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Grado en Odontología

SURGICAL TREATMENT OF PERI-IMPLANTITIS

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RESUMEN

Objetivo: Valorar el tratamiento quirúrgico de elección de la periimplantitis, evaluando los resultados clínicos según la técnica. **Material y Métodos:** Se realiza una investigación bibliográfica investigando en varias bases de datos: PubMed, MEDLINE, Cochrane y Google Scholar. Los artículos han sido seleccionados según criterios de inclusión definidos como un rango de diez años con palabras clave relevantes. **Resultados y Discusión:** Se incluyeron 21 estudios. Tanto la técnica no aumentativa como la aumentativa muestran resultados clínicos y radiográficos mejores para tratar la periimplantitis. Los resultados de los estudios que realizan una cirugía de colgajo de acceso combinada con recontorno óseo informan de reducciones de la profundidad de sondaje (PS), sangrado al sondaje y supuración con niveles óseos estables. La recuperación de la enfermedad suele producirse en el caso de implantes con una ligera pérdida ósea. 13 estudios que evalúan las técnicas aumentativas informan mejoras en los signos clínicos y radiográficos de la periimplantitis. Se puede conseguir un aumento significativo del nivel óseo y una reducción de 2-3 mm de la PS. El tipo de defecto intraóseo circunferencial muestra las mayores reducciones de la PS y de la pérdida de inserción clínica. Dos estudios muestran una mayor reducción de la PS y del relleno óseo radiográfico tras el tratamiento regenerativo en comparación con el no aumentativo. **Conclusión:** Tanto los procedimientos no aumentativos como los aumentativos pueden ser técnicas eficaces para tratar la periimplantitis. No hay pruebas suficientes para identificar y concluir cuál es la cirugía de elección. Según la morfología del defecto, la cirugía resectiva trata los defectos óseos supracrestales, en ninguno o en aspectos estéticos menores. Las técnicas regenerativas son más propensas a corregir los defectos circunferenciales infraóseos y defectos retentivos.

ABSTRACT

Objective: To assess the surgical treatment of choice of peri-implantitis, by evaluating clinical outcomes according to the approach.

Materials and Methods: A bibliographic research is carried out by investigating several databases: PubMed, MEDLINE, Cochrane and Google Scholar. Articles have been selected according to defined inclusion criteria such as a ten-years range with relevant key words.

Results and Discussion: 21 studies were included. Both non-augmentative and augmentative technique show good clinical and radiographic outcomes for treating peri-implantitis. Results from studies performing an access flap surgery combined with bone-recontouring report reductions of probing depth, bleeding on probing and suppuration with stable bone levels. Disease recovery usually occurs in the case of implants with slight bone loss. 13 studies assessing augmentative techniques report improvements in clinical and radiographic signs of peri-implantitis. Significant bone level gain and 2-3 mm reduction of probing depth can be achieved. Circumferential intrabony defect type displays greatest reductions of probing depth and clinical attachment loss. Two studies show higher reduction of probing depth and radiographic bone fill after regenerative treatment compared to non-augmentative one.

Conclusion: Non-augmentative and augmentative procedures both may be effective technique to treat peri-implantitis. There is insufficient evidence to identify and conclude which is the surgery of choice. According to the defect morphology, resective surgery addresses supra-crestal bone defects, in none or minor esthetic aspects. Regenerative techniques are more prone to correct infra-osseous circumferential defects and retentive defects.

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I. INTRODUCTION

In the past decades, implantology has taken a paramount place in dental practice and become a current trend in prosthetic rehabilitations (1). Nowadays, dental implants are considered a treatment of choice for edentulism both in fixed and removable prothesis on implants, when the conditions allow it. However, implant discipline faces biological complications which may jeopardize the future success of the implant. Peri-implant disease is defined as a pathology that affects the tissues around dental implants. Patients can suffer from peri-implant mucositis or more severely, peri-implantitis. Both pathologies present clinical and/or radiological signs, similar to gingivitis and periodontal disease (2).

Several approaches or methods have emerged to act against this inflammatory process and provide a proper peri-implant health. Those can be classified in two categories: non-surgical and surgical treatments. Non-surgical therapy implies a mechanical debridement by devices as curettes or laser. It intends to remove granulation tissue on the implant surface and should be considered as a first intention in the procedure (3). As for the surgical treatment, this involves an access flap surgery, resective surgery or a regenerative procedure. Depending on the severity of the peri-implantitis and its bone defect, one or more procedures may be performed (4).

In this section, we will address those following parts: 1) *definition of peri-implantitis and its diagnosis*; 2) *the surgical strategies*; 3) *the prevention of peri-implantitis*. Therefore, understanding those previous components will support the comparison of different therapies among the surgical ones and the determination of the most valuable one according to the most evidence-based literature.

I.1 Peri-implantitis

I.1.1 Definition

The 2017 European Workshop on Periodontology defined peri-implantitis as an irreversible inflammatory process characterized by an inflammation of the peri-implant connective tissue and a progressive loss of supporting bone around an osseointegrated implant (5). Two biological complications have to be differentiated: peri-implant mucositis and peri-implantitis. The presence of an inflammatory process is a characteristic that both conditions shared, yet peri-implantitis displays a loss of supporting bone (Figure 1). According to Schwarz et al., peri-implant mucositis likely leads to peri-implantitis. However, the changeover from peri-implant mucositis to peri-implantitis is not thoroughly understood (6). In the absence of an effective treatment, bone lysis continues, which can lead to a total loss of osseointegration and then the mobility of the implant. Peri-implantitis is therefore considered as a secondary implant failure.

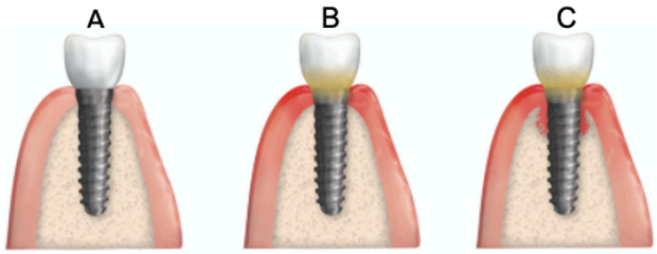

Figure 1. Illustration of the different peri-implant conditions (6).
(a) Peri-implant health. (2) Per-implant mucositis. (c) Peri-implantitis

I.1.2 Prevalence, etiology, risk factors/indicators

Variable prevalence of peri-implant diseases has been reported by a number of studies in the past years. Mombelli et al. assessed peri-implantitis after implant

surgery, for 5-10 years, and outlined a prevalence of 10% implants and 20% patients (7). A cross-sectional study reported, after 11 years follow-up, 33% of the implants and 48% of the patients presenting peri-implant mucositis. Additionally, peri-implantitis occurred in 16% implants and 26% patients (8). According to Derks and Tomasi's meta-analyses, peri-implant mucositis and peri-implantitis expressed a prevalence of 43% and 22%, respectively (9). A world consensus about peri-implant diseases prevalence does not exist. It may be due to the lack of uniformed case definition and diagnostic criteria involved in those studies.

Potential etiological factors are related to the outset and breakthrough of peri-implant diseases. Risk factors have to be distinguished from risk indicators. Indeed, a true risk factor is considered as such once studied in interventional studies. Whereas a risk indicator can be identified only in observational, retrospective and cross-sectional studies. For the World Workshop in 2017, Schwarz et al. provides an evidence-based overview on risk factors and indicators of peri-implantitis (6). Various factors are suggested to play a role facilitating the appearance of peri-implantitis (Figure 2).

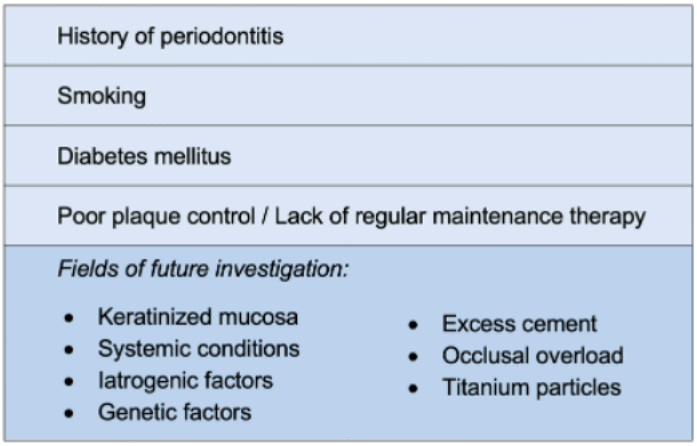

Figure 2. Potential risk factors/indicators for peri-implantitis (adapted version based on Schwarz et al. overview) (6)

History of periodontitis. A number of longitudinal studies indicates a correlation between peri-implantitis and periodontal patients. Karoussis et al. reports the incidence of peri-implantitis after ten years of 29% in patients with a history of periodontitis compared to 6% in group control patients (10). Roccuzzo et al. also demonstrated a significant similar outcome with a higher probing depth and bone loss in periodontally compromised patients (11). Cross-sectional studies were also carried out and have reported positive odds ratio in patient with a previous periodontitis. Those data suggest potential causal relationship between peri-implantitis and a previous periodontitis (12–14). Therefore, a strong evidence suggests that a history of periodontitis presents a risk factor/indicator for peri-implantitis.

Smoking. It is well known that smoking has a detrimental effect on general health and especially on oral health. It has been shown to be associated with tooth loss, clinical attachment loss and dental decays (15). According to meta-analyses conducted by Chrcanovic et al., tobacco is a risk factor leading to a 2-fold increase in implant loss after 5 years of use (16). Various studies highlighted a potential association between smoking and peri-implantitis. Karoussis et al. noticed that, in 10-year cohort study, 18% of implants with peri-implantitis where found in smoker patients, against 6% in non-smokers group. Cross-sectional studies supported those data reporting positive odds ratios (17,18). Nevertheless, lots of studies did not express such causal relationship. Aguirre-Zorzano et al. did not expose smoking as a risk factor/indicator for developing peri-implantitis, after analyzing 786 implants in periodontally compromised patients (19). Cross-sectional study with 916 implants, conducted by Dalago et al., identified several risk indicators such as a history of

periodontal disease. However, this study failed to identify smoking as a risk indicator (12). Other cross-sectional studies support those findings (8,20). Consequently, those data do not consider smoking as a true risk factor/indicator for peri-implantitis.

Diabetes mellitus. The link between periodontal diseases and diabetes has been widely studied. It is clearly determined that diabetes has a negative effect on periodontal health (21). Recently, it has been reported that this causal relationship has a reciprocal effect suggesting that periodontitis negatively impacts the glycemia level in diabetic patients (22). Moreover, Baeza et al. demonstrated that treating periodontitis with scaling and root planning has a significant impact in decreasing glycated hemoglobin (HbA1C) and systemic inflammation (C-reactive protein) in type 2 diabetic patients (23). Conversely, the link between diabetes and peri-implantitis has not been well established. Few studies have been reported a causal association between diabetes and peri-implantitis. Uncontrolled diabetic patients did not present a significant higher risk of peri-implant mucositis, but presented a higher risk of developing peri-implantitis (24). Another study, with a follow-up of 11 years, also showed that diabetic patients exposed a greater risk of developing peri-implantitis, or implant loss (8). However, lots of studies failed to identify a statically significant higher risk of peri-implantitis associated with diabetes (12,18,25). Although it is well known that diabetes impacts negatively the periodontal health such as developing periodontitis, no specific evidence suggests that this systemic disease can be considered a true risk factor/indicator for peri-implantitis.

Poor plaque control. Bacterial biofilm plays an important role in the development of decays and periodontal disease and is considered as its main etiological factor in their appearance. Biofilm characteristics of peri-implantitis is different from periodontitis. Not only periodontopathic pathogens are present but some opportunistic pathogens are involved as well (26). Not maintaining good oral hygiene may engender tooth loss in long-term (27). After performing a 5-year follow-up study, Costa et al. indicated the incidences of peri-implantitis of 18% and 43.9% in with and without preventive maintenance groups, respectively. A cross-sectional study found a positive association between non-compliance patients and higher risk to develop peri-implantitis. Whereas peri-implantitis was 86% less correlated for patients that comply to maintenance therapy (28). Results from several other studies matched with the findings previously mentioned and suggest the importance of regular maintenance protocol in the appearance of peri-implantitis (19,29–31). Moreover, it has to be pointed out that patient accessibility or ability to implant sites for oral hygiene is an important factor to take into account. Indeed, Serino and Ström notified that 48% of the implants with no access/ability for oral hygiene presented peri-implantitis compared to 4% of the implants with access/ability (32). Therefore, conclusive data indicate that poor plaque control involving lack of maintenance protocol is part of the risk factors/indicators of peri-implantitis.

Fields of future investigation. The following potential risks factors/indicators of peri-implantitis have been mentioned to exert a possible effect on the onset of peri-implantitis: keratinized mucosa, excess cement, iatrogenic factors, genetic factors, systemic conditions, occlusal overload and titanium particles.

Although keratinized mucosa (KM) is a structure that allows to preserve a gingival health around teeth, its presence importance is still not well demonstrated. Various studies have reported the positive impact that a high width of keratinized mucosa may have on peri-implant health such as less plaque accumulation, less tissue inflammation, and less brushing discomfort. The presence of a KM ≥ 2 mm around implants may have a protective effect on peri-implant tissues.

I.1.3 Peri-implantitis diagnosis

I.1.3.1 Clinical examination

As it worth for every oral disease, establishing a correct diagnosis of peri-implantitis is crucial for its proper care and support management. During the diagnosis phase, the symptomatology of the patient and the signs established by the dentist, both parameters should be considered. Clinical examination represents an essential step performed in all dentist's daily practice. After implant placement, the onset of peri-implantitis should be assessed by those following criteria:

- Clinical signs of inflammation
- Probing depth (PD)
- Bleeding on probing (BOP) and/or Suppuration
- Mobility

It is worth noting that peri-implant health is characterized by the absence of visual signs of inflammation and bleeding on probing, with normal bone support, compared to previous clinical records.

Clinical signs of inflammation. As previously mentioned, peri-implantitis is a pathologic condition presented in the peri-implant tissues, represented by an inflammation in the peri-implant mucosa (5). Inflammation implies four clinical signs: erythema, edema, redness and pain. Moreover, clinical signs of inflammation are also present in peri-implant mucositis, considered the previous stage of peri-implantitis. Therefore, dentist should first detect any changes of those parameters by visual inspection and digital palpation, in order to realize an early diagnosis implying an early treatment.

Probing depth. In periodontal practice, periodontal probing is commonly performed around teeth in order to assess probing depth and clinical attachment level (CAL) in relation to the cemento-enamel junction as well. This clinical parameter is also applied to implants and evaluates the peri-implant tissue sealing changes and gingival margin recession. Four or six sites around the implant shoulder are probed as natural teeth with a periodontal probe. According to Serino et al., due to the emergence of the prosthetic reconstruction that could interfere with the access probing, it is recommended to remove it in order to assess accurately and obtain reliable measurements (33). In healthy peri-implant mucosa, there is resistance to light force probing (<0.25 Ncm) where the tip of the periodontal probe stops at the junctional epithelium, resulting in a probing depth of 3 to 4 mm, values higher than in natural teeth. Whereas an increased probing depth can be observed in the presence of inflammation of peri-implant tissue. Indeed, the swelling of the inflamed tissue may lead to a reduced resistance of the junctional epithelium to probing, inducing this increase (2). De facto, peri-implant mucositis may also display an increased probing

depth. However, since the World Workshop in 2017, Berglundh et al. established two elements that must be taken into consideration in the diagnosis of peri-implantitis. As a matter of fact, peri-implantitis exhibits (i) an increase of probing depth compared to previous values or (ii) a probing depth ≥ 6 mm (in the absence of previous data) (2,34). Clinically, the periodontal probe overpasses the junctional epithelium and may reach the apical portion of it or even the underlining connective tissue.

Bleeding on probing and/or Suppuration. As in periodontal disease, the presence of bleeding on probing or suppuration indicates an inflammation of the peri-implant soft tissue. The existence of this clinical sign, if the probing is correctly performed, reveals the instability of the peri-implant mucosa, suggesting a peri-implant disease (35). Interestingly, recent studies have highlighted the correlation between the presence of suppuration and peri-implantitis and the use suppuration as an effective criterion for peri-implantitis diagnosis. Suppuration may be restricted in peri-implantitis case (36). It may be associated with bone loss and probing depth according to suppuration's grade (37).

Therefore, it is important to monitor the status of the peri-implant mucosa after implant placement during the maintenance period. Peri-implant mucositis and peri-implantitis both exhibit this clinical parameter and further diagnostic examination need to be realized in order to distinguish them (Figure 3). In that respect, bleeding on probing or suppuration remains an important and valid diagnostic tool in order to differentiate between an healthy and inflamed peri-implant soft tissue (34).

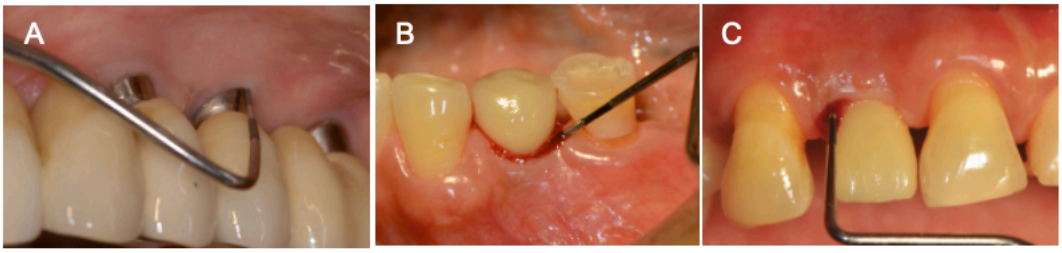

Figure 3. Gentle probing performed in different peri-implant status (34). (a) Peri-implant health. (b) Peri-implant mucositis. (c) Peri-implantitis

Mobility. The ultimate aim after implant placement is to achieve a correct osseointegration. The principles of osseointegration have been indicated firstly by Brånemark as the direct union of bone-to-implant interface under functional load (38). The term of "functional ankylosis" to characterize the osseointegration, has been declared by Schroeder, decades later. This implies that the success of implants is characterized, among other criteria, by the lack of mobility. However, we should consider two possible causes that generate perceived mobility in implants. On one hand, it might result from the loosening of the prosthetic restoration and/or its abutment, that may hide in the future bacterial plaque leading to the development of peri-implant diseases. In this case, restoration and/or abutment must be tightly adjusted, and occlusion should be verified as well (39). On the other hand, if the mobility is due to the lack of osseointegration, the implant viability is lost, and its failure is established. In this way, the implant must be removed. Thus, mobility is not useful in the early detection of peri-implant disease (35,40).

I.1.3.2 Radiographic examination

After a previous clinical examination that identifies the presence of inflamed peri-implant tissue, the types of peri-implant disease need to be distinguished: peri-

implant mucositis from peri-implantitis. As probing depth and bleeding on probing can be present in both contexts, the key factor in the diagnosis of peri-implantitis is established by radiographic examination. Indeed, radiographs after implant placement and following the prosthetic reconstruction should be performed and will be used as baseline of the crestal bone levels. Then, these “baseline radiographs” will be further compared to those one taken annually in order to monitor and detect any bone level changes (41).

Radiographic examination should be realized using intraoral periapical radiographs instead of orthopantomography for its higher accuracy in detecting bone level variations. However, they have limited ability to reveal bone level changes in the early stage of peri-implantitis (40). Moreover, a standardized technique should be used and preferably the parallel technique by means of positioners equipment to allow valid comparisons. Periapical radiograph is placed parallel to the implant axis and so perpendicular to the X-ray beam in order to expose a definite delimitation of the implant threads (35). It can not be omitted that only the interproximal crestal bone levels are identified. To counteract this situation, different X-ray projections may be considered. Other types of radiographs may be explored such as CBCT, that enables to assess the vestibular and palatal/lingual bone profile in complicated cases when the diagnosis is unclear with conventional radiographs.

Peri-implantitis is distinguished from peri-implant mucositis by a presence of progressive crestal bone loss, compared to previous examinations (Figure 4). It must be considered a bone loss apart from the one derived from bone remodeling. It is

generally recognized that bone remodeling around implants may be up to 2 mm the first year of functional loading, then a maximum value of 0.2 mm annually (42). Berglundh et al. in 2017 World Workshop, characterized peri-implantitis with bone loss levels ≥ 3 mm from the coronal part of the implant intraosseous portion to the apical defect, after bone remodeling. This value is taken as reference in the absence of anterior radiographic records (2,34).

