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A REVIEW OF CAUSES, DIAGNOSTICS AND EFFECTS OF PERIIMPLANTITIS

Cristiana Adina SALGAU[1], Andrei Ovidiu TANASE[1], Anca MORAR[2]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Marasti Blvd, District 1, Bucharest, Romania
[2]Faculty of Automatic Control and Computers, University Politehnica of Bucharest,
313 Splaiul Independentei, District 6, Bucharest, Romania

Corresponding author email: Cristianash@yahoo.com

Abstract

This paper aims to present a review of the causes, diagnostics, and effects of periimplantitis. To find relevant publications we used Google Scholar and PubMed as our databases and searched for articles from the years 2011-2021. Initial search results returned over 16000 articles in Google Scholar and 619 articles in PubMed, so a series of filters and criteria were used to select 28 papers used in this review. We found that periimplantitis represents an inflammation that affects both the hard and soft tissue around an implant. The most common cause of the disease is the accumulation of dental plaque around the dental implant. Periimplantitis is diagnosed by the following clinic signs and symptoms: swelling of the tissue around the implant, bleeding of the gingiva upon probing, the presence of harmful types of pathogen bacteria and bone crestal resorption (determined by radiologic evaluation). Many studies covered in this review were conducted on animals, using ligatures around the neck of the inserted implants to induce periimplantitis. Observations made while studying periimplantitis in animal trials can serve as a model for preventing, diagnosing, and treating periimplantitis in humans.

Key words*: dental plaque, diagnostic, ligatures, periimplantitis, prevention.*

INTRODUCTION

Dental implants have become the most widely used method to replace missing teeth. Although most dental implants are successful, there is a risk of further complications.

One such complication caused by dental implants is the disease called periimplantitis, which is an inflammation around the implant area caused by lack of proper hygiene and accumulation of bacteria. In advanced stages, it can lead to the loss of the affected implant. One study of 2,127 patients and 6,129 implants found that the prevalence of periimplantitis after a period of 2 years was 34% and 21% on the patient and implant levels respectively (Kordbacheh Changi et al., 2019).

With the number of dental implants increasing exponentially each year (Elani et al., 2018) it is becoming increasingly important to understand the causes, effects and treatment of periimplantitis.

This article will cover an overview from the literature from 2011-2021 on periimplantitis causes, diagnosis, and effects as well as other observations on the disease.

MATERIALS AND METHODS

Although there are several popular databases, such as IEEE Xplore and ScienceDirect, we decided to use Google Scholar as an initial search database, since it indexes scientific papers from all publishers. We also used PubMed as another database, due to its prestige in the medical field. Initially, we used the following keywords, to identify relevant publications: peri-implantitis OR periimplantitis OR peri implantitis AND diagnostic OR diagnosis OR prognosis OR prevention AND dogs OR humans. Since this search returned over 16000 articles, we decided to filter the results by searching for the following keywords, but only in the title: peri-implantitis OR periimplantitis OR peri implantitis. Also, to include only papers that discuss the diagnosis, prognosis, or prevention of peri-implantitis, we used the exclusion tool,

to eliminate articles that contain key words related to treatment (treat OR treatments OR treatment). This filtering step led to 1540 articles. We narrowed the search space even further, by including the following keywords: humans OR dogs or animals. The final filtering action led to 46 articles, which were examined (by reading the title and the abstract). Out of these articles, we selected 28 articles, based on the following criteria: English language, not before 2011, clinical trials, rather on animals than on humans, at least 3 patients for animal trials, patients with no other general risk factors, induced periimplantitis either by silk, cotton or metal ligatures in animals and periimplantitis by cementation in humans. As there is a lack of periimplantitis clinical trials on humans when compared to periimplantitis clinical trials on animals, the studies in this review will be focusing on studies conducted on animals, especially on canines. Table 1 summarizes the characteristics of the studied clinical trials, focusing on the procedures for inducing periimplantitis, the radiographic evaluation, number of subjects, type of implants, observations and results.

