-associated pathologic condition occurring in the tissue around dental implants, characterized by inflammation in the periimplant mucosa and subsequent progressive loss of supporting bone." The authors statedthat clinically, the inflammation around implants is manifested as erythema, edema, mucosal enlargement, bleeding on probing (67%) with or without suppuration (94%); with deeper probing depths (PD ≥6 mm at 59%) and bone loss radiographically with a combined supra and infra-osseous configuration progressing circumferentially around implants and faster than aroundteeth **(Schwarz et al., 2018)**. In the absence of baseline radiographs and probingdepths, radiographic bone level ≥3 mm and/or probing depths ≥6 mm in conjunction with profuse bleeding represents peri-implantitis **(Renvert et al., 2018).** In patients with poor maintenance compliance, it has been observed thereis a higher risk of developing peri-implantitis, especially if there is bleeding on probing. It has been shown that for implants presenting bleeding on probing, there was a 24.1% chance of being diagnosed with peri-implantitis **(Hashim et al., 2018).** In peri-implantitis tissue, adjacent to an ulcerated pocket epithelium, a great inflammatory lesion showing an evident granulation tissue and a dense inflammatory infiltrate was

detected (**Lucarini et al., 2019**) Risk factors of peri-implantitis 1-Patient Related Risk Factors Poor Plaque Control and Peri-Implant Mucositis A patient's self-performed plaque control is one of the most important factors influencing the implant's prognosis (**Schwarz et al., 2018).** A high plaque index was associated with an eightfold increase in susceptibility to peri-implantitis (**Kumar et al., 2018).** The accumulation of bacterial biofilm on implant and abutment surfaces leads to periimplant inflammation, also known as mucositis, Peri-implantitis is always preceded by a period of mucositis. The two share several risk factors including poor oral hygiene, smoking and sub- mucosal presence of excess cement. Implants diagnosed with mucositis are at risk of developing peri-implantitis (**Heitz-Mayfield & Salvi, 2018).** However, not all mucositis lesions progress to peri-implantitis, even when present for extensive periods of time (**Gualini & Berglundh, 2003**)

Periodontal Disease and Microbiological Aspects

The diagnosis, or history, of periodontal disease is the most researched factor associated with peri-implantitis. This is partially attributed to similaritiesin the subgingival microbiota between the diseased teeth and implants (**Ferreiraet al., 2018**). Current data suggests that peri-implantitis is associated with a specific microbiota resembling that of periodontal lesions, in addition to other microorganisms not commonly related to periodontitis (**Faveri et al., 2015).**

Nevertheless, it is well-accepted that peri-implantitis consistently presents with marked microbial diversity (**Canullo et al., 2015**) and that deeperperi-implant pockets exhibit significant microbial alterations and higher levels of dysbiosis (**Kroger et al., 2018).** Periodontal disease has been stronglyassociated with peri-implantitis (**Saaby et al., 2016).** Active periodontitis at the adjacent teeth is further considered a predictor of future peri-implantitis (**Kumar et al., 2018).** Periodontally compromised patients have

twice the risk of developing peri-implantitis compared with healthy individuals(**Ferreira et al., 2018**). Moreover, those with a history of generalised aggressiveperiodontitis are 5 times more prone to implant failure, and 14 times more susceptible to periimplantitis, compared with healthy (**Swierkot et al., 2012).** Fortunately, successful treatment of periodontal disease prior to implant placement has been shown to lower the risk of peri-implantitis and is therefore considered an essential initial part of the overall treatment plan (**Renvert & Quirynen, 2015**).

Lack of Maintenance phase

Has been shown to significantly lower the risk of peri-implant biologicalcomplications, and a minimum recall interval of 5–6 months has thus been recommended (**Monje et al., 2016).** Maintenance programs should be tailored to the individual's specific needs and susceptibility to both periodontal and peri-implant diseases. Factors used for risk assessment include the percentage of BOP, the prevalence of active residual pockets, oral hygiene level, smoking habits and the presence of systemic or genetic conditions (**Lang et al., 2015).** Individuals with highrisk profiles require three to four annual visits (**Armitage & Xenoudi, 2016),** and their attendance is detrimental for prevention and earlydetection of peri-implantitis (**Monje et al., 2017).** One out of five noncompliantpatients are diagnosed with peri-implantitis within 5 years (**Rokn et al., 2017**), On the other hand, compliance is associated with 86% fewer peri-implantitis cases. Unfortunately, those with greater needs have been known to be the least compliant. The extent and severity of periodontal disease, as well as the patient'ssmoking habits, affect adherence to maintenance programs (**Monje et al., 2017).**Therefore, it is the clinicians' duty to adequately inform their patients of the importance of regular supportive therapy for the prevention of peri-implantitis.