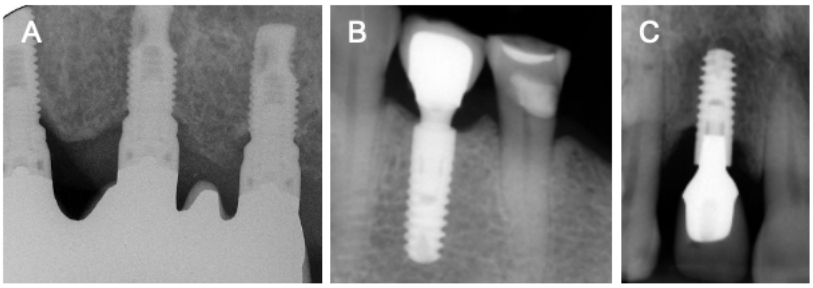

Figure 4. Radiographic images from Figure 3 cases (34) . (a) Peri-implant health. (b) Peri-implant mucositis. (c) Peri-implantitis

Various classifications of peri-implantitis have been proposed according to the bone loss severity. Schwarz and al. conducted an experimental study in humans and animals with the aim to assess and compare the bone defects of peri-implantitis (43). In human subjects, peri-implantitis occurred in a natural way, whereas in dogs, peri-implantitis was ligature-induced. From this experimental study, they identified two types of bone loss defects and classified them into two classes. Class I presents only intraosseous bone loss and is subdivided into five configurations Ia – Ie (Figure 5 and Figure 6A). Class II is characterized by horizontal bone loss (6B). Interestingly, Class Ie has been shown to be mostly associated with Class II defect (Figure 6C). Moreover, results from humans and dogs are both consistent to report that Class Ie is the most prevalent class of peri-implantitis, compared to the other ones: 55.3% and 86.6% in

CLASS I Intrabony defect	(Ia)	Vertical loss of vestibular alveolar bone, dehiscence-type defect
	(Ib)	Vestibular dehiscence-type defect + Semi-circular bone reabsorption at the center of the implant body
	(Ic)	Vestibular dehiscence-type defect + Circumferential bone reabsorption
	(Id)	Vestibular dehiscence-type defect + Circumferential bone reabsorption + Loss of the palatal/lingual cortical plate
	(Ie)	Circumferential bone reabsorption + Buccal and palatal/lingual cortical plates preserved
CLASS II	Horizontal bone loss defect	

Figure 6. Classification of peri-implantitis bone defects, reformulated from Schwarz et al. in 2007 (43)

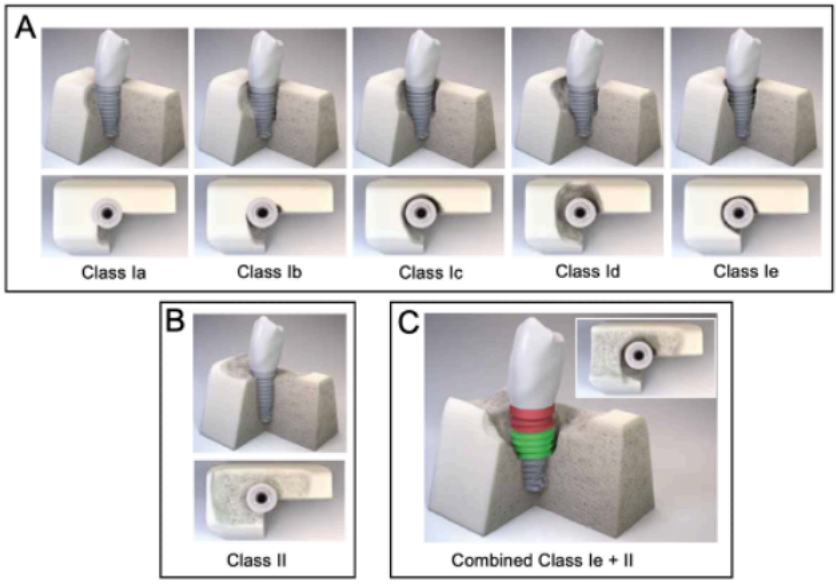

Figure 5. Illustration of peri-implantitis bone defects classification from lateral and occlusal views (40). (a) Class I defects: Ia - Ie. (b) Class II defect. (c) Combined defect with class Ie + II: horizontal bone loss in red and circumferential bone loss in green.

humans and dogs, respectively. Nevertheless, other studies did not draw the same conclusions. Although circumferential bone defect has not been identified as the most common one, dehiscence-type defect morphology in the buccal aspect was highlighted (33).

Years later, in 2015, Romanos et al. reported another type of peri-implantitis classification, according to bone loss of implant length (44). Peri-implantitis is categorized into three stages: *mild* with bone loss < 25%, *moderate* with bone loss between 25% - 50% and *advanced* with bone loss > 50%. However, this classification did not take into account the morphology of the bone defects which its relevancy can not be disregarded.

In 2019, Monje et al. published a modified classification from the one presented by Schwarz et al. in 2007 (45). It considers two criteria: the morphology and the severity of the bone defect characterizing the patient peri-implantitis. Firstly, the component in respect to the morphology accounts now for three classes. Definitions of classes I and II are generally similar than the previous classification: class I constitutes the intrabony defect and only regroups three subdivisions, class II describes the supracrestal or horizontal bone loss. Class III has been incorporated for representing the combined defects and determines three subdivisions (Figures 7 and 8).

CLASS I Infraosseous defect	Ia	Buccal dehiscence
	Ib	2-3 walls defect
	Ic	Circumferential defect
CLASS II	Supracrestal/horizontal defect	
CLASS III Combined defect	IIIa	Buccal dehiscence + horizontal bone loss
	IIIb	2-3 walls defect + horizontal bone loss
	IIIc	Circumferential defect + horizontal bone loss

Figure 7. New classification of peri-implantitis according to its bone defect morphology (45)

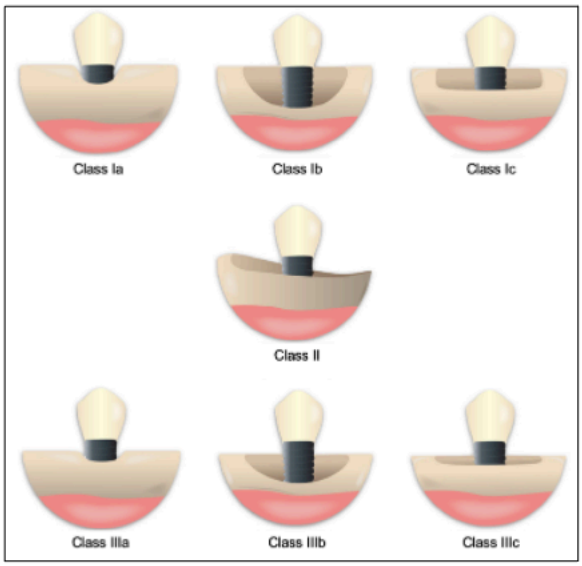

Figure 8. Illustration of the morphology defects (45)

Secondly, the severity is exposed according to three grades taking into account the depth of the defect and the bone loss evaluated in percentages (Figure 9). As exposed previously in the 2017 World Workshop, peri-implantitis is defined by a bone loss ≥ 3 mm from the implant neck to the apical part of the defect, grades of the defect depth begin at 3 mm.

GRADES	DEFECT DEPTH	BONE LOSS
Slight	3 - 4 mm	< 25%
Moderate	4 - 5 mm	≥ 25% - 50%
Advanced	> 6 mm	> 50%

Figure 9. New classification according to peri-implantitis severity bone defect (45)

From this study, it has been reported that the class Ib – intrabony loss with 2-3 walls defect, was the most frequent one with 55% compared to the other morphology types. The “moderate” severity stage was the most prevalent one. Moreover, the buccal bone loss was significatively affected, which is in agreement with previous studies. It is

important to mention that defect severity has been demonstrated to frequently depend on its morphology. Additionally, some factors related to the patient or the type of implant and its site may be correlated to the bone loss structure and severity.

Thus, peri-implantitis diagnosis is a first fundamental phase before initiating its treatment. A proper diagnosis involves both clinical and radiographic examinations. Clinical examination allows us to underscore the existence of peri-implant disease. Radiographic evaluation highlights the distinction between peri-mucositis and peri-implantitis (Figure 10). Moreover, it helps to characterize the morphology and severity of bone loss present in peri-implantitis. Performing initial records after implant placement or prosthetic loading is an important aspect that dentists should not avoid, in order to compare the previous context with the future one.

EXAMINATION	PERI-IMPLANT HEALTH	PERI-IMPLANT MUCOSITIS	PERI-IMPLANTITIS
Clinic	No BOP	BOP	BOP
Radiographic	No bone loss	No bone loss	Bone loss ≥ 3 mm apart from bone remodeling

Figure 10. Simplified clinical guidelines to achieve peri-implant diagnosis. (BOP = Bleeding on Probing)

I.2 Peri-implantitis surgical procedures

Non-surgical procedures, by means of curettes alone, may lead to an ineffective removal of contaminated tissues and the implant surface is still exposed to bacterial biofilms. Surgical therapy is therefore needed to have an adequate access to achieve a correct elimination of infectious tissue. It englobes different strategies that can be combined or not in order to have a proper bacteria-free cleansing and reshape the soft and hard tissues morphology, both promoting a good healing and re-osseointegration of the implant.

I.2.1 Decontamination of implant surface

Various procedures have been proposed to decontaminate the implant surface during surgical treatment. Those involve mechanical, chemical decontamination and the use of lasers as well.

Mechanical decontamination aims to remove bacterial deposits on implant surface physically. Different instruments such as curettes, ultrasonic devices, air-abrasive systems and implantoplasty are included. Curettes used are usually made of carbon fiber or titanium without altering the implant surface (33, 34). Ultrasonic devices with specific tips remove granulated tissues easily and allow a cleaner and smoother implant surface (47). Powered air-abrasive systems work by spraying abrasive powder on hard surfaces and removing oral biofilm, such as the one based on low-abrasive amino-acid glycine (48). Furthermore, the micro-structure implant surface type has been exposed to play a role in the decontamination complexity. Therefore, implantoplasty may be apply during surgery. It consists of creating a smooth

supracrestal implant surface by grinding the implant threads and reducing rough surface. It is performed with burs and stones under abundant irrigation to avoid any implant alteration (49).

Chemical decontamination implies a local treatment with anti-microbial solutions. One of those can be applied in the implant site such as topical chlorhexidine, tetracycline or minocycline, citric acid, hydrogen peroxide or 35% phosphoric acid gel, working together with mechanical debridement for eliminating bacterial deposits (50).

Laser therapy - standing for light amplification by stimulated emission of radiation - comprises different types including Er:YAG, carbon dioxide (CO_2), and diode lasers. The purpose of this approach advocate for emitting an energy capable of cutting hard and soft tissues. Controversy studies have been reported relating to the potential benefit of laser use. Lin et al. failed to highlight a significant benefit of adjunctive laser in surgical therapy, whereas using it in non-surgical therapy might display a potential advantage by reducing the inflammation (51).

I.2.2 Access flap surgery

The purpose of the access flap is to obtain an open visual access in order to debride properly the bone defect and remove the unhealthy hard and soft deposits. This surgical intervention is well known and consists in lifting a full-thickness flap to access the implant surface. Indeed, intra-sulcular incisions around the affected implants are performed and mucoperiosteal flaps are elevated in buccal and palatal/lingual aspects (Figures 1A and 1B). Thereafter, decontamination of the inflamed tissues is carried out by one or several techniques previously mentioned (section I.2.1). Both flaps are then repositioned at their initial place and discontinuous sutures are completed in order to

preserve the integrity of the peri-implant tissue (Figure 1C). Access flap surgery combined with a following decontamination is usually accomplished only in superficial bone defects.

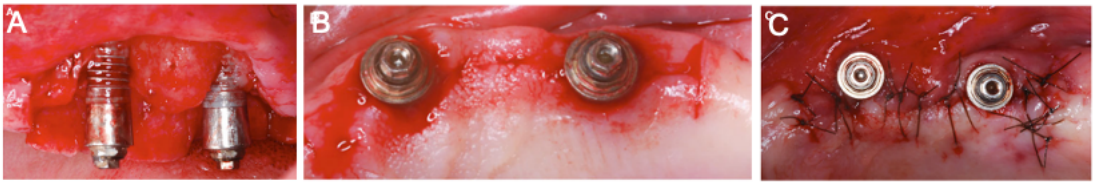

Figure 11. Surgical therapy: access flap. (52)
(a) Surgical incisions. (b) Mucoperiosteal flaps. (c) Suturing.

I.2.3 Resective surgery

Resective surgery is a surgical procedure that may be employed in periodontitis treatment by eliminating osseous defect around teeth and leaving a positive architecture of the bone. This technique is usually preceded by an apically positioned flap to realize a proper access for patient's oral hygiene. Facing peri-implantitis, resective surgery may be performed as well, achieving the same objective around affected implants (Figure 2). Ostectomy and osteoplasty using bone chisels are executed and implantoplasty can also be performed to smoothen the exposed implant part. Finally, mucoperiosteal flaps are sutured in a manner: (i) to allow the exposed implant part in contact with the oral cavity and, (ii) to facilitate a good access for patient's oral hygiene. It is worth noting that it is a procedure that should be done in nonaesthetic areas.

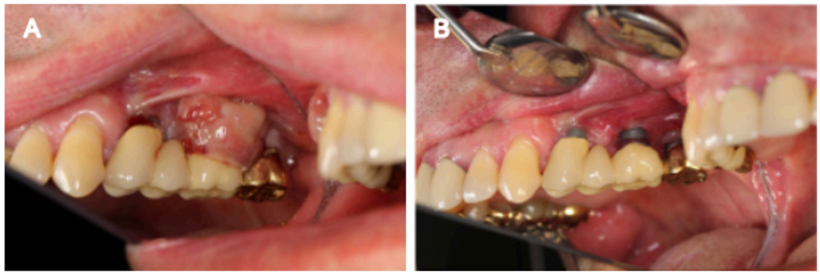

Figure 12. Resective surgery. (52)
(a) Peri-implantitis with granulation tissue. (b) Peri-implantation 1 week after resective therapy

I.2.4 Regenerative techniques

Regenerative procedures englobe the use of graft materials and/or resorbable membranes according to the precepts of guided bone regeneration (GBR). Its main objectives are: (i) maintain the tri-dimensional tissue structure during the healing period, preventing mucosa recession and, (ii) promote re-osseointegration thanks to regenerative materials. Concerning the proper technique, first intra-sulcular incisions are made and periosteal flaps are raised buccally and palatally/lingually (Figure 3).

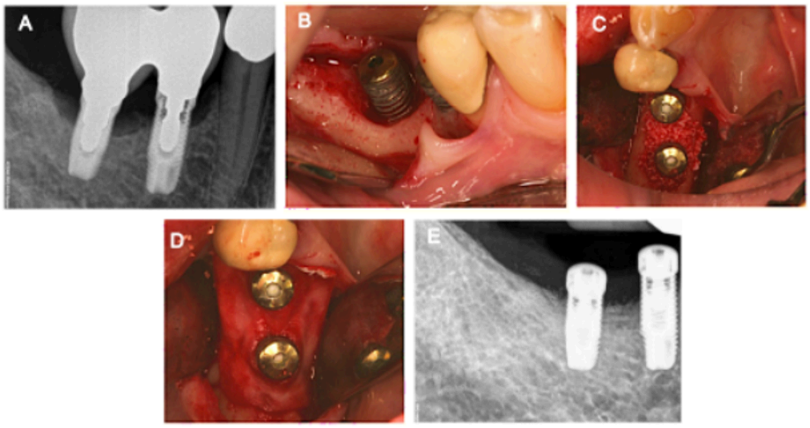

Figure 13. Regenerative procedure. (52)
(a) Pre-operative radiography of peri-implant defect. (b) Defect after degranulation.
(c) Defect fill with a xenograft material (BioOss®, Geistlich, Switzerland).
(d) Membrane application (BioGide®, Geistlich, Switzerland).
(e) Post-operative radiography 12 months after regenerative therapy

After eliminating granulated tissues, graft material is placed around the affected implant, filling the intrabony defect. Among augmentation materials, autografts, allografts, xenografts (as BioOss®) and other bone substitutes can be applied. Thereafter, the application of a membrane resorbable or non-resorbable may cover the graft material with the objective to exclude non-osteogenic tissues from interfering with bone regeneration. Finally, the flaps are repositioned at a coronal place and sutured (52).

I.3 Prevention of the peri-implantitis

I.3.1 Management of the peri-implant mucositis

Peri-implant mucositis forms part of the peri-implant diseases that jeopardize the peri-implant health. Characterized by an inflammation of peri-implant tissue, its development is still reversible. As mentioned earlier, it is assumed that peri-implant mucositis not properly treated may lead to peri-implantitis. That is to say, a resolution of the inflammation thanks to treatment, impedes a further severity stage as peri-implantitis with progressive bone loss.

With this knowledge, clinicians should emphasize the management of peri-implant mucositis as primary prevention of peri-implantitis. Preventive measures should be implemented at both patient and clinician's level. Costa et al. showed that from patients with existent peri-implant mucositis, 43.9% of them develop peri-implantitis in the absence of maintenance therapy (29). In the same way, Salvi et al. (53) affirmed the need of anti-infective preventive measures and reiterated the importance of treating

peri-implant mucositis to achieve long-term successful implants. The Jepsen et al. workshop (54) gave recommendations oral health care regarding patients and professionals to manage peri-implant mucositis:

- Mechanical plaque control, by means of either manual or electric toothbrushes, remains the most efficient preventive measure at patient's level.
- Oral hygiene instructions and mechanical debridement are compelling actions to reduce signs of inflammation at professional's level.
- Antiseptics, systemic antibiotics and other adjunctive controls did not prove their efficacy in the resolution of inflammation.

I.3.2 Control of the risk factors

As with any disease, the control of patient's risk factors is essential to prevent further complications. Elaborate a patient profile determined by its risk factors, such as host susceptibility, diabetes, smoking, bruxism, prosthetic design, habits, should be realized before any treatment with implants (55).

Medical history must be assessed before and after implant planning since any change in the patient's medical history may have consequences on the appearance or evolution of a peri-implant disease.

The interest of the oral health care professional in conducting a detailed pre-implant evaluation with each patient is to detect any risk factor in order to correct them before implant placement, since implants placement does not modify patient profile. To

determine the individual risk of implant failure, the patient's general pathology must be taken into account, and predisposing factors must be sought. After implant placement, patient’s risk factors, if exist, should be monitor during the maintenance therapy.

I.3.3 Peri-implantitis maintenance: patient and dentist perspectives

After implant placement, patients should integrate maintenance program to monitor the implant viability and its peri-implant structure. Studies gave different terms for this purpose: “peri-implant maintenance therapy” (PIMT) or “supportive periodontal therapy” (SPT). Analogy of periodontal diseases maintenance is made with the one for peri-implantitis, even though the latter presents larger lesions with an accelerated evolution than periodontitis.

Number of studies supports the importance of regular visits during PIMT/SPT (30,56–59). The right of information is fundamental, and it is recommended to inform the patient about possible appearance of biological complications and recall visits that he/she will have to follow as well. This should be specified in the informed consent that the patient will sign before implant surgery.

Regarding the frequency of intervals during PIMT, studies suggest at least two recall visits after implant placement (28,60). According to patient risk profile et his/her individual needs, dental visits can be spaced out every six months. It is clear that patients with high risk or with complex prosthetic rehabilitations (bridge on implants, implants-retained dentures or full arch rehabilitation with implants), intervals should be reduced at three to four months (61).

Each regular visit comprises complete clinical and radiographic examinations. Probing depth, bleeding on probing or suppuration, signs of inflammation should be evaluated. Moreover, new intraoral periapical X-rays are realized and compared to the previous one to see any progressive bone loss. Occlusion and mobility should be checked as well.

Furthermore, clinicians should have a proper prosthetic conception before implant therapy. The choice of implant type and its prosthetic reconstruction features should be sought as it may be a relative risk factor in the onset of peri-implant diseases. Indeed, surface implant type may induce the bacteria biofilm adhesion as high surface roughness. Oral biofilm seems to accumulate less in zirconia versus titanium implant type. Antibiotic coatings on surface implant are emerging and may decrease bacterial biofilm formation and accumulation (62).

Moreover, over-contoured reconstructions and submucosal margins restorations are critical in the development of peri-implantitis (60,63). Implant sites and prosthetic reconstructions must allow the patient to have a correct oral hygiene in implant area.

Maintenance therapy should take into consideration diverse factors at patient, clinical and implant levels. Personal plaque removal by means of toothbrushes and additional tools seems to preserve peri-implant health. Adjunctive antiseptics seem to have limited effect. Professional plaque removal is indispensable in the maintenance program. Recall visits should be respected and complications should be treated at early stages.

II. OBJECTIVES

GENERAL OBJECTIVE

The main objective of this sudy is to assess the surgical management of choice by evaluating clinical outcomes according to the approach.

SECONDARY OBJECTIVES

The secondary objectives of this research are:

- To highlight the different decision-trees available in respect to the diagnostic criteria
- To investigate the clinical and radiographical outcomes according to the surgical techniques
- To compare the surgical techniques facing peri-implantitis

III. MATERIALS AND METHODS

In order to carry out this study, several databases were investigated: PubMed, MEDLINE, Cochrane, Google Scholar.

The following keywords have been searched: “peri-implantitis” or “periimplantitis”, “peri-implant disease” together with “surgical therapy/treatment”, “management”, “regenerative procedure”, “resective approach”, “prevention”, “guidelines”, “protocols”.

Criteria of inclusion:

- English papers only
- Range of publication year between 2010 and 2020 for the selected articles in the Results section. To explain the basis of peri-implantitis in the Introduction part, this criterion was not applied.
- Meta-analysis, Randomized Controlled Trial, Review, Systematic review and case reports were included
- Keywords included either in the title or abstract
- Full texts available

Criteria for exclusion:

- Papers with other languages than English
- Publication year out of the range 2010-2020
- Full texts non available
- Titles or abstract not relevant

The selected articles were processed with the Mendeley bibliographic management software and organized in Vancouver style.