Table 1. Data about periimplantitis, extracted from reviewed clinical trials

Article	Type of subjects	No. of subject, no. & type of implants	Experimental procedures (to induce periimplantitis)	Observations on periimplantitis/periodontitis	Radiographic evaluation	Results
(Hall et al., 2011)	Humans	7 healthy patients and 7 patients that were having periimplantitis	No	The genetic markers have no significant difference between the healthy group and the perrimplantitis group	Yes	Patients with periimplantitis have the same gene expression as the healthy implant patients
(Slotte et al., 2012)	Humans	18 patients, 54 implants	No	Test qPCR as a non-invasive diagnostic tool	Yes	Further studies are needed
(Finne et al., 2012)	Humans	56 patients, 82 implants	No	Gingival recession can occur after the insertion of the implant	Yes	One piece implant has a high survival rate
(Degidi et al., 2012)	Humans	11 patients, 11 implants	No	Microbial adhesion to the implant or to the abutment of the implant is a risk factor for periimplantitits	Not mentioned in the paper	Implants that have the rougher abutment exposed to the oral cavity present a higher risk of periimplantitis
(Carcuac et al., 2013)	Animals	5 patients, 20 implants	Ligature to induce periimplantitis	Implant surface characteristics influence the inflammatory process in perrimplantitis	Not mentioned in the paper	More bone was lost at modified surface implants compared to turned surface implants.
(Charalampakis et al., 2014)	Animals	5 patients (dogs); 4 implants, 2 types (implant A: turned/implant B: iUnite, NobelBiocare AB)	Ligature to induce periimplantitis around implants and mandibular premolars. Ligatures were removed after 10 weeks	Microbial samples were taken with paper points after the removal of ligature (10 and 25 weeks after the removal)	Not mentioned in the paper	More bone was lost at modified surfaces in implants compared to teeth and turned surface implants
(Madi et al., 2014)	Animals	4 healthy female dogs, different implant types	Used cotton floss ligature to induce periimplantitis, removed after 4 months. The 5th open flap surgery was performed. Configuration of the periimplant bone defects were evaluated	Plaque accumulation on ligature caused periimplantitis. 20-30% of initial bone was lost around the implant	Yes	Periodontitis and induced periimplantitis in dogs are similar to periodontitis and periimplantitis disease in humans, respectively.
(Kütan et al., 2015)	Humans	56 patients, 56 implants	No	Platform switched placed 1 mm below the bone level will determine less resorption	Yes	The crestal bone level around implant is the success key factor

Article	Type of subjects	No. of subject, no. & type of implants	Experimental procedures (to induce periimplantitis)	Observations on periimplantitis/periodontitis	Radiographic evaluation	Results
(Neilands et al., 2015)	Humans	25 healthy patients, 25 patients with periimplantitis	No	A higher rate of Porphyromonas/ Prevotella and anaerobic Gram positive cocci was present in patients who were having periimplantitis than in healthy patients	Yes	More longitudinal studies required
(Ioannidis et al., 2015)	Humans	40 patients, 40 implants	No	Narrow implants prevent perrimplantitis	Yes	Ti-Zr 3,3 mm implants have the same success rate as the Ti implants with 4.1 mm diameter.
(Ishii et al., 2016)	Animals	3 patients, 12 pure titanium implants	Used dental floss over a period of 90 days to induce inflammation	UV radiation slows down periimplantitis. Rx shows less bone loss in UV-irradiated periimplantitis	Yes	If the implant is exposed to ultraviolet radiation, the bone resorption will be less pronounced when compared to the areas that weren't exposed to the radiation.
(Derks et al., 2016)	Humans	62 patients, 596 implants	No	The progression of the periimplantitis is not linear	No	The onset of periimplantitis usually appears 3 years after the use of implant
(Gamper et al., 2017)	Humans	60 patients, 151 implants	No	Both implant systems show a very high survival rate	Yes	No significant differences between the one piece and two piece dental implants
(Lin et al., 2017)	Animals	6 dogs, 36 Straumann dental implants	3 months after the implant stainless stell ligatures and silk ligatures were placed to produce periimplantitis	After ligature removal, the inflammation partially recovers. Bone loss was observed	Yes	To induce periimplantitis, SSL ligatures are much more effective than silk or cotton ligatures
(Wu et al., 2017)	Animals	6 patients (Labrador dogs)	Used cotton floss ligature to induce periimplantitis, removed after 2 months	Connectivity tissue loss, increase in inflammation in B and T cells, neutrophils, and macrophages.	Yes	Periimplantitis induced by ligatures in dogs is similar to human periimplantitis.
(Mencio et al., 2017)	Humans	20 patients, 20 implants	No	The patients were divided in two groups: group A - screwed implant- abutment connection and group B: cemented implant-abutment connection	No	Implants with screwed connection have a higher risk of developing periimplantitis than cemented implants.
(Christiaens et al., 2017)	Humans	23 patients, 50 implants	No	The best predictor for evaluating the periimplantitis is the bone sounding	Yes	Intraoral Rx may underdiagnose the periimplantitis. Therefore, clinical observation is very important for diagnostic
(Abi-Aad et al., 2018)	Humans	24 patients, 173 implants	No	No difference was found between the immediate implant and the conventional implant	Yes	Immediate implant loaded have similar results as one stage implant
(Huang et al., 2018)	Animals	6 dogs	Cotton ligature, oral hygiene was neglected to encourage bacteria formation for a 12-week period	Marginal bone loss	Yes	Implants located at the bone crestal position showed less infra-osseous problems than those implants placed at the subcrestal position in a periimplantitis.