Smoking

The negative effects of smoking on periodontal health have long been well established. It impacts innate and adaptive immune responses, impairing the host's defence mechanisms and its response to microbial challenges (**Johnson & Guthmiller, 2007**). Cigarette smoking also affects wound healing,as it is therefore detrimental to periodontal treatment (**Trombelli et al., 2018**). Smoking further increases the oxidative stress and inflammatory burden with marked alterations in microbial flora, it significantly affects implants' colonisation with periodontal pathogens such as Porphyromonas gingivalis (Pg)and Fusobacterium nucleatum (**Geisinger et al., 2017).** Besides, cigarettes are not only harmful to smokers, but mere exposure to environmental smokeincreases the risk of developing periodontal disease by 28% (**Sutton et al., 2017**). Smokers are almost twice more at risk of developing periimplantitis compared with nonsmokers (**Dreyer et al., 2018).** Moreover, it is associated with increased severity of peri-implantitis (**Saaby et al., 2016).** Nevertheless, smoking cessation has been shown to positively impact periodontal health, with favourable effects on both incidence and progression of the disease (Johannsen et al., 2014).

In addition to cigarettes commerciality, the popularity of noncigarette tobacco products has been alarmingly rising. Water pipes, also known as shisha,hookah or narjilah, have become a popular way of smoking tobacco among adolescents and adults alike (**Kim et al., 2016).** Their recreational use has become widely acceptable despite containing high levels of nicotine, and a multitude of carcinogens and heavy metal. Electronic cigarettes (e-cigarettes), or vaping, have lately

become an extremely widespread trend among individualsof all ages. Regardless of their nicotine content, e-cigarettes have been shown toincrease oxidative/ carbonyl stress and pro-inflammatory responses, with adverse effects on endothelial cells and fibroblasts, and concomitant dysregulation in periodontal repair **(Al-Aali et al., 2018).**

Systemic Conditions

Diabetes mellitus is one of the most thoroughly researched conditions. The disease affects insulin's secretion, its function or both, causing disruption ofglycaemic levels. This consequently results in a variety of neuropathological, retinal, microvascular and renal complications **(American DA., 2010).** Poor glycaemic control plays a pivotal role in the progression and severity of periodontitis **(Lalla & Papapanou, 2011).** This association has been explained by several vascular and cellular responses, leading to enhanced tissue destruction and impaired healing response **(Knight et al., 2016).** Poorly controlled diabetics are at 46% higher risk of developing peri-implantitis, with deeper peri-implant pockets and higher marginal bone loss, compared with theirnormoglycaemic controls **(Turri et al., 2016),** Interestingly, smokers and poorlycontrolled diabetics are considered at a similar risk for peri-implantitis. On the other hand, non-smokers with poor glycaemic control are 3.39 times at higher risk of developing peri-implantitis compared with normoglycaemic individuals **(Monje et al., 2017).**

Obesity is another highly prevalent condition with detrimental effects onperiodontal health **(Vohra et al., 2018).** Obesity is also associated with a generalised and constant hyper-inflammatory state, causing an altered immune response and increased production of proinflammatory cytokines, which adversely affect periodontal tissues and alveolar bone levels **(Pham et al., 2018)**. Clinical studies have established obesity as a risk factor for peri- implantitis **(Vohra et al., 2018)**. When compared with individuals with normalbody weight, obese patients present with significantly higher percentages of BOP, deeper peri-implant probing depths and increased marginal bone loss **(Alkhudhairy et al., 2018)**.

Despite their prevalence, few studies have examined the association between cardiovascular diseases and peri-implantitis. Most showed a significantly higher risk of peri-implantitis and additional bone loss for patientssuffering from heart disease **(Ting et al., 2018).**

Recently published systematic reviews have failed to confirm or refute osteoporosis, rheumatoid arthritis and Crohn's syndrome as a potential risk factor in the pathogenesis of peri-implantitis highlighting the need for randomized control trials in this regard to help evaluate this possibility **(Ting etal., 2018).**

Genetic Predisposition

Lee et al. in 2014 studied the role of genetic polymorphism in 6 patients with severe peri-implantitis and high rates of implant failure. They concluded that various gene sets are indirectly linked to the dysregulation of metal ion concentration like Ca2+ and Mn2+ that impair the activation of integrins and other factors that govern cell adhesion. Poor cell adhesion affects the process ofosseointegration of implants and modifies the host immune response. IL-6 G174C polymorphism has been linked to periodontitis and peri-implantitis. Theassociation between

CD14-159 C/T and TNFα -308 A/G polymorphisms with periimplantitis has been confirmed in a population of 369 Caucasian individuals **(Rakic et al., 2015).**