IV. RESULTS

IV.1 Decision-tree

In the past decades, several decision-tree have been proposed in order to manage the treatment plan of peri-implant diseases.

Lang et al. (64), in 2000, have introduced a therapeutic protocol which has been followed by many clinicians since this publication. Called CIST standing for Cumulative Interceptive Supportive Therapy, this therapy is based on diagnostic criteria for peri-implantitis. The frequency of maintenance visits is determined by the patient peri-implantitis type. Depending on the presence or absence of the clinical and radiological criteria below, the strategy is scalable.

The presence (+) or absence (-) of:

- Dental plaque (PII)
- Bleeding on probing (BOP)
- Suppuration
- Probing depth (PD) < 4 mm or > 5 mm around implants
- Bone loss visible on radiography

This therapeutic sequence consists of four interdependent steps. The anti-bacterial action is gradually adapted according to the severity and extent of the lesion. Depending on each clinical situation, one or a combination of modalities are suggested to apply (Figure 14). From this strategy procedure, surgical approach intervenes only when PD > 5 mm and a bone loss “+++”.

Clinical parameters					Maintenance classification	CIST
PII	BOP	Suppuration	PD mm	RX defect		
±	−	−	<4	−	0	(A)
+	+	−	<4	−	I	A
+	+	±	4–5	+	II	A+B
+	+	±	>5	++	III	A+B+C
+	+	±	>5	+++	IV	A+B+C+D
+	+	±	>5	++++	V	E

CIST modalities

A. Mechanical cleansing using rubber cups and polishing paste, acrylic scalers for chipping off calculus. Instruction for more effective oral hygiene practices.

B. Antiseptic therapy. Rinses with 0.1% to 0.2% chlorhexidine digluconate for 30 seconds using approximately 10 ml, for 3 to 4 weeks, supplemented by irrigating locally with chlorhexidine (preferably 0.2% to 0.5%) using a Luer syringe or local chlorhexidine gel application.

C. Antibiotic therapy
   1. Systemic ornidazole (2×500 mg/*die* or metronidazole (3×250 mg/*die* for 10 days or combination of metronidazole (500 mg/*die*) plus amoxicillin (375 mg/*die*) for 10 days.
   2. Local: application of antibiotics using controlled release devices for 10 days (25% tetracycline fibers).

D. Surgical approach
   1: Regenerative surgery using abundant saline rinses at the defect, barrier membranes, close flap adaptation and careful post-surgical monitoring for several months. Plaque control is to be assured by applying chlorhexidine gels.
   2. Resective surgery. Apical repositioning of the flap following osteoplasty around the defect.

E. Explantation using specially designed instruments.

Figure 14. CIST protocol (64)

Although this protocol is mainly followed, the diagnostic criteria taken into consideration did not include the new classification of peri-implantitis and did not distinguish the different defect morphologies or bone loss depths.

Few years later 2004, Lang et al. modified their previous CIST protocol (65). Within it, a bone loss threshold of 2 mm has been integrated (Figure 15). Surgical approach is considered with PD > 5 mm, BOP positive and bone loss > 2 mm. Nevertheless, nowadays, this updated CIST protocol can not be implemented facing peri-implantitis. The first three clinical and radiographical situations characterize a peri-implant mucositis. Moreover, as previously mentioned, peri-implantitis is defined PD ≥ 6 mm and bone loss ≥ 3 mm and presents different features and severity, that are not specified here.

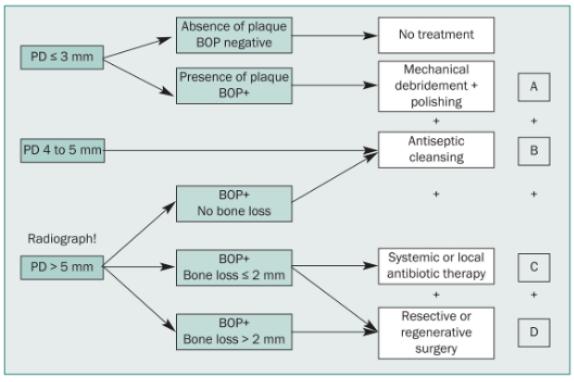

Figure 15. Updated CIST protocol (65)

Okayasu and Wang 2011 (66) illustrated the available choices in order to manage peri-implant diseases as a guide to help clinicians (Figure 16). Firstly, focused on mobility, it distinguished the extent of bone loss in two situations. If the bone loss > 50%, it is recommended to remove the implant. In the case of a bone loss ≤ 50%, the threshold between performing non-surgical or surgical approach is limited at 2 mm of bone loss. Surgical treatment is only implemented in implants showing a bone loss > 2 mm. However, the proposed decision-tree does not take into consideration other clinical parameters as probing depth, bleeding on probing or suppuration and does not distinguish the several stages of peri-implantitis.

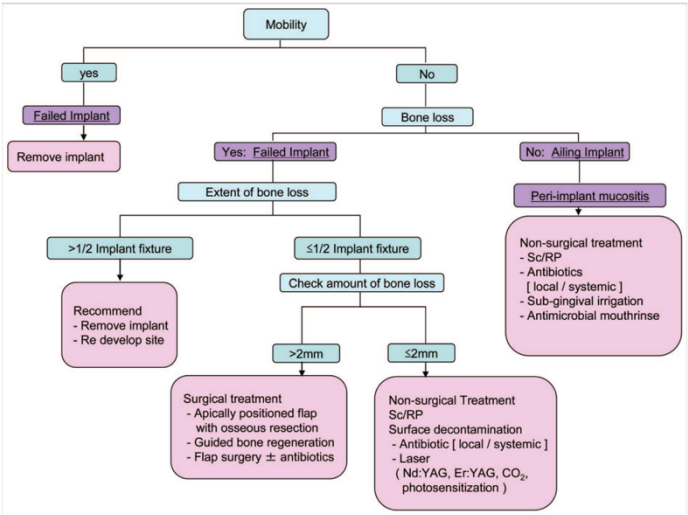

Figure 16. Decision-tree for peri-implant disease (66)

Padial-Molina et al. 2014 (67) exposed another flow chart in the management of peri-implant diseases (Figure 17). It considered different severities of probing depth, retentive bone loss and keratinized mucosa amount. With a PD of 6-7 mm, a surgical approach should be initiated with an open flap debridement and surface decontamination. A guided-bone regeneration may be indicated in case of retentive bone defects whereas resective surgery is performed in irregular bone architecture.

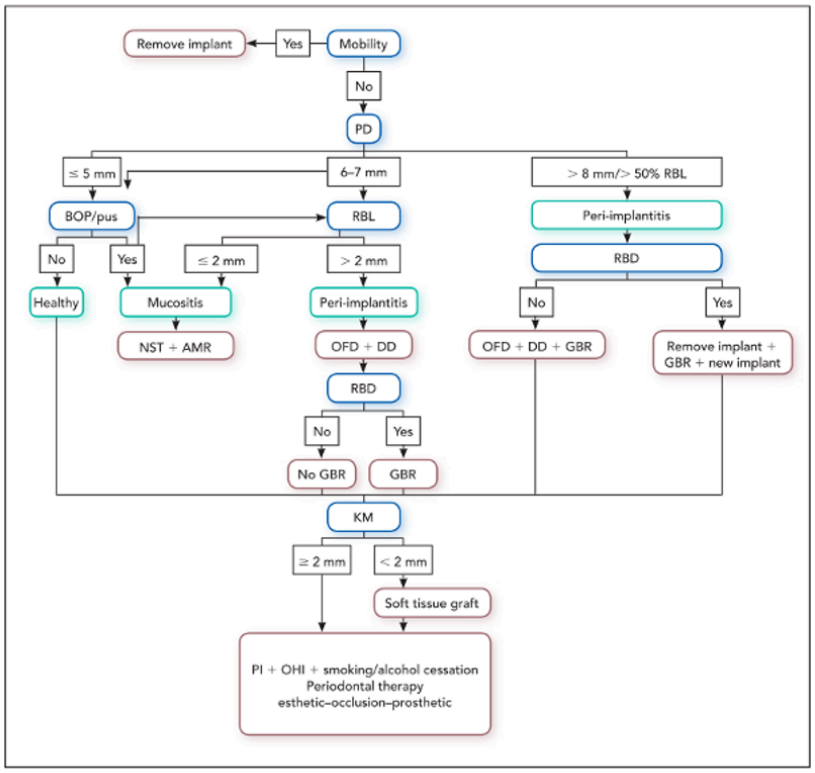

Figure 17. Guidelines to manage the treatment plan of peri-implantitis (67)

PD = probing depth; BOP = bleeding on probing; NST = nonsurgical therapy; AMR = antimicrobial mouthwashes; RBL = radiographic bone loss; OFD = open-flap debridement; DD = detoxification/ decontamination; RBD = retentive bone defect; GBR = guided bone regeneration; KM = keratinized mucosa; PI = Plaque Index; OHI = oral hygiene instructions.

Moreover, soft tissue graft should be realized with a quantity of keratinized mucosa < 2 mm. Severe peri-implantitis presenting a PD > 8 mm and a bone loss > 50%, with retentive bone loss or implant mobility, in those cases, it is recommended to proceed at the implant removal.

Ulterior studies suggest a pre-treatment phase that does not involve surgical treatment, only then if the infection could not be controlled, surgical strategies are considered (68,69). General recommendations englobe three different phases: pre-treatment,

surgical therapy if non-surgical treatment does not succeed and finally a post-operative phase with maintenance program (Figure 18).

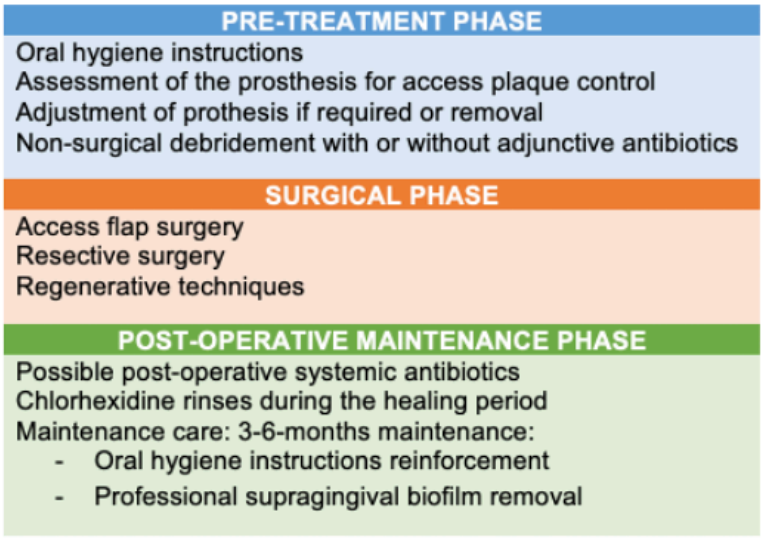

Figure 18. 3-phase general recommendations

IV.2 Clinical outcomes according to the surgical techniques

The results obtained thanks to the conducted bibliographic research, are summarized according to the year of publication, in the table below.

AUTHORS YEAR TYPE OF STUDY	SAMPLE	PROCEDURE	RESULTS
Schwarz et al. (2010) *Prospective study*	27 subjects 27 implants	Access flap Regeneration with NBM+CM	Reduced PD and CAL at 6 months post-surgery
Serino and Turri (2011) *Prospective study*	31 subjects 168 implants	Access flap Pocket elimination Bone-recontouring	- 77% subjects: PD < 6mm with no BOP/suppuration - 42% implants: persistent peri-implant diseases - 74% healthy- treated implants with 2–4mm bone loss *vs* 40% with bone loss ≥ 5mm - 39% implants with bone loss ≥ 7mm extracted

Froum et al. (2015) *Case series*	100 subjects 170 implants	Surface decontamination Regeneration: EMD, PDGF+ (ABB or MFDB) CM or SCTG	98.8% survival of implants 91% BOP reduced PD reduction: 5.10 mm Bone level gain: 1.77 mm Soft tissue gain: 0.52 mm
Hallström et al. (2017) *Randomized clinical trial*	39 subjects	Open flap debridement +/- adjunctive systemic antibiotics	No significant differences Effectiveness: 46.7% with surgery adjunctive with antibiotics *versus* 25%
Carcuac et al. (2017) *Randomized clinical trial*	100 subjects	Access flap surgery Bone-recontouring Systemic antibiotics and/or antiseptic agent for surface decontamination	PD reduction: 2.7 mm 40% BOP/suppuration reduction Steady marginal bone levels (bone loss 0.04 mm)
Sarmiento et al. (2018) *Case series*	32 subjects 45 implants	(1) Regenerative surgery (2) Resective surgery (3) Apically repositioned flap surgery	6-months follow-up, significant reductions: (1) PD: 7.2 *vs* 4.09 mm BOP: 100% *vs* 10.6% Independent on graft material (2) PD: 5.86 *vs* 3.63 mm BOP: 100% *vs* none (3) PD: 6.79 *vs* 4.32 mm BOP: 100% *vs* 14.3%
Berglundh et al. (2018) *Retrospective study*	50 subjects	Access flap surgery Resection if indicated	Notable reduction of PD and BOP and maintained bone levels
Renvert et al. (2018)	41 subjects	Surgical debridement +/- bone substitute (Endobon®)	At 1 year: Significant defect fill in treated implant with bone substitutes 47.6% (*vs* 35%) implants with no BOP and 42.9% (*vs* 5%) of implants success
Keeve et al. (2019) *Systematic review*	-	10 articles of non-augmentative surgical techniques	Reduction of inflammation in short-term Implantoplasty may improve clinical and radiographic parameters
Bianchini et al. (2019) *Retrospective study*	23 subjects 32 implants	Open flap access Resective surgery Implantoplasty	In 2 to 6-years follow-up: 83% (patients) and 87% (implants): disease resolution 87% stable bone level 89.3% no BOP 100% no suppuration

Parma-Benfenati et al. (2020) *Retrospective study*	45 subjects 57 implants	Open access flap + GBR	70.2% implants success PD reduction: 4.7 mm 62% BOP decrease 100% no suppuration Bone level increase: 5.9 mm
Aljohani et al. (2020) *Systematic review*	-	5 articles of surgical regenerative	Improved clinical parameters but no significative results
Aghazadeh et al. (2020) *Prospective study*	45 subjects 74 implants	Regeneration with autogenous or exogenous bone	4-wall defects demonstrated more defect fill Deeper defects resulted in more defect fill

Schwarz et al. (70) showed a reduced PD and clinical attachment loss (CAL) in classes Ib, Ic and Ie with moderate to advanced stages of peri-implantitis. Augmentative technique has been performed using an access flap surgery followed by a natural bone mineral combined with a collagen membrane. Significant reduction differences values were observed at 6 months, post-surgery: PD: 2.9, 1.4, 1.3 mm; and CAL: 2.5, 0.9, 0.9 mm, for classes Ie, Ib, Ic respectively. The defect Ie – circumferential intrabony – presented the most PD and CAL reduction after augmentative intervention.

Serino and Turri (71) evaluated the clinical outcomes of implants treated with an access flap surgery in combination with a resective surgery. The included implants with peri-implantitis presented at baseline: PD ≥ 6mm, BOP and/or suppuration and bone loss ≥ 2mm at mesial/distal part. After non-augmentative surgical treatment, 77% of the patients had PD < 6 mm without clinical signs of inflammation. 42% of the implants showed a persistent peri-implant disease. Interestingly, 74% of implants with 2–4 mm as bone loss baseline displayed peri-implant health. In contrast, only 40% of the

implants with a bone loss ≥ 5mm at baseline became healthy. 39% of the implants with bone loss ≥ 7mm were explanted.

Aghazadeh et al. (72) carried out a randomized clinical trial to assess peri-implantitis treated with regenerative procedure. Implants with PD ≥ 5 mm, with BOP/suppuration and angular bone defects ≥ 3 mm in depth are selected. Treatment implies a surgical debridement by access flap, regeneration with either autologous bone placement (AB) or bovine-derived xenograft (BDX), both recovered by a collagen membrane. Then, antibiotics post-surgery with azithromycin was prescribed. After one-year treatment, significant outcomes were collected in the BDX group with a reduced BOP, plaque index, suppuration and a gain bone level of 1.1 mm (versus 0.2 mm in AB group).

Esposito et al. (73) reported a Cochrane systematic review in which limited trials were observed regarding the surgical intervention studies. One study examined the use of Bio-Oss with resorbable membranes compared to nanocrystalline hydroxyapatite. The treated implants included peri-implant infraosseous defects > 3 mm. At 4-years follow-up, better improvements of PD and CAL have been reported in the case of regeneration using Bio-Oss and resorbable membrane: gain of 1.4 mm more than nanocrystalline hydroxyapatite.

Froum et al. (74) assessed a regenerative approach to treat peri-implantitis with long-term outcome. Before surgery, implants exhibited BOP, PD ≥ 6 mm, and bone loss ≥ 4 mm. Two groups were subdivided: (G1) major defect depth visible on radiographs; (G2) major buccal bone loss. The surgical approach exposed: access flap, surface

decontamination, enamel matrix derivative, combined with platelet-derived growth factor with bone substitutes, recovered by a collagen membrane or a connective tissue graft. At 3 to 7.5 years follow-up, reductions have been observed: PDs were 5.4 mm (G1) and 5.1 mm (G2) and bone level gains were 3.75 mm (G1) and 3 mm (G2). No bone loss has been recorded in this long-term study.

Heitz-Mayfiel et al. (75) evaluated the access flap surgery in combination with adjunctive systemic antibiotics of implants with moderate (2-4 mm bone loss) to advanced peri-implantitis (bone loss > 4 mm). Significant reductions in mean PD, BOP, suppuration, and a mean buccal gum recession of 1 mm, at 3 months after treatment. Those decreases were preserved at 6 months and one year follow-up. After one year, there was 100% survival of implants with PD < 5 mm, yet 47% presented no BOP or suppuration, besides 92% of implants exposed steady bone levels.

Faggion et al. (76) conducted a meta-analysis to compare the clinical outcomes between non-surgical and surgical approaches. Open access flap followed by augmentative technique with bone grafts and non-resorbable membranes generated a PD reduction of 3.52 mm, higher than non-surgical therapy. Surgical treatment with bone grafts and resorbable membranes obtained a CAL increase of 2.8 mm greater than non-surgical procedure.

Heitz-Mayfiel et al. (68) carried out a systematic review of non-surgical and surgical interventions. Although encouraging clinical outcomes, no specific recommendations have been drawn to treat peri-implantitis, due to limited evidence.

Schwarz et al. (77) achieved a combined therapy involving implantoplasty, regeneration and soft tissue volume augmentation of advanced peri-implantitis implants exposing a PD > 6 mm and an intrabony loss > 3 mm. At 6 months, this surgical procedure engendered significant reductions in BOP of 74.39%, PD of 2.53 mm, and CAL gain of 2.07 mm. Buccally, a mean mucosal height was slight and limited at 0.07 mm.

Chan et al. (78) analyzed outcomes from different surgical treatments. At baseline, PD extended from 4.8 to 8.8 mm and BOP values between 19.7% and 100%. All surgical procedures contributed to PD reductions: (1) access flap and debridement: 2.38 mm (37.9%); (2) resective surgery: 2.04 mm (33.4%); (3) bone grafts materials: 2.32 mm (37.1%); (4) GBR: 3.16 (48.2%). Surgeries involving bone grafts in combination with or without membranes showed a bone defect fill of 2.1.

Froum et al. (79) carried out the same surgical procedure previously realized in 2012. The included implants presented BOP, PDs ≥ 5 mm and bone loss ≥ 3 mm. From 2 to 10 years follow-up, there was 98.8% survival of treated implants. BOP was reduced in 91% of implants. Moreover, PD decreased by 5.10 mm, bone level increased by 1.77 mm, however a limited soft tissue increase of 0.52 mm was reported.

Hallström et al. (80) failed to demonstrate the impact of adjunctive antibiotics treatment combined with open flap debridement in implants with bone defect depth ≥ 3 mm, PD ≥ 5 mm and BOP or suppuration. No significant differences demonstrated reductions of PD, BOP, bone level and microbial charge. Nonetheless, one-year post-surgery,

effectiveness of 46.7% is showed with surgery adjunctive with antibiotics, compared to 25% by only an open flap debridement.

Carcuac et al. (81) assessed the possible improvements of diagnostic criteria treating advanced stages of peri-implantitis (PD ≥ 6 mm, BOP/suppuration and bone loss > 3 mm) with surgery approach implying resection, systemic antibiotics and/or local antiseptic agent to decontaminate the implant surface. After 3 years follow-up, improved PDs are underscored with a reduction of 2.7 mm, 40% BOP/suppuration reduction and steady marginal bone levels (bone loss of 0.04 mm). Limited impact of systemic antibiotics has been displayed.

Sarmiento et al. (4) investigated the effectiveness of three different surgical interventions: regeneration, resective surgery and apically positioned flap surgery, in implants with PD ≥ 5 mm and positive BOP with bone loss characterizing a severe stage of peri-implantitis. Interestingly, all three surgeries showed significant outcomes in respect to PD and BOP reductions, after 6-months follow-up. No bone levels records were reported.