Article	Type of subjects	No. of subject, no. & type of implants	Experimental procedures (to induce periimplantitis)	Observations on periimplantitis/periodontitis	Radiographic evaluation	Results
(Morelli et al., 2019)	Animals	6 patients	After 6weeks old ligatures were replaced, and they were removed completely after 3 months	Bleeding on probing	Yes	Bone resorption was more accentuated in narrower implants. Narrow implants show a tendency of faster progression of the induced periimplantitis compared to standard ones.
(Wu et al., 2019)	Animals	5 dogs, 20 Straumann implants	Used cotton floss ligature to induce periimplantitis	Inflammation, bleeding on probing suppuration. Bone loss was observed on RX	Yes	Bacteria proliferates around the implant and affects the stability of the implant
(Galarraga et al., 2019)	Humans	4 patients, 5 implants	No	All implants were lost in the subjects due to severe bone loss	Yes	Periimplantitis affects bone to implant contact. Radiographic evaluation does not show to full extent of periimplantitis
(Bolle et al., 2019)	Animals	6 dogs, 57 implants, 4 types (Straumann, Nobel, Global, Twinkon)	Submarginal ligatures	Implant type may influence bone loss and healing during implantitis.	Yes	Implant type may influence bone loss and healing during implantitis. Parameters of implant type may present risk factors for the periimplantitis. Further research must be conducted.
(Guarnieri et al., 2020)	Humans	56 older humans	No	Bone loss, chronic inflammatory infiltrate	Yes	Extremely careful cementation process to avoid further complications
(Yoon et al., 2020)	Animals	6 dogs, 24 implants	Silk ligature to induce periimplantitis	Mechanical debridement may impede periimplantitis progression of periimplantitis. Bone loss was observed on RX.	Yes	Mechanical debridement may impede periimplantitis progression of periimplantitis
(Galárraga-Vinueza et al., 2020)	Humans	4 patients	No	Biopsies reveal that cytokines, macrophages, and neutrophils are present at periimplantitis sites	Yes	Results are uncertain
(Pamato et al., 2020)	Humans	21 patients, 52 implants	No	A comparison between the titanium base abutments and the cement-retained abutment has shown no significant difference	Yes	Titanium base abutments have no negative impact in soft and hard tissue that surround the implant
(Scarano et al., 2021)	Humans	-	-	Cemented retained restoration on implants ensure a better fit and a better distribution of loading during function	Yes	Periimplantitis is associated with the excess of cementum around the implant tissue

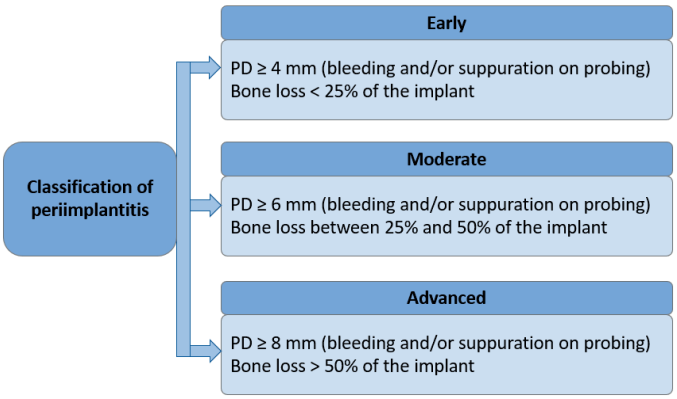

Figure 1. Classification of periimplantitis (according to Froum & Rosen, 2012)