2-Prosthetic related factor Occlusal Overload and Para-Functional Habits

Occlusal overload of implant-supported prostheses is a controversialsubject, and the exact mechanism in which it causes marginal bone loss is still debatable **(Pellegrini et al., 2016).** Yet several studies have demonstrated that overloading an implant beyond a certain threshold leads to marginal bone loss **(Isidor, 1997; Miyata et al., 2002; Fu et al., 2012).** The effect of overloading on peri-implant bone levels can be accentuated by sub-optimal implant positioning, poorly designed prosthetic reconstructions, inadequate bone quantity or its poor quality. Para-functional habits leading to elevatednon-axial occlusal forces may also increase marginal bone loss **(Fu et al., 2012)**.Attrition and wear of natural dentition or prosthetic reconstructions may be used

for diagnosis of occlusal overload and parafunctional habits. The presence of wear facets on implant supported prostheses is associated with a 2.4 increase inthe prevalence of peri-implantitis **(Dalago et al., 2017)**

Implant Material and Surface Characteristics

Micro cavities are present at implant-abutment connection level in two- piece implant systems, a consequence of current manufacturing limitation that allow bacterial infiltration and inflammation around the neck of the implant **(Penarrocha-Diago et al., 2017)** Surface modifications creating micro-rough implant surfaces accelerate the osseointegration process of titaniumimplants. A systematic review and meta-analysis by Rakic et al. that the prevalence of peri-implantitis was 18.5% at the patient level and 12.8% at the implant level, as well as, implant surface characteristics could play a major rolein the initiation of peri-implantitis **(Rakic et al., 2018).** Moreover, the review stated demonstrated a significant association between moderately rough surfacesassociated with a low prevalence rate of peri-implantitis. So far, titanium has been the material of choice in implant dentistry. Nonetheless, zirconia ceramic implants have been

progressively emerging **(Hashim et al., 2016).** Zirconia's greatest assets lie in its biocompatibility, superior soft tissue integration **(Cionca et al., 2017)** low affinity to plaque **(Roehling et al., 2017)** and reduced inflammatory processes when compared with titanium **(Cionca et al., 2017).** It was hence hypothesized that zirconia implants would finally offer the solution for peri-implant disease. Unfortunately,a recent animal study had clearly demonstrated that zirconia implants can be affected by peri-implantitis **(Roehling et al., 2019).** Still, zirconia demonstratedsignificantly lower marginal bone loss compared with titanium implants with similar surface topographies. Clinical studies have also demonstrated different degrees of bone loss around zirconia implants with variable designs **(Pieralli etal., 2017)** but additional long-term data is still required to establish both prevalence and treatment protocols.

Residual cement

In a retrospective analysis by **Linkeviciuset al in 2013,** it was observed that residual cement predisposes a patient to peri-implant disease; the risk is further elevated in case of individuals with a history of periodontitis **(Linkevicius et al., 2013)**.Thus in such cases screw retained prosthesis is a better treatment option Surgical related factor While the number of implants does not seem to influence the risk for peri-implantitis **(Passoni et al., 2014)**, their position is critical for long-term success,Implant malpositioning represents a significant risk factor for peri-implantitis **(Canullo et al., 2016).** Crestal bone resorption could occur when an implant is placed too close to the natural teeth or even other implants **(Lindhe et al., 2015)**This could compromise access for plaque control, and thus increasethe risk of periimplant disease. Also, fixtures located outside the bony envelopeor those with thin facial bone (< 1 mm) are more prone to mucosal recession, especially in patients with thin biotypes. This exposure of the fixture's rough surface increases plaque retention **(Giovannoli et al., 2019),** and thus the risk ofperi-implantitis. Bone and/or soft tissue grafting is recommended in such cases **(Lindhe et al., 2015),** keeping in mind that augmentation procedures do not increase the risk of biological complications **(Salvi et al., 2018).** Moreover, placing an implant 6 mm or more apical to the cemento-enamel junction of the neighbouring teeth increases its risk of peri-implantitis 8.5 times. Adeep submucosal position also complicates plaque control and increases the susceptibility to peri-implant inflammation **(Kumar et al., 2018).** with or without concomitant clinical signs of inflammation, such as redness, edema, fistula, and/or abscess formation. Endodontic evaluation of teeth adjacent to implant sites should be performed for primary prevention of periapical peri-implantitis **(Sarmast et al., 2017).**

Conclusions

1-peri-implant disease has multifactorial causes that need to address and prevent them from working together
2-There is a strong relationship between bacterial plaque and the development of peri-implantitis.
3-plque retention around implant with weak soft tissue attachment in combined with poor hard and soft tissue thickness all work together to initiate per-implant disease.
4-most of delay implants placed in compromised sites (loss of hard and soft tissues), these sites if not rehabilitated will lead into compromised relation between the prosthesis and the adjacent tissues. This will lead into difficult oral hygiene maintenance.

Abbreviations

Abbreviation	Definition
PPD	Probing pocket depth
BOP	Bleeding on probing
BL	Bone level
CBL	Crestal bone level
CHX	Chlorhexidine
CA	Citric acid
HP	Hydrogen peroxide
GCF	Gingival crevicular fluid
EDTA	Ethyldiaminetetraacetic acid
PEEK	Polyetheretherketone
AP	Air power

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