Berglundh et al. (82) assessed the performance of an access flap surgery combined with bone-recontouring if needed, on severe peri-implantitis implants with PD ≥ 6 mm, positive BOP and/or suppuration and bone loss ≥ 3 mm. This surgical approach has proven to be effective by notable reduction of PD and BOP and maintained bone levels in the long-term follow-up.

Renvert et al. (83) studied the potential effect of the use of bone substitutes in following surgical debridement in three- and four-wall bone defects. Significant defect fill resolution was only observed in treated implant with bone substitutes, one-year post-therapy. The combined treatment reported 47.6% implants with no BOP and 42.9% of implants success compared to 35% and 5% in the group control respectively.

Keeve et al. (84) screened the effect of surgical treatment combined with implantoplasty. Its impact led to a reduction of inflammation in short-term. Implantoplasty may improve clinical and radiographic parameters.

Bianchini et al. (85) investigated a combined surgical therapy with resection and implantoplasty. In 2 to 6-years follow-up, 83% of patients and 87% of implants treated, did not present peri-implantitis. 87% of implants showed a stable bone level, 89.3% did not show a positive BOP and 100% were with no suppuration.

Parma-Benfenati et al. (86) achieved to highlight the benefice of using a guided bone regeneration facing moderate to advanced peri-implantitis. 70.2% of implants succeeded in long-term follow-up. PD reduction mean reached 4.7 mm, 62% of BOP decreased, 100% presented no suppuration and the mean bone level increased by 5.9 mm.

Aljohani et al. (87) failed to demonstrate significant effectiveness of regenerative treatments although this approach showed improvement of clinical parameters.

Aghazadeh et al. (88) reported the outcomes of surgical interventions using bone augmentation in implants with ≥ 2 bone wall defects. A correlation has been demonstrated between the defect depth and its defect fill. Moreover, significant defect fill is exposed in the configuration of 4-wall defects implants. Also, more the defect was deep, more defect fill was obtained.

V. DISCUSSION

V.1 Discussion of the results

In the present bibliographic research, selected studies, from 2010 to nowadays, expose various surgical interventions treating peri-implantitis. Non-augmentative and augmentative treatments are proposed. Clinical outcomes regarding the approach are reported and present variable results.

V.1.1 Non-augmentative approaches

Non-augmentative procedures involve access flap, resective surgery or bone-contouring or both. Their objective is to facilitate the removal of granulation tissue and bacterial biofilm by having an adequate access and leave a positive architecture of bone defect.

Results from studies performing an access flap surgery combined with bone-recontouring report an overall improvement of the clinical parameters of peri-implantitis. Indeed, this technique is effective in the majority of treated implants. Probing depth, bleeding on probing and suppuration values are reduced after treatment. Also, stable bone levels are preserved.

However, total establishment of peri-implant health may rely on the severity of the initial bone loss before treatment. The disease recovery usually occurs in the case of implants presenting slight bone loss < 5 mm. In contrast, incomplete resolution of the disease or persistent peri-implantitis likely appears in implants with moderate to

advanced bone loss ≥ 5mm. Implants that still show signs of peri-implantitis after therapy, tend to present disease progression.

Some studies, conducted with this type of surgery, reveal a reduced inflammation only in a limited short-term period. Others manage to obtain encouraging results in the long-term follow-up. In the latter, patients follow a maintenance therapy in which 4-months visits are implemented with oral hygiene and plaque control. As previously mentioned, peri-implantitis prevention with a supportive periodontal therapy is essential after placement. Therefore, this may explain the achievement of long-term results. It is necessary to remind that resective surgery should be performed in non-demanding esthetic areas due its gingival recession generated afterwards.

Certain research combines implantoplasty with access flap debridement, bone-contouring. Smoothening the implant surface by performing an implantoplasty after surface decontamination contribute to the upgrade of the clinical and radiographic criteria. Studies report an important rate of disease recovery and steady marginal bone level as well, after treatment including implantoplasty. Hence, it may have a positive impact to adjunct it in non-augmentative technique.

Regarding the anti-infective surgical treatment, the use of systemic antibiotics post-surgery is controversial. Two studies show its effectiveness and maintained results at 3 to 12 months. Whereas one study fails to prove the positive effect of adjunctive systemic antimicrobials in the surgical procedure.

V.1.2 Augmentative approaches

Augmentative technique includes access flap surgery and regenerative procedures with the use of bone substitutes with or without barrier membrane. Its main purpose is to have a proper debridement and surface decontamination then, fill the bone defects to enhance bone formation around affected implants.

Outcomes from studies evaluating regenerative treatment show a significant effect on the survival of the treated implants. Indeed, thirteen out of fourteen studies selected with regeneration, report improvements in clinical and radiographic signs of peri-implantitis. Probing depth, bleeding on probing and suppuration all show a decrease after regenerative treatment. It may be assumed that with regenerative procedure, 2 to 3 mm reduction of probing depth can be achieved. Significant bone level gain is observed as well. It appears to be effective in moderate to advanced stages of peri-implantitis, under maintenance therapy control. Besides the observed reductions of clinical parameters, one recent systematic review fail to expose significant results in each regenerative approach.

Furthermore, clinical outcomes may depend on the morphology bone defects. One study indicates that circumferential intrabony defect type displays the greatest reductions of probing depth and clinical attachment loss after regeneration using natural bone mineral and a collagen membrane. Moreover, another study demonstrates that 4-walls defects display the more defect fill compared to 2- and 3-walls defects. Also, defect depth allows more defect bone fill. Those facts may be explained by the presence of retentive walls that are more prone to keep bone

substitutes materials into the bone defect. However, bone defects offering a buccal dehiscence may be not favorable to operate with.

In two studies, where non-augmentative and augmentative techniques are assessed, regenerative treatment using grafts materials or guided-bone regeneration, show higher reduction of probing depth and higher radiographic bone fill.

Concerning the type of graft materials employed, there is no consensus report. In one study, bovine xenograft seems to provide higher bone defect fill radiographically, compared to autologous bone. Nonetheless, no evidence recommends the use of a specific regeneration materials, such as autogenous, xenogenic grafts or bone substitutes. The advantage of the use of barrier membranes is still not clear (52).

Interestingly, despite the lack of a large number of studies, one systematic review highlights the benefit of surgical regenerative therapy over non-surgical one. Comparing probing depth and clinical attachment loss, surgical regeneration achieves higher reduction than non-surgical treatment.

Finally, one case series combines regenerative technique with implantoplasty. Thanks to its promising results at short-term, this combination may be of interest in the cases of advanced peri-implantitis without jeopardizing the esthetic area of the implant site.

Both non-augmentative and augmentative technique show good clinical and radiographic outcomes for treating peri-implantitis.

V.2 Limitations

From the twenty-one selected articles, important limitations and future improvements have to be expressed regarding different aspects of the study designs.

Among the screened studies, there is no worldwide consensus for diagnostic criteria of peri-implantitis, applied by all clinicians. Defect morphology and the severity stages are frequently not specified. This prevents a correct application of the intervention on the specific type of peri-implantitis. Future studies should characterize the defect bone configuration and the severity staging. Inclusion and exclusion standards should be clearly notified. Also, observed outcomes have to be deducted in the same way.

Heterogeneity is also presented in the parameters assessing implant success after peri-implantitis surgical treatment. There are variable probing depths or bone losses to determine successful implants. Success parameters must be uniform and standardized to allow proper comparisons.

The absence of significant results by some studies, may be due to small size samples. Indeed, poor sample size can either hidden a true difference or not. In this way, large number of subjects and implants should be introduced to draw reliable conclusions.

Studies with high-power evidence should be conducted as randomized controlled trials. The design should include the different types of surgical treatments to be able to compare them at a clinical and radiographic levels. Patients should be followed in short and long-term in order to prove predictable results.

Any single protocol for surgical intervention is impossible to suggest due to the heterogeneity of studies. De facto, emphasis has to be made on long-term studies in order to confirm or not whether the surgical procedure given is relevant and reliable; and to establish protocols.

It is worth noting that it exists various implant surfaces, types and systems. Their micro or macrostructure might be associated with surgical outcomes. Any study in the present research takes into consideration this factor which may be important. No comparison of surgical outcomes according to the implant features is exposed. Further investigation should include this aspect to obtain a direct relation if it does exist, between surface/type/system implant and the surgery type.

Surprisingly, any reported study addresses outcomes at patient level. No symptomatology is indicated. Further studies should integrate patient-centered outcomes such as presence of soreness, discomfort or pain experienced during maintenance period after treatment.

Up to now, there is insufficient evidence for electing the most effective surgical procedure with the best clinical outcomes. However, it does not signify that the interventions mentioned in the results section are not relevant. They are effective, yet their predictability is still uncertain. Any surgical treatment can not be applied in a definitive way, only recommendations or suggestions may be issued.

VI. CONCLUSION

From this present research, various decision flow charts have been highlighted according to the diagnostic criteria of peri-implantitis. The bone loss extent threshold at 2 mm is a common feature to initiate surgical strategies. However, lack of distinction according to morphology bone defect and severity still remains. Nevertheless, global common recommendations among them are suggested by taking into consideration three stages. Pre-treatment phase includes non-surgical debridement to treat slight peri-implantitis. Initiation of surgical strategies should be performed when there is no resolution of in the previous phase and in the case of more severe stages of peri-implantitis i.e., moderate to advanced one. Final phase consists of maintenance protocol after surgical therapy in which six-month recall visits should be advocated. Surgical strategies facing peri-implantitis are distinguished by non-augmentative and augmentative procedures. Both display overall improvements of clinical and radiographic parameters.

There is insufficient evidence to identify and conclude which is the surgery of choice. However, according to the morphology of bone defect, one type may be recommended over another. Open flap debridement is the first common surgery step. Resective surgery addresses the defects affecting the supra-crestal bone parts, in none or minor esthetic aspects. Regenerative techniques using bone substitutes with or without barrier membranes, are more prone to correct infra-osseous circumferential defects and retentive defects such as 4-walls bone defects. Despite the lack of studies, implantoplasty might improve clinical outcomes in combined defects. Further randomized clinical trials with large number of patients are needed and will allow to compare different surgeries and to highlight statistically significant impact for each.

VII. SOCIAL RESPONSABILITY

The present bibliographic research englobes diverse levels of social responsibility. Implantology is challenging extended field that proposes the best option to rehabilitate dental loss. However, placing an implant still remains a costly treatment that not all patients can afford. That is why, establish a proper patient profile before implant therapy may prevent further complications. Correct diagnosis is primordial both at dental and economic levels. Expose the different surgical strategies to treat peri-implantitis allow the patients to choose among various options. The ultimate finality is to treat peri-implantitis with the hope to save the implants viability and its functions. In this way, patients would not have to afford a novel implant therapy prestation.

VIII. TABLE OF FIGURES

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X. ANNEXES

INVITED REVIEW ARTICLE

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Current trends in dental implants

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Abstract (J Korean Assoc Oral Maxillofac Surg 2014;40:50-60)

Tooth loss is very a very common problem; therefore, the use of dental implants is also a common practice. Although research on dental implant designs, materials and techniqaes has increased in the past few years and is expected to expand in the future, there is still a lot of work involved in the use of better biomaterials, implant design, surface modification and functionalization of surfaces to improve the long-term outcomes of the treatment. This paper provides a brief history and evolution of dental implants. It also describes the types of implants that have been developed, and the parameters that are presently used in the design of dental implants. Finally, it describes the trends that are employed to improve dental implant surfaces, and current technologies used for the analysis and design of the implants.

Key words: Dental implants, History, Design, Surfaces, Osseointegration

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I. Introduction

Tooth loss is very common and it can happen as a result of disease and trauma; therefore, the use of dental implants to provide support for replacement of missing teeth has a long and multifaceted history[1-5].

Statistics provided by the American Association of Oral and Maxillofacial Surgeons show that 69% of adults ages 35 to 44 have lost at least one permanent tooth to an accident, gum disease, a failed root canal or tooth decay. Furthermore, by age 74, 26% of adults have lost all of their permanent teeth[6]. Therefore, the use of dental implants reveals that about 100,000-300,000 dental implants are placed per year, which approximates the numbers of artificial hip and knee joints placed per year[7].

Research on dental implant designs, materials and techniques has increased in the past few years and is expected to expand in the future[1,4,8] due to the recent growth of the global market for dental implants and the rising in the demand for cosmetic dentistry.

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II. Dental Implant Evolution

The history of dental implants can be traced back to ancient Egypt, where carved seashells and/or stones were placed into human jaw bone to replace missing teeth. Other documented examples of early implants are those fabricated from noble metals and shaped to recreate natural roots[9].

Dental implants have a history of several centuries starting with the early civilizations more than 2,000 years ago in South and North America and regions of the Middle Asia and Mediterranean. Archeological findings have indicated that these civilizations replaced missing teeth using carved stone, shells, bones and gold[3,10].

Around 1930s, archaeological excavations in Honduras revealed that the Mayan civilization had the earliest known examples of dental implants, dating from about 600 AD, when a fragment of mandible with implants was found. The specimen had three pieces of shells carved into tooth shapes placed into the sockets of three missing lower incisor teeth. Later on, it was also observed that there was compact bone formation around two of the implants[4,11].

In the Middle Ages, dental implantation was performed by

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2017 WORLD WORKSHOP

WILEY Journal of Clinical Periodontology

Peri-implant diseases and conditions: Consensus report of workgroup 4 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions

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SUPPLEMENT ARTICLE

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Diagnosis and non-surgical treatment of peri-implant diseases and maintenance care of patients with dental implants – Consensus report of working group 3

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Abstract: The following consensus report is based on four background reviews. The frequency of maintenance visits is based on patient risk indicators, homecare compliance and prosthetic design. Generally, a 6-month visit interval or shorter is preferred. At these visits, peri-implant probing, assessment of bleeding on probing and, if warranted, a radiographic examination is performed. Diagnosis of peri-implant mucositis requires: (i) bleeding or suppuration on gentle probing with or without increased probing depth compared with previous examinations; and (ii) no bone loss beyond crestal bone level changes resulting from initial bone remodelling. Diagnosis of peri-implantitis requires: (i) bleeding and/or suppuration on gentle probing; (ii) an increased probing depth compared with previous examinations; and (iii) bone loss beyond crestal bone level changes resulting from initial bone remodelling. If diagnosis of disease is established, the inflammation should be resolved. Non-surgical therapy is always the first choice. Access and motivation for optimal oral hygiene are key. The patient should have a course of mechanical therapy and, if a smoker, be encouraged not to smoke. Non-surgical mechanical therapy and oral hygiene reinforcement are useful in treating peri-implant mucositis. Power-driven subgingival air-polishing devices, Er: YAG lasers, metal curettes or ultrasonic curettes with or without plastic sleeves can be used to treat peri-implantitis. Such treatment usually provides clinical improvements such as reduced bleeding tendency, and in some cases a pocket-depth reduction of ≤ 1 mm. In advanced cases, however, complete resolution of the disease is unlikely.

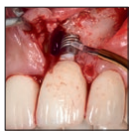
Key words: *Peri-implant diseases, peri-implantitis, peri-implant mucositis, non-surgical therapy, maintenance, supportive care*

INTRODUCTION

Dental implants have long been used to replace missing teeth. Initially, it was believed that the possible drawbacks of dental implant treatment were minimal if the implants were fully integrated into the bone. Over the years, however, it has become clear that biological complications frequently occur. Biological complications associated with dental implants are mostly infections induced by a bacterial biofilm, resulting in an inflammatory response in the soft tissues and bone surrounding implants. The inflammatory lesions located in the soft tissues have been referred to as peri-implant mucositis. If the inflammatory response progresses further and results in a loss of the bone beyond the initial bone remodelling, it is referred to as peri-implantitis[1,2].

The prevalence of peri-implant mucositis has, in a recent systematic review, been reported in the range of 19%–65% and the prevalence of peri-implantitis in the range of 1%–47%[3]. The wide range may be dependent on the different patient populations investigated in the studies included in the review, but it may also reflect differences in diagnostic criteria. In a paper using different levels of severity, a substantial variance in disease prevalence was highlighted[4]. The differences in criteria used to characterise peri-implant

Surgical Alternatives for Treating Peri-implantitis



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The objective of this case series was to describe surgical approaches that can be used to efficiently and effectively treat peri-implantitis as measured by positive changes in clinical parameters. A total of 32 patients with 45 implants were treated surgically to eliminate peri-implantitis. Baseline clinical parameters measured prior to surgery were compared to those made 6 months postsurgery to evaluate the efficacy of each procedure. Implants demonstrating signs of peri-implantitis were treated by one of three approaches: (1) *regenerative surgery,* (2) *osseous resective surgery, or* (3) *apically repositioned flap surgery. In all instances, the exposed implant surfaces were debrided and decontaminated. Relative to baseline values, regenerative surgery yielded statistically significant changes in probing depth (PD) (7.21 ± 0.27 mm to 4.09 ± 0.14 mm) and percentage of sites exhibiting bleeding on probing (BoP) (100.0% ± 0.0% to 10.6% ± 3.3%) as measured at the 6-month recall visit (P ≤ .05). The decrease in probing depth was not dependent on the type of graft material used (P ≤ .05). Resective surgery yielded statistically significant changes in PD (5.86 ± 0.23 mm to 3.63 ± 0.14 mm) and the percentage of sites exhibiting BoP (100.0% ± 0.0% to none) (P ≤ .05). Finally, the implants treated via apically repositioned flap surgery demonstrated statistically significant decreases (P ≤ .05) in both PD (6.79 ± 0.27 mm to 4.32 ± 0.16 mm) and BOP (100.0% ± 0.0% to 14.3% ± 6.7%) (P ≤ .05). Regenerative, resective, and apically positioned flap surgery can be utilized to successfully treat peri-implantitis.*
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Peri-implantitis is defined as an inflammatory process affecting the hard and soft tissues around an osseointegrated implant in function, resulting in radiographic evidence of progressive peri-implant bone loss and bleeding on probing (BoP).[1] It has been reported that up to 47% of implant failures result from inflammation-induced bone loss.[2] In a recent systematic review, Atieh et al[3] reported an estimated prevalence for peri-implantitis of 18.8% for patients and 9.6% for implants.[3] Although the prevalence rates vary between studies, there is no debate that peri-implantitis occurs with a clinically alarming frequency. Numerous factors contribute to the etiology of the condition, including residual subgingival cement, improper implant positioning, and absence of peri-implant attached gingiva.[4] In many patients, the accumulation of a bacterial biofilm is responsible for eliciting the inflammatory reaction that culminates in bone resorption. The microflora associated with biofilm-induced peri-implantitis contains many of the same anaerobic, Gram-negative bacterial species thought to be involved in the pathogenesis of periodontitis, although recent publications suggest that there may also be organisms unique to peri-implantitis lesions.[5,6] While the diagnosis is not indicative of implant

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2017 WORLD WORKSHOP

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A new classification scheme for periodontal and peri-implant diseases and conditions – Introduction and key changes from the 1999 classification

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The proceedings of the workshop were jointly and simultaneously published in the *Journal of Periodontology* and *Journal of Clinical Periodontology*.

Abstract

A classification scheme for periodontal and peri-implant diseases and conditions is necessary for clinicians to properly diagnose and treat patients as well as for scientists to investigate etiology, pathogenesis, natural history, and treatment of the diseases and conditions. This paper summarizes the proceedings of the World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions. The workshop was co-sponsored by the American Academy of Periodontology (AAP) and the European Federation of Periodontology (EFP) and included expert participants from all over the world. Planning for the conference, which was held in Chicago on November 9 to 11, 2017, began in early 2015.

An organizing committee from the AAP and EFP commissioned 19 review papers and four consensus reports covering relevant areas in periodontology and implant dentistry. The authors were charged with updating the 1999 classification of periodontal diseases and conditions[1] and developing a similar scheme for peri-implant diseases and conditions. Reviewers and workgroups were also asked to establish pertinent case definitions and to provide diagnostic criteria to aid clinicians in the use

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JOURNAL OF Periodontology

2017 WORLD WORKSHOP

Peri-implantitis

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The proceedings of the workshop were jointly and simultaneously published in the *Journal of Periodontology* and *Journal of Clinical Periodontology*.

Abstract

Objectives: This narrative review provides an evidence-based overview on peri-implantitis for the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions.

Methods: A literature review was conducted addressing the following topics: 1) definition of peri-implantitis; 2) conversion from peri-implant mucositis to peri-implantitis, 3) onset and pattern of disease progression, 4) characteristics of peri-implantitis, 5) risk factors/indicators for peri-implantitis, and 6) progressive crestal bone loss in the absence of soft tissue inflammation.

Conclusions:

1) Peri-implantitis is a pathological condition occurring in tissues around dental implants, characterized by inflammation in the peri-implant connective tissue and progressive loss of supporting bone.

2) The histopathologic and clinical conditions leading to the conversion from peri-implant mucositis to peri-implantitis are not completely understood.

3) The onset of peri-implantitis may occur early during follow-up and the disease progresses in a non-linear and accelerating pattern.

4a) Peri-implantitis sites exhibit clinical signs of inflammation and increased probing depths compared to baseline measurements.

4b) At the histologic level, compared to periodontitis sites, peri-implantitis sites often have larger inflammatory lesions.