RESULTS AND DISCUSSIONS

Periimplantitis is defined as an inflammatory response of the tissue surrounding the dental implant. The main factor that causes periimplantitis is dental plaque accumulation around the neck of the implant. Early stages begin with mucositis, when the biofilm causes inflammation at the gingival level surrounding the implant. If the dental plaque is not properly removed, the inflammation of the gingiva will continue to progress until mucositis becomes periimplantitis. Mucositis is limited to affecting the soft tissue only. It becomes periimplantitis when the gingival inflammation starts affecting the bone. Therefore, periimplantitis includes the inflammation of the soft tissue as well as bone resorption. Some clinical parameters that are used for diagnosis of the periimplantitis disease are: dental plaque, periimplant mucosa health, bleeding on probing, keratinized mucosa around the implant, suppuration and resorption of the crestal bone. Insufficiency of keratinized mucosa around the dental implants has been associated with an increase of dental plaque accumulation, mucosal recession and peri-implantitis (Kungsadalpipob et al., 2020) A careful evaluation of all the factors stated above helps determine the presence and severity of periimplantitis. Figure 1 shows the different stages of progression in the periimplantitis disease.

In clinical trials conducted on animals, to study periimplantitis, there is a series of steps that must be followed. The first step is the extraction of the teeth that will be replaced. After approximately 3 months, a dental implant procedure will take place through a surgical intervention. The purpose of the surgical intervention is the replacement of the natural tooth root with an artificial one. After the surgery is complete, a period of three months is necessary for healing of the surgical area. During the three months, controlled hygiene with mouth wash is applied to prevent the premature formation of inflammation. After the healing process and osteointegration of the implant into the bone is complete, one of three different ligature types are applied around the neck of the implant to induce periimplantitis. The three main types of ligatures are: metal, silk and cotton.

For studies conducted on humans, the periimplantitis was caused by leftover cementum in the sulcus of the gingiva around the implant and dental plaque.

The dental plaque includes the microbiota that coats the implant. Certain strains of microflora can cause dental implant failure. Some of these strains include: bacteria which is black pigmented such as Prevotella nigrescens, Prevotella intermedia, and Phorphyromonas gingivalis as well as bacteria that are gram negative such as Spirochetes, Bacteroides, Forsythusfusobacteria, and Aggregatibacter actinonomycetemcomitans (Heydenrijk et al., 2002). Radiographic imagistic is important for detecting and determining the stage of the periimplantitis. If the implant is found to present mobility, then it is completely compromised and must be removed. A clinical diagnosis characterized by bleeding upon

probing with or without suppuration, an increased peri-implant pocket depth ≥5 mm or a radiograph showing marginal bone loss ≥2 mm is an indication of periimplant disease. (Nguyen-Hieu et al., 2012).

The best way to avoid periimplantitis, implant failure and removal is detecting the early stage of periimplant mucositis and managing it. (Jepsen et al., 2015).

Currently the diagnosis of implants is based mostly on clinical and radiological signs. However, molecular tests, as well as biomarkers in peri-implant crevicular fluid (PICF) show promise and may help detect and prevent early periimplantitis (Alassy et al., 2019; Carinci et al., 2019).

Implant narrowness, shape and coating material are some of the factors which can affect periimplantitis risk. However, most studies can agree that if the implant is surrounded by dental plaque then there is a high likelihood of periimplantitis developing. To avoid the formation of the dental plaque that causes periimplantitis a good dental hygiene is required. Excellent dental hygiene usually results in the prevention of periimplantitis and the complications associated with this disease, which determines the successful rate of the implant.

CONCLUSIONS

Based on current literature, our review on periimplantitis revealed that the most common cause of the disease is lack of proper hygiene and accumulation of dental plaque around the dental implant. Periimplantitis is associated and diagnosed with swelling of the affected area, bleeding of the gingiva, the presence of certain types of pathogen bacteria and bone resorption. All studies covered in this review on animal trials used ligatures to induce periimplantitis so it can be observed. Preventing, diagnosing, and treating periimplantitis in its early stages maximizes the success rate of the implant.

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MISCELLANEOUS