4c) Surgical entry at peri-implantitis sites often reveals a circumferential pattern of bone loss.

5a) There is strong evidence that there is an increased risk of developing peri-implantitis in patients who have a history of chronic periodontitis, poor plaque control skills, and no regular maintenance care after implant therapy. Data identifying "smoking" and "diabetes" as potential risk factors/indicators for peri-implantitis are inconclusive.

CLINICAL ORAL IMPLANTS RESEARCH

The epidemiology of peri-implantitis

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Key words: epidemiology, peri-implantitis, prevalence, review, risk factors

Abstract

Aim: To review the literature on the prevalence and incidence of peri-implantitis.

Methods: Out of 322 potentially relevant publications we identified 29 articles concerning 23 studies, with information on the presence of signs of peri-implantitis in populations of at least 20 cases.

Results and conclusions: All studies provided data from convenience samples, typically from patients who were treated in a clinical center during a certain period, and most data were cross-sectional or collected retrospectively. Based on the reviewed papers one may state that the prevalence of peri-implantitis seems to be in the order of 10% implants and 20% patients during 5–10 years after implant placement but the individual reported figures are rather variable, not easily comparable and not suitable for meta-analysis. Factors that should be considered to affect prevalence figures are the disease definition, the differential diagnosis, the chosen thresholds for probing depths and bone loss, differences in treatment methods and aftercare of patients, and dissimilarities in the composition of study populations. Smoking and a history of periodontitis have been associated with a higher prevalence of peri-implantitis.

Missing teeth can be replaced successfully with reconstructions anchored on osseointegrated implants. Several narrative and systematic reviews are available reporting the survival of implants in relation to subject-specific factors such as tobacco smoking, systemic diseases, or periodontitis (Mombelli & Cionca 2006; Schou et al. 2006; Karoussis et al. 2007; Klokkevold & Han 2007; Quirynen et al. 2007; Ong et al. 2008; Bornstein et al. 2009; Heitz-Mayfield & Huynh-Ba 2009; Safii et al. 2010). The total literature available today suggests that over a period of 10 years roughly 1 of 20 implants is lost. A meta-analysis of five suitable studies (Hardt et al. 2002; Karoussis et al. 2003; Mengel & Flores-de-Jacoby 2005; Mengel et al. 2007; Gatti et al. 2008) revealed that the odds for implant survival were significantly higher in subjects without than with a history of periodontal disease (Safii et al. 2010). Greater than the risk for total implant failure are, however, the odds that a technical complication (Pjetursson et al. 2007) or an inflammatory condition of the peri-implant tissues may arise. The incidence of peri-implant diseases is currently a controversial issue. Conflicting statements have been made with regards to the magnitude and the long-term consequences of this problem. At least in part this may be due to different interpretations and definitions of disease states and differences in study populations.

What is peri-implantitis?

"Peri-implantitis" (or "Periimplantitis") has been introduced as a term for infectious pathological conditions of peri-implant tissues more than two decades ago (Levignac 1965; Mombelli et al. 1987). At the 1st European Workshop on Periodontology in 1993 it was agreed that this term should be used specifically for destructive inflammatory processes around osseointegrated implants in function that lead to peri-implant pocket formation and loss of supporting bone (Albrektsson & Isidor 1994). The definition implied that initial healing had been uneventful and osseointegration was achieved as anticipated. Hence, bone loss following implant installation due to remodeling had to be distinguished from bone loss due to a subsequent infection.

The typical signs and symptoms of peri-implant mucositis and peri-implantitis were discussed in the context of consensus conferences on several occasions and have been defined (Mombelli 1994, 1999; Lindhe et al. 2008; Zitzmann & Berglundh 2008; Lang

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Prevalence and Predictive Factors for Peri-Implant Disease and Implant Failure: A Cross-Sectional Analysis

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Background: Long-term studies worldwide indicate that peri-implant inflammation is a frequent finding and that the prevalence of peri-implantitis correlates with loading time. Implant loss, although less frequent, has serious oral health and economic consequences. An understanding of predictive factors for peri-implant disease and implant loss would help providers and patients make informed decisions.

Methods: A cross-sectional study was performed on 96 patients with 225 implants that were placed between 1998 and 2003. Implant placement data were collected from patient records, and patients presented for a clinical and radiographic follow-up examination. Implant status and periodontal status were determined, the data were analyzed to determine the prevalence of peri-implant disease or implant loss, and a predictive model was tested.

Results: The mean follow-up time for the patients was 10.9 years. The implant survival rate was 91.6%. Peri-implant mucositis was found in 33% of the implants and 48% of the patients, and peri-implantitis occurred in 16% of the implants and 26% of the patients. Individuals with peri-implantitis were twice as likely to report a problem with an implant as individuals with healthy implants. Peri-implantitis is associated with younger ages and diabetes at the time of placement and with periodontal status at the time of follow-up. Implant loss is associated with diabetes, immediate placement, and larger-diameter implants.

Conclusions: One in four patients and one in six implants have peri-implantitis after 11 years. The data suggest that periodontal and diabetes status of the patient may be useful for predicting implant outcomes. *J Periodontol 2015;86:337-347.*

KEY WORDS

Dental implants; diabetes mellitus; follow-up studies; peri-implantitis; periodontitis; risk factors.

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With >2 million dental implants placed annually in the United States,[1] characterization of long-term dental implant outcomes is essential. The long-term survival rate of dental implants was reported recently to be 97%,[2] and yet there is no clear predictive model for implant survival. In addition, survival rates do not take into account the presence of biologic complications, and, despite the remarkably high survival rate of dental implants, there are increasing numbers of patients presenting with peri-implant diseases.[3] Given the possible systemic ramifications of chronic inflammation, it is essential to better understand peri-implant disease prevalence and risk factors so that peri-implant inflammation can be prevented or treated. These peri-implant diseases may lead to discomfort, surgical and non-surgical treatment and their associated costs,[4] negative effects on systemic health, or eventual loss of the implant.[5] Determining the future burden of peri-implant diseases is necessary for patient consent, clinician decision-making, and allocation of resources.

Peri-implant diseases have been classified as either peri-implant mucositis or peri-implantitis, with both described as infectious diseases. Peri-implant mucositis has been defined as soft tissue inflammation around a functioning dental implant with bleeding on probing (BOP), and peri-implantitis is distinguished by accompanying loss of supporting marginal

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Peri-implant health and disease. A systematic review of current epidemiology

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Derks J, Tomasi C. Peri-implant health and disease. A systematic review of current epidemiology. J Clin Periodontol 2015; 42 (Suppl. 16): S158–S171. doi: 10.1111/jcpe.12334.

Abstract

Background: To develop preventive strategies addressing peri-implant diseases, a thorough understanding of the epidemiology is required.

Aim: The aim was to systematically assess the scientific literature in order to evaluate the prevalence, extent and severity of peri-implant diseases.

Material & Methods: Data were extracted from identified studies. Meta-analyses for prevalence of peri-implant mucositis and peri-implantitis were performed. The effect of function time and disease definition on the prevalence of peri-implantitis was evaluated by meta-regression analyses. Data on extent and severity of peri-implant diseases were estimated if not directly reported.

Results: Fifteen articles describing 11 studies were included. Case definitions for mucositis and peri-implantitis varied. The prevalence of peri-implant mucositis and peri-implantitis ranged from 19 to 65% and from 1 to 47%, respectively. Meta-analyses estimated weighted mean prevalences of peri-implant mucositis and peri-implantitis of 43% (CI: 32–54%) and 22% (CI: 14–30%), respectively. The meta-regression showed a positive relationship between prevalence of peri-implantitis and function time and a negative relationship between prevalence of peri-implantitis and threshold for bone loss. Extent and severity of peri-implant diseases were rarely reported.

Conclusion: Future studies on the epidemiology of peri-implant diseases should consider (i) applying consistent case definitions and (ii) assessing random patient samples of adequate size and function time.

Key words: Incidence; Peri-implant disease; Prevalence

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Peri-implant mucositis is defined as the presence of a plaque-related inflammatory soft tissue infiltrate without concurrent loss of peri-implant bone tissue, while peri-implantitis should demonstrate inflammation in combination with bone loss (Albrektsson & Isidor 1994, Zitzmann & Berglundh 2008).

Conflict of interest and source of funding statement

The authors declare no conflict of interest. The study was self-funded.

At the 7th EWOP, similarities and differences between periodontal and peri-implant diseases were addressed, focusing on host response and bacterial challenge characteristics (Lang & Berglundh 2011). The importance of prevention was highlighted, as mucositis was found to be potentially progressing into peri-implantitis if left untreated, but reversible if adequately treated.

At the 6th European Workshop on Periodontology (EWOP), issues related to peri-implant diseases were discussed. Mucositis was found to occur in more than 50% of all implant-carrying subjects, while peri-implantitis was found to affect between 28% and 56% of subjects (Lindhe & Meyle 2008). The observed variability for reported prevalence of peri-implant diseases between different studies may be explained, in part, by methodological issues, such as the heterogeneous use of case definitions (Tomasi & Derks 2012).

At the 8th EWOP, the occurrence of biological complications at dental implants was identified as a main outcome domain when evaluating the efficacy of implant therapy (Tonetti & Palmer 2012). To facilitate future

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Long-term implant prognosis in patients with and without a history of chronic periodontitis: a 10-year prospective cohort study of the ITI® Dental Implant System

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Key words: chronic periodontitis, peri-implantitis, success, survival, smoking

Abstract:
Aim: The aim of this 10-year study was to compare the failure, success and complication rates between patients having lost their teeth due to periodontitis or other reasons.
Material and methods: Fifty-three patients who received 112 hollow screw implants (HS) of the ITI® Dental Implant System were divided into two groups: group A – eight patients with 21 implants having lost their teeth due to chronic periodontitis; group B – forty five patients with 91 implants without a history of periodontitis. One and 10 years after surgical placement, clinical and radiographic parameters were assessed. The incidences of peri-implantitis were noticed over the 10 years of regular supportive periodontal therapy.
Results: Success criteria at 10 years were set at: pocket probing depth (PPD) $\leq$ 5 mm, bleeding on probing (BoP−, bone loss < 0.2 mm annually. The survival rate for the group with a past history of chronic periodontitis (group A) was 90.5%, while for the group with no past history of periodontitis (group B) it was 96.5%. Group A had a significantly higher incidence of peri-implantitis than group B (28.6% vs. 5.8%). With the success criteria set, 52.4% in group A and 79.1% of the implants in group B were successful. With a threshold set at PPD $\leq$ 6 mm, BoP− and bone loss < 0.2 mm annually, the success rates were elevated to 62% and 81.3% for groups A and B, respectively. Relying purely on clinical parameters of PPD $\leq$ 5 mm and BoP−, the success rates were at 71.4% and 94.5%, and with a threshold set at PPD $\leq$ 6 mm and BoP−, these proportions were elevated to 81% and 96.7% for groups A and B, respectively.
Conclusions: Patients with implants replacing teeth lost due to chronic periodontitis demonstrated lower survival rates and more biological complications than patients with implants replacing teeth lost due to reasons other than periodontitis during a 10-year maintenance period. Furthermore, setting of thresholds for success criteria is crucial to the reporting of success rates.

Osseointegrated titanium oral implants were first used to serve as anchors for prosthetic reconstructions in fully edentulous patients to increase their subjective chewing comfort (Adell et al. 1981; Babbush et al. 1986; Mericske-Stern et al. 1994). Later on, implants were widely used for the replacement of missing teeth in partially edentulous patients. Thus, the scope of indications was expanded to avoid the preparation of intact or previously successfully crowned neighboring teeth (Priest 1999). Furthermore, the replacement of one or several strategically important, but missing tooth abutments help facilitate the restoration of short or

CLINICAL ORAL IMPLANTS RESEARCH

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Ten-year results of a three arms prospective cohort study on implants in periodontally compromised patients. Part 2: clinical results

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Key words: biological complications, CIST, dental implants, implant failure, peri-implantitis, periodontally compromised patients, periodontitis, supportive periodontal therapy, survival, tooth loss

Abstract

Objectives: The aim of this study was to compare long-term outcomes of implants placed both in patients treated for periodontitis and in periodontally healthy patients (PHP).

Material and methods: One hundred and twelve partially edentulous patients were consecutively enrolled in private specialist practice and divided into three groups according to their initial periodontal condition: PHP, moderately periodontally compromised patients (PCP) and severely PCP. Implants were placed to support fixed prostheses, after successful completion of initial periodontal therapy [full-mouth plaque score (FMPS) <25%, full-mouth bleeding score (FMBS) <25%]. At the end of active periodontal treatment (APT), patients were asked to follow an individualized supportive periodontal therapy (SPT) program. Diagnosis and treatment of peri-implant biological complications was performed according to cumulative interceptive supportive therapy. At 10 years, clinical measures were recorded by two calibrated operators, blinded to the initial patient classification, on 101 patients, as 11 were lost to follow-up. The number of sites treated according to therapy modalities C and D (antibiotics and/or surgery) during the 10 years was registered.

Results: Eighteen implants were removed for biological complications. Antibiotic and/or surgical therapy was performed in 10.7% of cases in PHP, in 27% of cases in moderate PCP and in 47.2% cases in severe PCP, with a statistically significant differences between PHP and severe PCP ($P = 0.002$). At the final examination, the percentage of implants, with at least one site which presented a PD $\geq$6 mm, was respectively 1.7% for PHP, 15.9% for moderate PCP and 27.2% for severe PCP, with a statistically significant difference between PHP and moderate PCP ($P = 0.005$) and PHP and severe PCP ($P = 0.0001$).

Conclusion: Patients with a history of periodontitis presented a statistically significant higher number of sites which required additional treatment. Therefore, patients with a history of periodontitis should be informed that they are more at risk for peri-implant disease. This underlines the value of the SPT in enhancing long-term outcomes of implant therapy, particularly in subjects affected by periodontitis. Therefore, the approach for multiple preventive dental extractions and implant placement, based on the assumption the implants perform better than teeth, should be followed with extreme caution.

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During the last decades, the use of dental implants for replacement of missing teeth has become a routine procedure also in the rehabilitation of the periodontally compromised patients (PCP), even though biological complications are underreported (Berglundh et al. 2002) as the prognosis of implant treatment is often reported as survival rates. In a previous publication on the material included in this article, solid screws 10-year survival rate varied from 98% in periodontally healthy subjects (PHP) to 90% in severe PCP (Roccuzzo et al. 2010). Moreover, the lack of adhesion to supporting periodontal therapy (SPT) was associated with a higher incidence of bone loss and implant loss. These results are in concordance with other recent long-term studies (Tomasi et al. 2008; De Boever et al. 2009; Matarasso et al. 2010; Schmidlin et al. 2010). Nevertheless, to better describe

CLINICAL ORAL IMPLANTS RESEARCH

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Risk indicators for Peri-implantitis. A cross-sectional study with 916 implants

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Key words: clinical assessment, clinical research, clinical trials, diagnosis, epidemiology

Abstract

Objectives: The aim of this study was to identify systemic and local risk indicators associated with peri-implantitis.

Material and methods: One hundred eighty-three patients treated with 916 osseointegrated titanium implants, in function for at least 1 year, were included in the present study. The implants were installed at the Foundation for Scientific and Technological Development of Dentistry (FUNDECTO) - University of Sao Paulo (USP) - from 1998 to 2012. Factors related to patient's systemic conditions (heart disorders, hypertension, smoking habits, alcoholism, liver disorders, hepatitis, gastrointestinal disease, diabetes mellitus I and II, hyperthyroidism or hypothyroidism, radiation therapy, chemotherapy, menopause, osteoporosis, active periodontal disease, history of periodontal disease and bruxism), implant's characteristics (location, diameter, length, connection, shape, and antagonist), and clinical parameters (wear facets, periodontal status on the adjacent tooth, plaque accumulation on the adjacent tooth, modified plaque index, sulcus bleeding index, probing depth, bleeding on probing, width of keratinized tissue and marginal recession).

Results: An increased risk of 2.2 times for history of periodontal disease (PD), 3.6 times for cemented restorations compared to screw-retained prostheses, 2.4 times when wear facets were displayed on the prosthetic crown and 16.1 times for total rehabilitations when compared to single rehabilitations were found. Logistic regression analysis did not show any association between the implant's characteristics and peri-implantitis.

Conclusions: A history of periodontal disease, cemented prostheses, presences of wear facets on the prosthetic crown and full mouth rehabilitations were identified as risk indicators for peri-implantitis. Implants' characteristics were not related to the presence of peri-implantitis.

The word peri-implantitis is used to describe destructive infectious pathologies in the soft tissues around dental implants resulting in bone loss (Lindhe & Meyle 2008). Bone remodeling after implant placement should be distinguished from bone loss due to subsequent infection. The presence of bacteria at the implant-abutment interface and its proximity to the bone may result in bone loss (Berglundh et al. 1991; Quirynen & van Steenberghe 1993; Jansen et al. 1997). The microbiota adhering to the implant surface results in an inflammatory response. The marginal bone is affected, which may be due to the absence of a periodontal ligament and a reduced number of fibroblasts and blood vessels (Zeza & Pilloni 2012; Wilson 2013).

Current guidelines for the diagnosis of peri-implantitis were determined in the seventh (Lang & Berglundh 2011) and eighth (Sanz & Chapple 2012) European Workshop on Periodontology. Peri-implantitis is characterized by increased depth of the peri-implant sulcus >4 mm; bleeding and/or suppuration on probing and marginal bone loss ≥2 mm, very often detected accidentally in radiographs during professional maintenance care, since pain does not seem to be a common phenomenon (Mombelli 1999; Lindhe et al. 2008; Lang & Berglundh 2011). If the apical osseointegration is maintained, the disease can progress without any notable signs of implant mobility (Mombelli & Lang 1998).

It is assumed that risk indicators associated with periodontal disease actively contribute to peri-implantitis, thus patients with increased susceptibility to periodontal disease, poor oral hygiene and smoking habits

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History of Chronic Periodontitis Is a High Risk Indicator for Peri-Implant Disease

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The success rates in implant dentistry vary significantly among patients presenting previous history of periodontitis. The aim of this study was to evaluate if patients with history of chronic periodontitis (CP) are more susceptible to peri-implant disease (PID) than those without history of CP. Two hundred and fifteen individuals, under periodontal maintenance, presenting 754 osseointegrated implants, were selected for this study. The patients were divided into two groups according to the peri-implant status: Control group (patients without PID; n=129) and PID group (patients with PID; n=86). All peri-implant regions were clinically evaluated, including analyses of mucosa inflammation, edema and implant mobility. Periapical radiography assessed the presence of peri-implant bone loss. According to the clinical/radiographic characteristics, patients in Control and PID groups were diagnosed as having CP or not. Nominal variables were evaluated by the chi-square test. The distribution of numeric variables was analyzed by Shapiro-Wilk test. Student's t-test and Mann-Whitney test were used to analyze significant differences for parametric and non-parametric data. A p-value <0.05 was considered significant. There was a highly significant correlation between CP history and PID (p<0.0001). Patients with CP had 4 times more chance of developing PID than patients with healthy periodontal tissues. Also, CP patients showed higher bleeding on probing (p=0.002) and bone loss around implant (p=0.004) when compared with patients without CP. In conclusion, history of CP is a high risk factor for the development of PID, irrespective of gender or region of implant placement.

Key Words: chronic periodontitis, diagnosis, mucositis, peri-implantitis.

Introduction

In 2008, the Sixth European Workshop on Periodontology (1) presented a series of risk indicators for implant survival, such as lack of oral hygiene, diabetes, smoking and history of periodontitis, which were related to the development of peri-implant disease (PID). The previous history of periodontitis has shown to influence the success rate in Implant Dentistry (2). Patients without history of periodontitis present an average of 96.5% of implant survival in comparison with 90.5% of survival in individuals with history of periodontitis (3). Curiously, periodontal disease is the main cause of dental loss in approximately 60% of the Brazilian population aged between 35 and 44 years needing oral rehabilitation (4).

The human oral cavity is colonized by at least 600 different bacterial species, which are most innocuous. From these, at least, 400 species are found in the subgingival region (5) and, therefore, the periodontal pockets act as a reservoir for periodontal pathogens (6).

The transmission of periodontal pathogens from residual dentition to the implant has been reported. In patients with a high number of periodontal pathogens there is an increased risk of cross infection between periodontal and peri-implant sites (7). Several studies (8,9) have shown that the periodontal pathogens *Actinobacillus actinomycetemcomitans (Aa), Porphyromonas gingivalis (Pg), Prevotella intermedia (Pi), Prevotella nigrescens, Bacteroides forsythus and Treponema denticola (Td)* can be found in the areas of the PID.

One month after reopening surgery to expose the implants, periodontal pathogens can be detected around implant surface and, in the same individual, the same bacteria found in the residual periodontal pocket are found in the peri-implant sulcus (7). However, not only the presence of these pathogens is capable of causing disease. The local immune response, determined by the interaction among molecules and cells, can promote greater protection or susceptibility to several inflammatory and infectious diseases, including PID.

In periodontitis, the local inflammatory reaction to bacterial infection activates the innate immune system, resulting in the release of an array of cytokines and other mediators and propagation of inflammation through the gingival tissues (10,11). The failure to encapsulate this "inflammation front" within gingival tissue results in the expansion of the response to adjacent alveolar bone (10). Moreover, the host response is influenced by several possible risk factors including genetic factors. Previous studies indicated that chronic periodontitis (CP) may have a genetic background (12,13), as well as PID (14,15).

Patients who receive implants and have history of previous periodontitis have previously shown tissue-

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Effectiveness of Implant Therapy Analyzed in a Swedish Population: Prevalence of Peri-implantitis

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Abstract

Peri-implantitis is an inflammatory disease affecting soft and hard tissues surrounding dental implants. As the global number of individuals that undergo restorative therapy through dental implants increases, peri-implantitis is considered as a major and growing problem in dentistry. A randomly selected sample of 588 patients who all had received implant-supported therapy 9 y earlier was clinically and radiographically examined. Prevalence of peri-implantitis was assessed and risk indicators were identified by multilevel regression analysis. Forty-five percent of all patients presented with peri-implantitis (bleeding on probing/suppuration and bone loss >0.5 mm). Moderate/severe peri-implantitis (bleeding on probing/suppuration and bone loss >2 mm) was diagnosed in 14.5%. Patients with periodontitis and with ≥4 implants, as well as implants of certain brands and prosthetic therapy delivered by general practitioners, exhibited higher odds ratios for moderate/severe peri-implantitis. Similarly, higher odds ratios were identified for implants installed in the mandible and with crown restoration margins positioned ≤1.5 mm from the crestal bone at baseline. It is suggested that peri-implantitis is a common condition and that several patient- and implant-related factors influence the risk for moderate/severe peri-implantitis (ClinicalTrials.gov NCT01825772).

Keywords: endosseous dental implantation, implant-supported dental prosthesis, adverse effects, multivariate analysis, biological complication, treatment outcome

Introduction

Peri-implantitis is a pathologic condition occurring in patients with dental implants and is characterized by inflammation in peri-implant tissues and loss of supporting bone (Lindhe and Meyle 2008; Lang and Berglundh 2011). Untreated disease leads to loss of implants. Peri-implantitis lesions are considerably larger and present with more aggressive features than lesions in periodontitis around teeth (Carcuac and Berglundh 2014). Treatment of the condition can be inconvenient and uncomfortable for the patient and is demanding in terms of resources and economy. Thus, as the global number of individuals that undergo restorative therapy through dental implants increases, peri-implantitis is considered to be a major and growing problem in dentistry.

Previous reports on the prevalence of peri-implantitis are associated with several inadequacies. Tomasi and Derks (2012) reported in a review that many studies provided only implant-based data without considering the number of affected patients. In addition, analyses were performed on so-called convenience samples of limited size, and such patient groups may not be representative of the target population (Sanz and Chapple 2012). Reviews in the field have recognized 7 case definitions for peri-implantitis based on the amount of bone loss occurring over time (Mombelli et al. 2012; Tomasi and Derks 2012; Derks and Tomasi 2015). The inconsistencies in case definitions in the literature also reflected the large variation in disease prevalence. Derks and Tomasi (2015) reported in a systematic review a weighted mean prevalence of peri-implantitis of 22% (95% confidence interval, 14% to 30%) with a positive relationship between prevalence and time in function of the implants.

Recommendations for research on the occurrence of peri-implantitis have underlined the importance of randomly selected patient samples of sufficient size and adequate assessments of crestal bone changes in radiographs (Sanz and Chapple 2012; Jepsen et al. 2015). As the adult population in Sweden is provided with federal financial support for dental care that includes implant-supported restorative therapy, the register administered by the Swedish Social Insurance Agency (Försäkringskassan) provides access to data on patients representing effectiveness in implant dentistry (Derks, Håkansson, Wennström, Tomasi, et al. 2015). Hence, in this study, we

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Relationship between smoking and dental status in 35-, 50-, 65-, and 75-year-old individuals

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Axelsson P, Paulander J, Lindhe J: Relationship between smoking and dental status in 35-, 50-, 65-, and 75-year-old individuals. J Clin Periodontol 1998; 25: 297–305.

Abstract. The aim of the present study was to examine the dental status and smoking habits in randomized samples of 35-, 50-, 65-, and 75-year-old subjects (n=1093), recruited for a cross-sectional epidemiological study in the County of Värmland, Sweden. The following clinical variables were recorded by 4 well-calibrated dentists: number of edentuolous subjects, number of missing teeth, probing attachment level, furcation involvement, CPITN scores, DMF surfaces, plaque and stimulated salivary secretion rate (SSSR). In addition, the subjects reported in a questionnaire their tobacco habits, oral hygiene habits, dietary habits etc. The percentage of smokers in 35-, 50-, 65-, and 75-year-olds was 35%, 35%, 24% and 12%, respectively. In 75-year-olds, 41% of the smokers were edentulous compared to 35% of non-smokers. The difference in number of missing teeth between smokers and non-smokers was 0.6 (p=0.15), 1.5 (p=0.013), 3.5 (p=0.0007) and 5.8 (p=0.005) in the 4 age groups. Smokers had the largest mean probing attachment loss in all age groups. The differences between smokers and non-smokers in mean attachment level were 0.37 (p=0.001), 0.88 (p=0.001), 0.85 (p=0.001) and 1.33 mm (p=0.002) in the 35-, 50-, 65-, and 75-year-olds, respectively. Treatment need assessed by CPITN was in all age groups greatest among smokers. The number of intact tooth surfaces was fewer in 35-, 50-, and 75-year-old smokers than in non-smokers. The number of missing surfaces (MS) was higher in 50-, 65-, and 75-year-old smokers than in non-smokers. In addition, 35-year-old smokers exhibited a significantly larger number of decayed and filled tooth surfaces (DFS) than non-smokers. Male smokers had significantly higher SSSR than non-smoking males (p=0.012). Plaque index and oral hygiene were similar in smokers and non-smokers. Smokers reported a more frequent intake of sugar containing soft drinks (p=0.000) and snacks (p=0.003) than non-smokers. The opposite was reported for consumption of fruit (p=0.003). It was concluded that smoking is a significant risk indicator for tooth loss, probing attachment loss and dental caries.

Key words: analytic epidemiology; smoking; tooth loss; attachment loss; CPITN; caries prevalence; plaque; salivary secretion rate; oral hygiene habits; dietary habits

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The main objective of epidemiological surveys of a cross section design is to provide important information about the distribution of e.g. oral diseases in a population, but the data generated can also be used to assess the relative importance of indicators for a given disease or group of diseases (Beck et al. 1990, Hansen et al. 1990, Horning et al. 1992, Grossi et al. 1994, Beck 1994, Wolff et al. 1994, Wiktorsson 1995).

Findings from a number of cross-sectional studies have indicated that smokers have more missing teeth and more advanced periodontal disease than non-smokers (Table 1). Most of the studies referred to were carried out in selected groups of adults stratified into age intervals. Such a selection may result in a scewed distribution of individuals recruited to the study, and this may influence the interpretation of the data obtained. To our knowledge, no study has been published in which the effect of smoking on both caries and periodontal diseases was evaluated in a randomized sample of adults belonging to well defined age groups (indicator age groups).

The aim of the present study was to assess the prevalence and severity of periodontal disease and dental caries in smokers and non-smokers in a randomized sample of 35-, 50-, 65-, and 75-year-old subjects.

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Review

Smoking and dental implants: A systematic review and meta-analysis

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ABSTRACT

Objective: Recent studies implicate smoking as a significant factor in the failure of dental implants. This review aims to test the null hypothesis of no difference in the implant failure rates, risk of postoperative infection, and marginal bone loss for smokers versus non-smokers, against the alternative hypothesis of a difference.
Data: Main search terms used in combination: dental implant, oral implant, smoking, tobacco, nicotine, smoker, and non-smoker.
Sources: An electronic search was undertaken in September/2014 in PubMed/Medline, Web of Science, Cochrane Oral Health Group Trials Register plus hand-searching.
Study selection: Eligibility criteria included clinical human studies, either randomized or not. The search strategy resulted in 1432 publications, of which 107 were eligible, with 19,836 implants placed in smokers, with 1259 failures (6.35%), and 60,464 implants placed in non-smokers, with 1923 failures (3.18%).
Conclusions: The insertion of implants in smokers significantly affected the failure rates, the risk of postoperative infections as well as the marginal bone loss. The results should be interpreted with caution due to the presence of uncontrolled confounding factors in the included studies.
Clinical significance: Smoking is a factor that has the potential to negatively affect healing and the outcome of implant treatment. It is important to perform an updated periodic review to synthesize the clinical research evidence relevant to the matter.

1. Introduction

Nicotine is the most important constituent among more than 4000 potentially toxic substances in tobacco products. It is the main chemical component responsible for tobacco addiction, appears to mediate the haemodynamic effects of smoking, and has been implicated in the pathogenesis of numerous diseases.[1] Studies have also demonstrated the detrimental effects of smoking on oral health. A clinical study[2] observed that smokers had a higher prevalence of moderate and severe periodontitis and higher prevalence and extent of attachment loss and gingival recession than non-smokers, suggesting poorer periodontal health in smokers. In addition, smokers had a higher number of missing teeth than non-smokers. Concerning the bone-implant interface, the deleterious effects

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CLINICAL ORAL IMPLANTS RESEARCH

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Prevalence of periimplant disease in partially edentulous patients: a practice-based cross-sectional study

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Key words: cross-sectional study, implant, periimplant disease, periimplant mucositis, prevalence

Abstract

Objectives: Evaluation of the prevalence rates of periimplant mucositis and periimplantitis in partially edentulous patients in a private dental practice.

Material and methods: The data of 89 patients were collected (52 female, 37 male, age at time of implant placement: 51.8 ± 10.3 years). All patients had been treated with dental implants of the same type and fixed superstructures between January 1999 and June 2006 (observational period: 68.2 ± 24.8 months).

Results: The patient-related prevalence rate of periimplant mucositis (probing depth ≥ 4 mm and bleeding on probing [BOP]) was over all 44.9%. The respective rates in non-smokers without periodontal history were 30.4% and in smokers with periodontal history 80%. The multiple logistic regression analysis identified a significant association of mucositis with the independent variable "smoker" (odds ratio [OR] 3.77; $P = 0.023$). The patient-related prevalence rate of periimplantitis (probing depth ≥ 5 mm, BOP/pus, radiographic bone loss) was 11.2% (smokers with periodontal history: 53.3%, non-smokers: 2.8%). No periimplant disease was diagnosed in non-smoking patients without periodontal history and with a good compliance after treatment. Statistical analysis identified a significant association of periimplantitis with "smoker" (OR: 31.58; $P < 0.001$) and "compliance" (OR: 0.09; $P = 0.011$). Periodontal history in general showed no significant association with periimplantitis.

Conclusions: Smoking and compliance are important risk factors for periimplant inflammations in partially edentulous patients.

Comprehensive data on survival or success of endosseous implants are documented in numerous clinical studies. In the beginning, the studies were focused on successfully osseointegrated implants in different ranges of indication and bone qualities as well as on the influence of various implant designs (Gernhardt & Ulbrich 2000). Subsequent studies evaluated implant failures during the prosthetic period in function more explicitly. Besides technical complications, biological failures were a failure risk for implant restorations during function (Norowski & Bumgardner 2009). In most cases, progressive periimplant inflammation was the reason for biologically induced failures in an advanced state. They destroyed the periimplant hard tissue and finally led to implant loss (Lang et al. 2000).

To some extent, periimplant diseases require comprehensive intervention to save the implant. Moreover, at the moment not all available therapies are based on firm scientific ground. Regeneration of periimplant tissue that was lost due to inflammation is not a predictable outcome. Therefore, patients, cost bearers, and dental professionals should be interested in an efficient prevention of periimplant diseases. To evaluate the potential effect of periimplant infections on the long-term success of implant therapy, precise information on the incidence of these diseases is required. In a structured review, Zitzmann and Berglundh (2008) noticed that only limited data are available on the frequency of periimplant diseases. The authors evaluated cross-sectional and longitudinal studies covering more than 50 implants with an observational period of at least 5 years each. Frequency of periimplant mucositis ranged between 24% and 91%. Only three publications determined the frequency of periimplantitis, five publications analyzed the data (Karoussis et al. 2004; Brägger et al. 2005; Fransson et al. 2005, 2008; Roos-Jansaker et al. 2006a, 2006b, 2006c). After a period in function of 9–11 years, between 28% and 56% of the patients were diagnosed with periimplantitis.

Several authors presumed that the published frequencies of periimplant diseases rather under-

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Nine- to fourteen-year follow-up of implant treatment. Part III: factors associated with peri-implant lesions

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Roos-Jansåker A-M, Renvert H, Lindahl Ch, Renvert S. Nine- to fourteen-year follow-up of implant treatment. Part III: factors associated with peri-implant lesions. J Clin Periodontol 2006; 33: 296–301. doi: 10.1111/j.1600-051X.2006.00908.x. © Blackwell Munksgaard, 2006.

Abstract

Objective: The aim of the present paper was to analyse, on patient and implant basis, factors related to peri-implant lesions.

Material and Methods: Two hundred and eighteen patients treated with titanium implants were examined for biological complications at existing implants 9–14 years after initial therapy. The effects of several potentially explanatory variables, both on patient and on implant levels, were analysed.

Results: On the implant level, the presence of keratinized mucosa ($p = 0.02$) and plaque ($p = 0.005$) was associated with mucositis (probing depth $\geqslant 4$ mm+bleeding on probing). The bone level at implants was associated with the presence of keratinized mucosa ($p = 0.03$) and the presence of pus ($p < 0.001$). On the patient level, smoking was associated with mucositis, bone level and peri-implantitis ($p = 0.02$, < 0.001 and 0.002, respectively). Peri-implantitis was related to a previous history of periodontitis ($p = 0.05$).

Conclusions: Individuals with a history of periodontitis and individuals who smoke are more likely to develop peri-implant lesions.

Key words: associated factors; mucositis; peri-implant bone level; peri-implant lesions; peri-implantitis

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Biological complications occur around implants (Mombelli & Lang 1998, Leonhardt et al. 1999, Berglundh et al. 2002, Quirynen et al. 2002, Roos-Jansåker et al. 2003, 2006a, b). In a previous report, 48% of the implants were found to have peri-implant mucositis [defined as probing depth $\geqslant 4$ mm and bleeding on probing (BOP)] and 13.3% of the implants had a bone level at three to four threads (3.1–3.7 mm) after 9–14 years in function (Roos-Jansåker et al. 2006b). Peri-implantitis may lead to complete disintegration and implant loss (Esposito et al. 1998a, Quirynen et al. 2002, Roos-Jansåker et al. 2006a) even if extensive treatment aiming at resolving the peri-implant infection has been performed (Leonhardt et al. 2003).

It is likely that patient-associated factors may be important for the development peri-implantitis. Patients susceptible to periodontal disease have been reported to develop more peri-implantitis (for a review, see Van der Weijden et al. 2005). Smoking is another risk factor that has been associated with peri-implant infections (Haas et al. 1996, Lindquist et al. 1996, Esposito et al. 1998b, Baelum & Ellegard 2004), and in patients treated for peri-implant infections, the outcome of treatment seemed to be negatively influenced by smoking (Leonhardt et al. 2003). The importance of oral hygiene for the development of peri-implantitis was also highlighted in a paper by Lindquist et al. (1996).

In a previous publication, the frequencies of peri-implant lesions 9–14 years after implant therapy were reported (Roos-Jansåker et al. 2006b). The aim of the present paper was to analyse, on patient and implant basis, associated factors related to peri-implant lesions.

Material and Methods

This study was approved by the Institutional Review Board, University of Lund, Sweden. All participating individuals signed an informed consent. The study reports on patients treated with titanium implants (Brånemark System®, Nobelpharma. Göteborg, Sweden) at the

CLINICAL ORAL IMPLANTS RESEARCH

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Prevalence of peri-implant inflammatory disease in patients with a history of periodontal disease who receive supportive periodontal therapy

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Key words: mucositis, peri-implantitis, periodontitis, supportive periodontal therapy

Abstract

Objectives: To describe the status of implants in periodontally compromised patients who regularly receive supportive periodontal therapy (SPT) and to determine the factors associated to peri-implant inflammatory disease in those patients.

Material and methods: Clinical and radiographic data of implants in periodontal patients who, after being treated and included in a SPT programme, wore implant prostheses for at least 6 months were recorded. The implants were classified according to the criteria of the 6th European Workshop on Periodontology in health, mucositis and peri-implantitis. Logistic regression analysis was performed to analyse the individual and adjusted effects of each study variable on mucositis or peri-implantitis, using SUDAAN to account for clustering (multiple implants within the patient).

Results: A total of 786 implants were placed in 239 patients. At patient level, 60.3%, 24.7% and 15.1% were classified as healthy, mucositis and peri-implantitis patients, respectively. At implant level, the respective percentages were 77.4%, 12.8% and 9.8%. For mucositis, at implant level, the adjusted ORs indicate a significant association with plaque index ($P = 0.050$), type of periodontitis ($P = 0.030$) and location ($P = 0.045$). For peri-implantitis, the adjusted ORs indicate a significant association with plaque index ($P < 0.001$) and location ($P = 0.002$).

Conclusions: The prevalence of peri-implant inflammatory disease in periodontal patients who regularly undergo SPT is clinically significant. The factors associated with peri-implant inflammatory disease were plaque index and implant location, and mucositis was also affected by the type of periodontitis the patient had.

In the last few decades, the use of dental implants has become an appropriate method of treatment for replacing teeth in patients with both complete and partial tooth loss (Esposito et al. 2005b).

It has been questioned whether the good results obtained in periodontally healthy patients can be reproduced in periodontally compromised patients. In fact, although it has been shown that implants can successfully be used in periodontal patients who have received periodontal therapy and regularly receive supportive periodontal therapy (SPT) (Nevins & Langer 1995; Ellegaard et al. 1997; Nevins 2001), the rate of both biological complications (peri-implant mucositis and peri-implantitis) and implant failure is greater in this group of patients (Mengel et al. 2001; Hardt et al. 2002; Karoussis et al. 2003; Roos-Jansåker et al. 2006a,b,c).

When referring to complications or implant loss, a distinction has to be made between what occurs at early onset, that is, immediately after implantation, or later on. Early failure is due to the inability to establish osteointegration, defined as the direct structural and functional connection between living bone and implant surface (Brånemark et al. 1985). However, peri-implant mucositis and peri-implantitis should be considered as late-onset complications of implant therapy.

The 6th European Workshop on Periodontology defined mucositis as an inflammatory lesion that affects the soft tissue, whereas peri-implantitis also affects the supporting bone, and in its final stages leads to implant loss (Lindhe & Meyle 2008). It also confirmed that both mucositis and peri-implantitis are of infectious origin (Lindhe & Meyle 2008). The microbiota associated with the peri-implantitis process is generally similar to the

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CLINICAL ORAL IMPLANTS RESEARCH

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Prevalence and risk factors for peri-implant disease in Belgian adults

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Abstract

Objectives: This study aimed to evaluate in a Belgian population the frequence of mucositis and peri-implantitis in patients with implants of at least 5 years of function. Another outcome was to access implants/patients characteristics as possible risk indicators for peri-implantitis.

Material and methods: One hundred and three patients (38 males/65 females) with a total of 266 implants were examined. Implants had been inserted in university hospitals as well as in private clinics and the mean time of implants in function was 8.5 years (±3.2). The average patients' age within the population was 62 years (±13.4). General health informations were recorded as well as habits regarding smoking, maintenance visits and oral hygiene. Full mouth clinical parameters (PII, BoP, PPD) were assessed and radiographs taken to determine the periodontal status and implants diagnosis.

Results: Prevalences of mucositis and peri-implantitis at the patient's level were respectively 31% and 37%. They were 38% and 23% at the implant's level. Subjects older than 65 years (OR = 1.39) and those with active periodontitis (OR = 1.98) were prone to peri-implantitis. The association was stronger for hepatitis (OR = 2.92) and totally edentulous patients (OR = 5.56). Finally, at the implant's level, a significant correlation was found in the multi-level analyses between rough surfaces, overdentures and peri-implantitis.

Conclusion: After 8.5 years an important proportion (±60%) of implants presented biological complications. Furthermore, a positive correlation was showed between age, periodontitis, absence of teeth, rough surfaces and peri-implantitis. Consequently, patients with such characteristics should be informed before implant placement and frequently re-called after for maintenance visits.

During the last years, dental implantology has become a reliable and predictable solution to replace missing teeth.

Infectious peri-implant diseases are classified in two categories: peri-implant mucositis and peri-implantitis. Peri-implant mucositis (corresponding to gingivitis) can be identified as a reversible inflammatory reaction of the soft tissues surrounding an implant. Peri-implantitis (corresponding to periodontitis) can be identified by inflammatory reactions associated with loss of supporting bone around implant in function (Albrektsson & Isidor 1994).

According to Newman Dorland (1994), prevalence is defined as "the number of cases of a disease that is present in a population at one point in time".

Until today, few studies have regarded to prevalence and risk factors for peri-implant disease (Berglundh et al. 2002; Fransson et al. 2005; Roos-Jansåker et al. 2006a,b,c). In fact, Fransson et al. 2005 studied the prevalence for peri-implant disease with implants of 5 years in function but did not search for risk factors. Ferreira et al. (2006) evaluated the prevalence and the risk factors for peri-implant disease with implants between 6 months and 5 years of function. Roos-Jansåker et al. (2006a,b,c) studied the prevalence and the risk factors for peri-implant disease with implants of 9 14 years in function. As a consequence, there is a lack of studies in the literature that have evaluated at the same time the prevalence for peri-implant disease both at the subject and implant levels (Zitzmann & Berglundh 2008).

Esposito et al. (1998) identified the following factors to be associated with biological complications of implants: "medical status of the patient, smoking, bone quality, bone grafting, irradiation therapy, parafunctions, operator experience, degree of surgical trauma, bacterial contamination, lack of preoperative antibiotics, immediate loading, non-submerged procedure, number of implants supporting a prosthesis, implant surface characteristics and design".

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SPECIAL REVIEW IN PERIODONTAL MEDICINE

Periodontal disease: associations with diabetes, glycemic control and complications

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OBJECTIVE: This report reviews the evidence for adverse effects of diabetes on periodontal health and periodontal disease on glycemic control and complications of diabetes.
DESIGN: MEDLINE search of the English language literature identified primary research reports published on (a) relationships between diabetes and periodontal diseases since 2000 and (b) effects of periodontal infection on glycemic control and diabetes complications since 1960.
RESULTS: Observational studies provided consistent evidence of greater prevalence, severity, extent, or progression of at least one manifestation of periodontal disease in 13/17 reports reviewed. Treatment and longitudinal observational studies provided evidence to support periodontal infection having an adverse effect on glycemic control, although not all investigations reported an improvement in glycemic control after periodontal treatment. Additionally, evidence from three observational studies supported periodontal disease increasing the risk for diabetes complications and no published reports refuted the findings.
CONCLUSION: The evidence reviewed supports diabetes having an adverse effect on periodontal health and periodontal infection having an adverse effect on glycemic control and incidence of diabetes complications. Further rigorous study is necessary to establish unequivocally that treating periodontal infections can contribute to glycemic control management and to the reduction of the burden of diabetes complications.
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Keywords: periodontal disease; diabetes; epidemiology; periodontal treatment

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Introduction

Diabetes mellitus and periodontal disease are two common chronic diseases that have long been considered to be biologically linked. Diabetes is an important chronic disease globally as reflected in the World Health Organization (WHO) declaring the rate of increase in diabetes prevalence is an epidemic. The WHO estimated there were 30 million people who had diabetes worldwide in 1985. This number increased to 135 million by 1995, and reached 217 million in 2005. By 2030 WHO predicts this number to increase to at least 366 million (Smyth and Heron, 2006). This growth in diabetes prevalence, driven principally by increasing prevalence of type 2 diabetes, is occurring in both developing and developed countries. The two countries with the largest predicted increases are India and China and the US ranked third (Smyth and Heron, 2006).

Susceptible individuals with diabetes and those with chronically poor metabolic control can experience microvascular and macrovascular complications leading to a significant burden for the individual and society. This burden includes direct costs of medical care and indirect costs, such as lost productivity, which result from diabetes-related morbidity and premature mortality (Harris, 1995; Hogan *et al*, 2003). Health care spending for people with diabetes is more than double what spending would be without diabetes, and direct and indirect expenditures attributable to diabetes in 2002 in the US were conservatively estimated at $132 billion, with slightly more spent on chronic complications attributable to diabetes than on diabetes care itself (Hogan *et al*, 2003). The International Diabetes Federation estimated that diabetes accounts for 5–10% of the total healthcare budget in many countries (Smyth and Heron, 2006).

Gingivitis and periodontitis are the most common periodontal diseases. For example, in the US approximately 50% of the population in all age groups exhibit reversible gingival inflammation (Albandar and Kingman, 1999). Moderate or severe periodontitis, with destruction of periodontal attachment tissues is much

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REVIEW ARTICLE

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Effects of periodontal disease on glycemic control, complications, and incidence of diabetes mellitus

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1 | INTRODUCTION

Diabetes, especially if poorly controlled, can increase the risk of periodontal disease and ultimately tooth loss. On the other hand, in individuals with diabetes, concurrent periodontitis can adversely affect glycemic control and increase the risk of complications such as cardiovascular disease, retinopathy, and kidney disease. This has been called the "2-way street", describing the bidirectional link between diabetes and periodontal disease. In this review, we will focus on the effects of periodontal disease on glycemic control and complications of patients with diabetes. We will also review the emerging evidence of the effects of periodontitis on increasing the risk of incident diabetes and prediabetes. Diabetes is a major cause of death and morbidity and is increasing in prevalence. Periodontal disease is one of the most common chronic infections of man, hence the reciprocal adverse relationship between these diseases is of great importance in clinical practice and in design of public health measures to manage these diseases.

2 | THE BURDEN OF DIABETES

Diabetes mellitus is a group of metabolic disorders in which hyperglycemia occurs, resulting from definitive insulin function and/or reduced insulin production. In the USA, 30.3 million individuals (9.4% of the population) had diabetes in 2015. The prevalence increases with age, and 1 in 4 adults aged ≥65 years affected by diabetes. About 25% of those with diabetes in the USA are unaware of having the disease. Type 2 diabetes accounts for ~90% of the cases in the USA, whereas type 1 diabetes, caused by autoimmune beta cell destruction, and gestational diabetes mellitus, accounts for the majority of the remaining cases.[1] There are other types of diabetes that are caused by a genetic defect in insulin secretion or insulin production (monogenic diabetes, congenital diabetes), diseases (cystic fibrosis-related diabetes), or drugs/chemicals (steroid diabetes), which can be misdiagnosed as type 1 or type 2 diabetes.

One 3rd of adults in the USA have prediabetes with elevated levels of blood glucose which predisposes to diabetes, with almost a half of adults aged >65 years being affected.[2] Hyperglycemia affects 16% or 1-in-6 pregnancies worldwide, of which 84% are a result of gestational diabetes.[3] A large proportion of women with gestational diabetes mellitus will eventually develop type 2 diabetes. For example, they are 17 times more likely to do so in the 3-6 years postpartum than women without gestational diabetes mellitus.[4] The estimated number of adults with type 2 diabetes globally almost tripled between 2002 and 2017, not only reflecting increases in the USA, but also in most other countries in the last 2 decades.[2]

3 | DIABETES COMPLICATIONS

Complications of diabetes include acute and chronic complications such as dehydration, poor wound healing, myocardial infarction, stroke, limb ischemia, kidney disease, neuropathy, neurocognitive decline, hyperosmolar coma, retinopathy, and serious foot infections.[5]

People with diabetes and chronically poor glycemic control experience death, heart disease, and stroke at rates that are 2-4 times higher than those without diabetes.[6,7] Diabetic retinopathy is the leading cause of new cases of blindness, and diabetic kidney disease is the leading cause of kidney failure in the USA.[5] As the incidence of diabetes increases, so do the complications leading to significant morbidity and mortality. Since it is mainly hyperglycemia (especially of long duration) that leads to complications, they are similar for most types of diabetes.

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Effect of periodontal treatment in patients with periodontitis and diabetes: systematic review and meta-analysis

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Abstract

The evidence is inconclusive regarding the effect of periodontal treatment on glycemic control and systemic inflammation in patients with type 2 diabetes (T2D) and periodontitis Objective: To evaluate the effect of scaling and root planing (SRP) on the metabolic control and systemic inflammation of patients with type 2 diabetes (T2D). Methodology: A literature search was conducted using the MEDLINE database via PubMed and the Cochrane Central Register of Controlled Trials, from their oldest records up to July 2018. Only randomized clinical trials (RCT) were considered eligible for evaluating the effect of periodontal treatment on markers of metabolic control [glycated hemoglobin (HbA1C)] and systemic inflammation [C-reactive protein (CRP)] in patients with T2D. The quality of the studies was evaluated using the Cochrane Collaboration risk assessment tool. Meta-analyses were performed for HbA1c and CRP using random effects models. The size of the overall intervention effect was estimated by calculating the weighted average of the differences in means (DM) between the groups in each study. Heterogeneity was assessed using the Q-statistic method (x^2 and I^2). The level of significance was established at $p<0.05$. Results: Nine RCT were included. SRP was effective in reducing HbA1c [DM=0.56 (0.36-0.75); $p<0.01$] and CRP [DM=1.89 (1.70-2.08); $p<0.01$]. No heterogeneity was detected ($I^2=0\%$, $p>0.05$). Conclusions: SRP has an impact on metabolic control and reduction of systemic inflammation of patients with T2D.

Keywords: Periodontitis. Cardiovascular diseases. Diabetes mellitus.

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Journal of Clinical Periodontology

Prevalence and risk variables for peri-implant disease in Brazilian subjects

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Abstract

Objectives: The aim of this study was to verify the prevalence of peri-implant disease and analyse possible risk variables associated with peri-implant mucositis and peri-implantitis. The study group consisted of 212 partially edentulous subjects rehabilitated with osseointegrated implants.

Material and Methods: The implants placed were examined clinically and radiographically to assess the peri-implant status. The degree of association between peri-implant disease and various independent variables was investigated using a multinomial regression analysis.

Results: The prevalence of peri-implant mucositis and peri-implantitis were 64.6% and 8.9%, respectively. In univariate modelling, healthy peri-implant subjects presented lower plaque scores, less periodontal bleeding on probing, and less time elapsed since placement of supra-structures. In multivariate analyses, the risk variables associated with increased odds for having peri-implant disease included: gender, plaque scores, and periodontal bleeding on probing. Presence of periodontitis and diabetes were statistically associated with increased risk of peri-implantitis. The only two factors, which did not contribute to the presence of the disease, were the time elapsed since placement of supra-structures and the frequency of visits for maintenance care.

Conclusion: Our data suggest that subjects with periodontitis, diabetes, and poor oral hygiene were more prone to develop peri-implantitis.

Key words: osseointegrated implants; peri-implant disease; peri-implant mucositis; peri-implantitis; risk factors

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The well-documented high success rates of osseointegrated dental implants has lead to their use as a common clinical protocol to reestablish oral health in edentulous and partially edentulous subjects (Adell 1983, Quirynen et al. 1992, Karoussis et al. 2003, Lang et al. 2004). Nevertheless, the long-term maintenance of osseointegration, after incorporation of supra-structures, depends on the healthy preservation of marginal soft and hard peri-implant tissues.

Biological complications in implants, such as peri-implant mucositis and peri-implantitis, have been described in some studies; however, data regarding the prevalence of these conditions are inconsistent (Berglundh et al. 2002, Pjertusson et al. 2004, Fransson et al. 2005, Roos-Jansaker et al. 2006). The presence of different risk variables, together with their role in the aetiopatogenesis of peri-implant disease, needs to be clarified in order to further elucidate the health/disease process affecting the marginal tissues surrounding dental implants. Controversial data is available in dental literature about the risk variables and subjects who present a higher risk of developing peri-implant disease. Moreover, only a few studies have been designed to identify the possible risk variables that may in fact influence the occurrence of peri-implant disease (Brägger et al. 1997, Karoussis et al. 2004, Roos-Jansaker et al. 2006).

The aim of the present study was to identify the prevalence of peri-implant disease in partially edentulous subjects treated with osseointegrated implants, using clinical parameters, as well as to analyse the possible disease association with demographic, behavioural, and biological risk variables.

Material and Methods

The present study was performed in accordance with the Helsinki declaration of human studies and received approval from the Ethics Committee of the Federal University of Minas Gerais. In addition, an informed written consent was obtained from each subject.

CLINICAL ORAL IMPLANTS RESEARCH

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Factors related to peri-implantitis – a retrospective study

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Key words: peri-implantitis, periodontitis, risk assessment, smoking, systemic disease

Abstract

Objectives: Retrospectively, we assessed the likelihood that peri-implantitis was associated with a history of systemic disease, periodontitis, and smoking habits.

Methods: Data on probing pocket depth (PPD), bleeding on probing (BOP), and radiographic bone levels were obtained from individuals with dental implants. Peri-implantitis was defined as described by Sanz & Chapple 2012. Control individuals had healthy conditions or peri-implant mucositis. Information on past history of periodontitis, systemic diseases, and on smoking habits was obtained.

Results: One hundred and seventy-two individuals had peri-implantitis (mean age: 68.2 years, SD ± 8.7), and 98 individuals (mean age: 44.7 years, SD ± 15.9) had implant health/peri-implant mucositis. The mean difference in bone level at implants between groups was 3.5 mm (SE mean ± 0.4, 95% CI: 2.8, 4.3, $P < 0.001$). A history of cardiovascular disease was found in 27.3% of individuals with peri-implantitis and in 3.0% of individuals in the implant health/peri-implant mucositis group. When adjusting for age, smoking, and gender, odds ratio (OR) of having peri-implantitis and a history of cardiovascular disease was 8.7 (95% CI: 1.9, 40.3 $P < 0.006$), and odds ratio of having a history of periodontitis was 4.5 (95% CI 2.1, 9.7, $P < 0.001$). Smoking or gender did not significantly contribute to the outcome.

Conclusions: In relation to a diagnosis of peri-implantitis, a high likelihood of comorbidity was expressed by a history of periodontitis and a history of cardiovascular disease.

The 7th and the 8th European Workshops on Periodontology have provided the current guidelines for the definition of peri-implantitis (Lang & Berglundh 2011; Sanz & Chapple 2012). Thus, dental implants with peri-implantitis must have evidence of ≥2-mm bone loss from the expected marginal bone at implant installation and with concurrent bleeding on probing (BOP) and/or suppuration. Implants with a distance <2.0 mm between bone level and implant platform level or other reference point and with no BOP or suppuration represent healthy conditions. If bleeding and/or suppuration can be identified at such implants, the diagnosis is peri-implant mucositis (Renvert et al. 2008; Lang & Berglundh 2011).

Several studies have identified a high prevalence of peri-implantitis (i.e. Fransson et al. 2005; Roos-Jansåker et al. 2006; Koldsland et al. 2010; Simonis et al. 2010; Rinke et al. 2011). Data on 103 individuals with dental implants in function ≥8.5 years have shown that 37% of the individuals presented with peri-implantitis in 37% having a high likelihood of active periodontitis or being edentulous and ≥65 years of age (Marrone et al. 2012). In contrast, a study comprising 303 individuals with implants in function over 10 years demonstrated that the prevalence of peri-implantitis was only 1.8% (Buser et al. 2012). Another study including 36 non-smoking individuals over ≥10 years has reported a subject-based prevalence rate of peri-implantitis in 9.1% of cases (Frisch et al. in press).

A relationship between severe chronic periodontitis and peri-implantitis has been identified (Aloufi et al. 2009). Recent data also suggest that peri-implantitis is a polymicrobial anaerobic infection (Charalampakis et al. 2012). Infectious susceptibility is most likely an important factor in peri-implantitis. Thus, it seems logical that a past history of periodontitis is linked to an increased risk of peri-implantitis. Individuals older than 65 years, having active periodontitis, or being edentulous also appear to have high odds of developing peri-implantitis (Marrone et al. 2012).

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Peri-implantitis: A Comprehensive Overview of Systematic Reviews

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The objective of this systematic review was to perform a comprehensive overview of systematic reviews and meta-analyses pertaining to peri-implantitis in humans, including the prevalence and incidence, the diagnostic findings, microbial findings, effects of systemic diseases, and treatment of peri-implantitis. Electronic databases were searched for systematic reviews and meta-analyses of peri-implantitis. In view of the limitations of the included systematic reviews, the outcome of this overview suggested that (1) occurrence of peri-implantitis was higher in patients with periodontitis, in patients who smoke, and after 5 years of implant function; (2) the microbial profile of peri-implantitis was different from periodontitis; (3) risk for peri-implantitis was higher in patients with uncontrolled diabetes and cardiovascular disease; (4) there was no strong evidence to suggest the most effective treatment intervention for peri-implantitis, although most peri-implantitis treatments can produce successful outcomes; and (5) postimplant maintenance may be crucial in patients with a high risk of peri-implantitis.

Key Words: dental implant, peri-implant, bone loss, peri-implantitis, systematic review

INTRODUCTION

Dental implants have become widely used in restoring the fully or partially edentulous patient. They have become a predictable alternative to fixed and removable partial dentures and were often the treatment of choice.[1,2] High implant survival rates of 92.8%–97.1% over a follow-up period of 10 years indicated that dental implants were a valid treatment option for the dental rehabilitation of the partially and fully edentulous patient.[3,4] However, despite its high survival rates, dental implants were prone to biological complications like peri-implantitis.[5] Peri-implantitis was described as a destructive inflammatory lesion affecting hard and soft tissues of the osseointegrated implant causing bone loss and peri-implant pocketing.[6] Peri-implantitis can be asymptomatic, showing only signs of bleeding on probing, attachment loss, and bone loss. Or peri-implantitis can manifest clinical signs of increasing probing depths, suppuration, draining sinus, and peri-implant mucosal swelling or recession.[7] If peri-implantitis was not detected early and treated, the bony destruction could extend the whole lengthen of the implant, resulting in loss of implant stability.[7] Thus, early peri-implantitis detection and effective treatment is crucial in a practice that focuses on implant rehabilitation of the edentulous patient.

Some studies indicated that patients, who have lost 1 implant due to peri-implantitis, were more prone to implant failure.[8,9] Patients with periodontal disease seemed to experience more implant loss due to peri-implantitis than periodontally healthy patients.[10,11] Patients who smoke were also at risk for peri-implantitis, but non-smoking patients can develop peri-implantitis, and not all smoking patients develop peri-implantitis.[12,13] Radiographically, patients with periodontitis and smokers have also reported significantly more marginal bone loss around their implants.[14] Thus, these factors predisposing peri-implantitis should be closely examined when treatment planning the dental patient for implants.

The aim of this comprehensive review was to provide a systematically derived overview of systematic reviews pertaining to different aspects of peri-implantitis that will help the clinician understand and manage peri-implantitis in their practice.

MATERIAL AND METHODS

Focused questions

- What is the prevalence, incidence, or risk of peri-implantitis in periodontal health and disease?
- What factors are associated with peri-implantitis?
- What treatment intervention is most effective in treating peri-implantitis?

Literature and study design

A systematic search was conducted of PubMed, Embase, Web of Science, Cochrane library, and Google Scholar for systematic reviews and meta-analyses of peri-implantitis published from October 1989 until October 2016. The keywords used for the

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Journal of Clinical Periodontology

The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults

Results after 30 years of maintenance

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Axelsson P, Nyström B, Lindhe J: The long-term effect of a plaque control program on tooth mortality, caries and periodontal disease in adults. Results after 30 years of maintenance. J Clin Periodontol 2004; 31: 749–757. doi: 10.1111/j.1600-051X.2004.00563.x. © Blackwell Munksgaard, 2004.

Abstract

Background: The biofilm that forms and remains on tooth surfaces is the main etiological factor in caries and periodontal disease. Prevention of caries and periodontal disease must be based on means that counteract this bacterial plaque.

Objective: To monitor the incidence of tooth loss, caries and attachment loss during a 30-year period in a group of adults who maintained a carefully managed plaque control program. In addition, a comparison was made regarding the oral health status of individuals who, in 1972 and 2002, were 51–65 years old.

Material and Methods: In 1971 and 1972, more than 550 subjects were recruited. Three hundred and seventy-five subjects formed a test group and 180 a control group. After 6 years of monitoring, the control group was discontinued but the participants in the test group was maintained in the preventive program and was finally re-examined after 30 years. The following variables were studied at Baseline and after 3, 6, 15 and 30 years: plaque, caries, probing pocket depth, probing attachment level and CPITN. Each patient was given a detailed case presentation and education in self-diagnosis. Once every 2 months during the first 2 years, once every 3–12 months during years 3–30, the participants received, on an individual need basis, additional education in self-diagnosis and self-care focused on proper plaque control measures, including the use of toothbrushes and interdental cleaning devices (brush, dental tape, toothpick). The prophylactic sessions that were handled by a dental hygienist also included (i) plaque disclosure and (ii) professional mechanical tooth cleaning including the use of a fluoride-containing dentifrice/paste.

Results: Few teeth were lost during the 30 years of maintenance; 0.4–1.8 in different age cohorts. The main reason for tooth loss was root fracture; only 21 teeth were lost because of progressive periodontitis or caries. The mean number of new caries lesions was 1.2, 1.7 and 2.1 in the three groups. About 80% of the lesions were classified as recurrent caries. Most sites, buccal sites being the exception, exhibited no sign of attachment loss. Further, on approximal surfaces there was some gain of attachment between 1972 and 2002 in all age groups.

Conclusion: The present study reported on the 30-year outcome of preventive dental treatment in a group of carefully monitored subjects who on a regular basis were encouraged, but also enjoyed and recognized the benefit of, maintaining a high standard of oral hygiene. The incidence of caries and periodontal disease as well as tooth mortality in this subject sample was very small. Since all preventive and treatment efforts during the 30 years were delivered in one private dental office, caution must be exercised when comparisons are made with longitudinal studies that present oral disease data from randomly selected subject samples.

Key words: caries; longitudinal study; periodontal disease; tooth mortality

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Association of Preventive Maintenance Therapy Compliance and Peri-Implant Diseases: A Cross-Sectional Study

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Background: This study aims to investigate association between peri-implant maintenance therapy (PIMT) and the frequency of peri-implant diseases and to further identify factors that contribute to failure of PIMT compliance.

Methods: A cross-sectional study on patients who were healthy and partially edentulous was conducted. They were grouped in the following categories according to PIMT compliance: 1) regular compliers (RC) (≥2 PIMT/year); 2) erratic compliers (EC) (<2 PIMT/year); and 3) non-compliers (NC) (no PIMT). Radiographic and clinical analyses were carried out including probing depth (PD), plaque index (PI), bleeding on probing (BOP), mucosal redness (MR), suppuration (SUP), keratinized mucosa dimension, and marginal bone loss. A multiple logistic regression model was estimated at implant and patient level to obtain adjusted odds ratios (ORs) and to control possible confounding effects among variables.

Results: Overall, 206 implants in 115 patients fulfilled inclusion criteria. At patient level, it was shown that association between compliance and peri-implant condition was statistically significant ($P = 0.04$). Compliance was associated with 86% fewer conditions of peri-implantitis. The probability of PIMT compliance was substantially associated with frequency of peri-implantitis (OR = 0.13, $P = 0.01$). Patients with a history of periodontal disease multiplied their probability of being EC (versus NC) 4.23 times with respect to not having a history of periodontal disease ($P = 0.02$). Moreover, light smokers significantly resulted to be NC compared with RC ($P = 0.04$) and EC ($P = 0.02$). Nevertheless, mucositis was not found to be statistically associated with level of compliance. In addition, PD, PI, BOP, MR, and SUP varied significantly according to PIMT compliance and peri-implant condition.

Conclusions: Peri-implant maintenance compliance ≥2 PIMT/year seems to be crucial to prevent peri-implantitis in healthy patients. Furthermore, history of periodontal disease and disease severity, as well as its extent and a smoking habit, appear to be factors that influence the compliance risk profile (NCT02789306). *J Periodontol 2017;88:1030-1041.*

KEY WORDS

Dental implants; maintenance; mucositis; peri-implantitis; periodontitis; risk factors.

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Lack of supportive periodontal maintenance therapy has been demonstrated to be strongly associated with tooth mortality.[1-4] Hence, it has been suggested that a professional mechanical plaque removal treatment must be programmed to prevent periodontal tissue breakdown.[5] Nevertheless, early studies in the field of periodontology pointed out that ≈80% of patients do not adhere to a regular schedule, with only 16% being compliers after active periodontal therapy.[1,2] It was further shown that implementing efforts in identifying and targeting erratic and non-complying individuals with more information could increase compliance to 32%.[6] Biologic plausibility remains due to three dominant facts: 1) in susceptible hosts, plaque and its byproducts represent the primary etiology of periodontal disease;[7] 2) after episodes of inflammation, periodontal tissues are moderately more susceptible due to changes in gene expression that are not encoded by DNA itself;[8] and 3) recolonization of putative bacteria such as spirochetes and motile rods occurs as soon as 4 to 8 weeks after active periodontal treatment.[9]

Likewise, peri-implant diseases are defined as plaque-induced chronic inflammatory conditions.[10] Peri-implant maintenance therapy (PIMT) has been strongly encouraged according to patient risk profiling, with 5- to 6-month recall intervals being suggested for non-susceptible individuals.[11] In this context, it was reported that peri-implantitis

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Peri-implant disease in subjects with and without preventive maintenance: a 5-year follow-up

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Abstract

Aim: To determine the incidence of peri-implantitis in individuals with mucositis in a 5-year follow-up study.

Material and Methods: A sample of 212 partially edentulous individuals, rehabilitated with dental implants, underwent periodontal and peri-implant clinical examinations in 2005 (baseline). Five years later, 80 individuals who had been diagnosed with mucositis in the baseline examination were re-examined. These individuals were divided into two groups: one group with preventive maintenance during the study period (GTP; $n = 39$), and another group without preventive maintenance (GNTP; $n = 41$). The following parameters were clinically evaluated: plaque index, bleeding on periodontal and peri-implant probing, periodontal and peri-implant probing depth, suppuration and peri-implant bone loss. The influence of biological and behavioural risk variables associated with the occurrence of peri-implantitis was analysed using univariate and multivariate logistic regression analyses.

Results: The incidence of peri-implantitis in the global sample was 31.2% (GNTP = 43.9% and GTP = 18.0%).

Conclusion: The absence of preventive maintenance in individuals with pre-existing peri-implant mucositis was associated with a high incidence of peri-implantitis. Clinical parameters, such as bleeding on peri-implant probing, periodontal probing depth and the presence of periodontitis were associated with a higher risk of developing peri-implantitis.

Key words: maintenance; peri-implant mucositis; peri-implantitis; periodontitis; risk factors

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Pathological processes, such as peri-implant mucositis and peri-implantitis, have been diagnosed in the tissues around implants in function (Lang & Berglundh 2011). According to the Sixth European Workshop on Periodontology, "peri-implant diseases are infectious in nature. Peri-implant mucositis describes an inflammatory lesion that resides in the mucosa, while peri-implantitis also affects the supporting bone" (Lindhe & Meyle 2008, Lang Lang & Berglundh 2011). Despite the high success rates of dental implants, it is clear that osseointegrated implants are susceptible to diseases that may eventually lead to dental implant loss (De Boever et al. 2009).

A great challenge in implant therapy is the ability to detect individuals at higher risk for early and/or late implant loss. Previous studies have indicated some potential risk variables, especially periodontitis, peri-implant mucositis, smoking, diabetes, poor plaque index and a lack of preventive maintenance associated with peri-implant disease and late implant loss (Leonhardt et al. 2002, Ross-Jansåker et al. 2006, Aglietta et al. 2010, Anner et al. 2010, Simonis et al. 2010, Zupnik et al. 2011); whereas poor bone quality and inadequate surgical procedures can be

Conflict of interest and source for research

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CLINICAL ORAL IMPLANTS RESEARCH

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Prevalence of peri-implantitis in patients not participating in well-designed supportive periodontal treatments: a cross-sectional study

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Key words: maintenance, mucositis, peri-implantitis, prevalence

Abstract

Objectives: This retrospective cross-sectional study aimed to evaluate the prevalence of biologic complications of implants in patients treated by fixed implant supported prosthesis without regular maintenance program.

Materials and methods: One hundred thirty-four patients with 478 implants, installed during a 10-year period (2001–2010), were recruited for clinical and radiographic follow-up examinations. The periodontal and implant health status were assessed to determine the prevalence of peri-implant diseases.

Results: The mean ± SD loading time for implants was 4.43 ± 2.25 years. Fifty-five percentage of the implants were tissue-level implants. Peri-implantitis was diagnosed in 20% of patients and 8.8% of implants. Subject-based and implant-based prevalence of mucositis amounted to 48.5% and 40%, respectively. Mean crestal bone loss in tissue-level and bone-level implants were 0.28 ± 0.53 mm and 1.37 ± 1.5 mm, respectively. Smoking and lack of keratinized mucosa was associated with peri-implantitis at an odds ratio of OR = 2.57 and 3.89, respectively.

Conclusions: After a 5-year period of loading without any regular maintenance program, one out of five patients would experience peri-implantitis. Tissue-level implants had lower values of peri-implantitis prevalence and crestal bone loss.

Dental implants have been successfully used to replace missing teeth. Despite the high survival rate of 95–100%, (Swierkot et al. 2012), there would be technical and biological complications after prosthesis delivery (Berglundh et al. 2002; Visser et al. 2006). In the shade of such complications, recent studies have reported lower long-term success rate (50%) (Simonis et al. 2010; Swierkot et al. 2012).

Peri-implant diseases are the most common problems, associated with dental implants and addressed in a number of Consensus Workshops (Lindhe & Meyle 2008; Lang & Berglundh 2011; Klinge et al. 2012; Sanz & Chapple 2012).They are defined as inflammatory reactions in implant surrounding tissues in the osseointegrated functional implant after normal bone remodeling. These lesions are classified as peri-implant mucositis and peri-implantitis. (Lang & Berglundh 2011; Mombelli et al. 2012). If left untreated, peri-implant mucositis could be progressive (Derks & Tomasi 2015). Crestal bone resorption is considered as the main characteristic of peri-implantitis although bleeding on probing, increased pocket depth and suppuration may be observed (Lang & Berglundh 2011). Several systemic as well as behavioral and local factors have been identified as the risk indicators of peri-implant diseases. Such factors may include genetic traits, diabetes mellitus, smoking, history of periodontitis, irregular maintenance programs, poor plaque control, inadequate widths of keratinized mucosa, and implant diameter and surface (Heitz-Mayfield 2008; Renvert et al. 2014; Saaby et al. 2016; Canullo et al. 2015; Daubert et al. 2015). In a more recent review by Derks & Tomasi (2015), a meta-analysis has been conducted on the results of 11 studies. The results estimated the weighted mean prevalence of peri-implant mucositis (43%) and peri-implantitis (22%). The incidence of peri-implantitis in subjects with regular

CLINICAL ORAL IMPLANTS RESEARCH

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Clinical and microbiological findings in patients with peri-implantitis: a cross-sectional study

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Key words: BoP, keratinized mucosa, microbiota, peri-implantitis

Abstract

Objective: The aim of this study was to analyze clinical and microbiological characters in subjects and implants affected and not affected by peri-implantitis. Additionally, same features were analyzed also intra-individually, comparing healthy and diseased implants within the same subject.

Materials and methods: A total of 534 patients who received at least 1 implant and coming to routine check-up or spontaneous visits at the University of Valencia were recruited. Clinical parameters including Bleeding on probing (BoP), Probing pocket depth (PPD), and Pi were screened. Samples for microbiological analysis were obtained from three locations: peri-implant sulci (PIS), inner parts of the implant connections (I), and gingival sulci of neighboring teeth (GS). Quantitative real-time PCR was performed for total counts of 10 microorganisms.

Results: A total of 534 patients with 1507 dental implants were analyzed. The prevalence of peri-implantitis was found 10.3% for patients and 7.3% for implants. Higher percentage of healthy periodontal subjects were found in the non-peri-implantitis group. The analysis within the 53 patients affected by peri-implantitis revealed that the implants affected by peri-implantitis presented a higher percentage of plaque, BoP, and number of implants presenting <2 mm attached gingiva. Additionally, more cemented crowns and implants inserted in bone-augmented sites were found among the diseased implants. The microbiologic analysis presented no relevant differences between the analysis at the peri-implant sulcus (PIS) and the connections inside the abutments surfaces (PI). The microbial composition at the neighboring teeth (GS) resembled the composition found at the PIS with a high frequency of *Pg, Tf, Pi, PM,* and *Ec.*

Conclusions: The results of this study seem to indicate that inadequate oral hygiene and the presence of bleeding from the gingiva/mucosa in patients with dental implant were associated with an higher prevalence of peri-implantitis; moreover, in the patients affected by peri-implantitis, the lack of sufficient height keratinized mucosa (<2 mm) and bone regenerative procedures at implant level were also associated to higher prevalence of peri-implantitis as well.

One of the key factors for the long-term success of oral implants is the maintenance of healthy tissues around them. Bacterial plaque accumulation induces inflammatory changes in the soft tissues surrounding oral implants and it may lead to their progressive destruction (peri-implantitis) and ultimately to implant failure (Mombelli et al. 1987; Albrektsson et al. 1994).

While mucositis is a marginal inflammation without attachment/bone loss, peri-implantitis is described as an inflammatory reaction of soft tissues associated with loss of marginal supporting bone around an implant in function (Zitzmann & Berglundh 2008).

On the other hand, different etiopathological figure was described by Albrektsson et al. (2012a,b), which pointed out the importance of an unbalanced foreign body reaction to explain crestal bone loss/peri-implantitis process.

The occurrence of peri-implantitis was described to be not rare. Depending on the different diagnostic criteria to define peri-implantitis, in the same patients' sample, a substantial variance in prevalence ranging from 11.3% to 47.1% has been reported (Koldsland et al. 2010; Mir-Mari et al. 2012). Nevertheless, peri-implantitis was described with dramatically lower occurrence in a retrospective long-term study (Buser et al. 2012).

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Peri-implantitis in partially edentulous patients: association with inadequate plaque control

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Key words: partially edentulous, periodontitis, peri-implantitis, plaque control

Abstract

Objective: The aim of the present study was to describe some clinical periodontal features of partially edentulous patients referred for the treatment of peri-implantitis.

Material and methods: The 23 subjects involved in this study were selected from consecutive patients referred to the department of Periodontology Södra Älvsborgs Hospital, Borås, Sweden, for treatment of peri-implantitis during 2006. The patients had clinical signs of peri-implantitis around one or more dental implants (i.e. $\geq$6 mm pockets, bleeding on pockets and/or pus and radiographic images of bone loss to $\geq$3 threads of the implants) and remaining teeth in the same and/or opposite jaw. The following clinical variables were recorded: *Plaque Index* (PI), *Gingival Bleeding Index* (GBI) *Probing Pocket Depth* (PPD), *Access/capability to oral hygiene at implant site* (*yes/no*), *Function Time*. The patients were categorized in the following sub-groups: *Periodontitis/No periodontitis*, *Bone loss/No bone loss at teeth, Smoker/Non-smokers*.

Results: Out of the 23 patients, the majority (13) had minimal bone loss at teeth and no current periodontitis; 5 had bone loss at teeth exceeding 1/3 of the length of the root but not current periodontitis and only 5 had current periodontitis. Six patients were smokers (i.e. smoking more than 10 cig/day). The site level analysis showed that only 17 (6%) of the 281 teeth present had $\geq$1 pocket of $\geq$6mm, compared to 58 (53%) of the total 109 implants (28 ITI® and 81 Brånemark®); 74% of the implants had no accessibility to proper oral hygiene. High proportion of implants with diagnosis of peri-implantitis were associated with no accessibility/capability for appropriate oral hygiene measures, while accessibility/capability was rarely associated with peri-implantitis. Indeed 48% of the implants presenting peri-implantitis were those with no accessibility/capability for proper oral hygiene (65% positive predict value) with respect to 4% of the implants with accessibility/capability (82% negative predict value).

Conclusion: The results of the study indicate that local factors such as accessibility for oral hygiene at the implant sites seems to be related to the presence or absence of peri-implantitis. Peri-implantitis was a frequent finding in subjects having signs of minimal loss of supporting bone around the remaining natural dentition and no signs of presence of periodontitis (i.e. presence of periodontal pockets of $\geq$6 mm at natural teeth). Only 6 of the examinated subjects were smokers. In view of these results we should like to stress the importance of giving proper oral hygiene instructions to the patients who are rehabilitated with dental implant and of proper prosthetic constructions that allow accessibility for oral hygiene around implants.

CLINICAL ORAL IMPLANTS RESEARCH

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Probing at implants with peri-implantitis and its relation to clinical peri-implant bone loss

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Key words: bone loss, diagnosis, Implant dentistry, peri-implantitis, probing depth

Abstract

Objectives: To evaluate the probing depth at implants with signs of peri-implantitis before and following the removal of the prosthetic reconstructions and its relation with the peri-implant bone level as revealed by open access flap surgery.

Material and methods: Twenty-nine patients with 89 implants with diagnosis of peri-implantitis were included in the study. The probing pocket depth at implants before (PPD-1) and following (PPD-2) the removal of the prosthetic reconstructions was measured at four sites of the implants. These measurements were also analysed in relation to the amount of peri-implant bone loss measured during peri-implant surgery.

Results: The results showed that in only 119 (37%) of the sites, the measurements were similar between PPD-1 and PPD-2; in 124 sites (39%), the difference was ±1 mm, in 47 sites (15%) it was ±2 mm and in the rest of the sites it was ±3 mm. A high linear and statistically significant (P = <0.001) correlation between PPD-2 and the bone loss measured at implants for all and single surfaces was observed (r = 0.67, range 0.64–0.69), while PPD-1 yielded a weak and no statistically significant correlation (r = 0.35, range 0.27–0.42). The analysis of the bone loss at implants showed that 59 implants (66%) had an amount of bone loss that was similar at all the four surfaces, while in 30 implants, the bone loss differed for the various sites. A higher extent of bone loss was often detected at the buccal compared with the other sites.

Conclusion: The results of this study yielded differences in the pocket probing measurements at implants with or without the prosthetic reconstruction in place and that the probing pocket depth following the removal of the prosthesis had a high correlation with the amount of bone loss at implants assessed during surgery.

Probing of the peri-implant mucosa either in the presence or absence of bleeding on probing is an important assessment to distinguish a tissue condition of peri-implant health or disease. (Zitzmann & Berglundh 2008). In healthy peri-implant conditions, experimental studies have indicated that when a light probing force was used (0.2–0.3 N), the tip of the probe will stop coronal to the bone level, at the apical extension of the barrier epithelium. However, in sites with peri-implant disease, the probe tip penetrated to a position closer to the alveolar bone crest (Lang et al. 1994; Schou et al. 2002; Abrahamsson & Soldini 2006). This reflected an increase in the probe penetration as the degree of inflammation around implants increased.

Clinical studies indicated that probing depth was deeper at implants presenting with radiographic bone loss compared with implants with no bone loss (Mombelli et al. 1997; Hultin et al. 2002; Fransson et al. 2008). Thus, it is evident that probing may be useful to identify implants with bone loss.

Clinically, probing around implants is influenced by a variety of factors, such as the profile of the abutments and implants as well as the shape of the prosthetic construction (Lang & Berglundh 2011). These factors may have an effect on the insertion angle of the probe, sometimes rendering it impossible to probe at four sites of the implants. At the sixth European workshop on Periodontology, it was emphasized that "the profile of the implant and the contour of the reconstruction might hinder probing at four surfaces per implant; in such a case, at least one surface must be identified, where proper probing can be performed" (Lindhe & Meyle 2008).

It may be suggested that an increase in probing depth around implants may be correlated with the presence of radiographic bone loss. However, at present, there are no studies that have evaluated probing around

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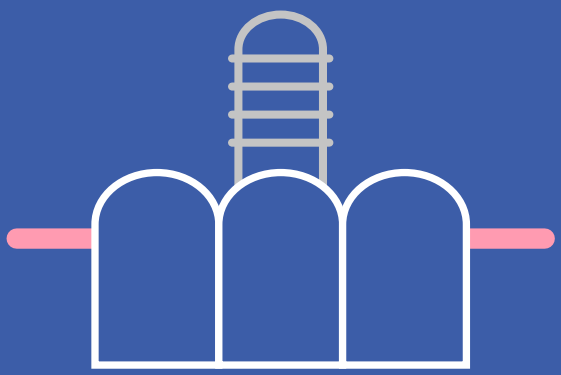
EFP
New Classification
of periodontal and peri-implant diseases

04. Peri-implant health, peri-implant mucositis, and peri-implantitis

Guidance for clinicians

- The previous (1999) classification of periodontal diseases did not include peri-implant diseases and conditions.
- The 2017 World Workshop presented case definitions and considered the characteristics of peri-implant health, peri-implant mucositis, and peri-implantitis.
- Bleeding on probing (BoP) is used to distinguish between healthy and inflamed peri-implant mucosa.
- Bone loss is used to differentiate between peri-implant mucositis and peri-implantitis.
- The progression of peri-implantitis is faster than that observed in periodontitis and occurs in a non-linear and accelerating pattern.



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European Federation of Periodontology

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.

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ORIGINAL RESEARCH

WILEY CLINICAL ORAL IMPLANTS RESEARCH

Clinical characteristics of peri-implant mucositis and peri-implantitis

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Abstract

Objectives: To evaluate and correlate clinical parameters associated with peri-implant diseases based on established case definitions.

Materials and Methods: A total of 75 patients exhibiting 269 implants (healthy: 77; peri-implant mucositis: 77; peri-implantitis: 115) were included in this observational study. Clinical parameters included bleeding on probing (BOP), probing depths (PDs), and suppuration (Supp).

Results: Healthy sites were associated with the absence of BOP, while mean BOP in peri-implant mucositis and peri-implantitis patients amounted to 20.83% and 71.33%, corresponding to 43% and 86% at the implant level ($p < .001$), respectively. Peri-implantitis patients exhibited significantly higher mean PD values (4.46 mm) when compared with the peri-implant mucositis group (2.70 mm, $p < .001$). Supp was limited to peri-implantitis cases and detected in 30.16% of the patients (implant level: 17.39%). The regression model revealed a significant linear association between the number of BOP-positive sites around the implant (minimum 0, maximum 6) and mean PD values at peri-implant mucositis and peri-implantitis sites at both patient and implant levels.

Conclusions: The clinical parameters investigated were shown to be associated with the severity of peri-implant diseases.

KEYWORDS
clinical characteristics, peri-implant diseases

1 | INTRODUCTION

Peri-implant diseases are initiated by the host response to a bacterial challenge and comprise of two clinical phenotypes, peri-implant mucositis and peri-implantitis (Lang, Berglundh, & Working Group 4 of Seventh European Workshop on Periodontology, 2011; Lindhe, Meyle, & Group D of European Workshop on Periodontology, 2008). While the former is restricted to the peri-implant soft tissues, peri-implantitis also affects the supporting bone (Lindhe, Meyle, & Group D of European Workshop on Periodontology, 2008). Consequently, it is thought that peri-implantitis follows peri-implant mucositis (Jepsen et al., 2015).

While there seems to be a common sense on the definition of the disease (Schwarz, Derks, Monje, & Wang, 2018), the respective case definitions vary considerably in the literature (Derks & Tomasi, 2015). These are commonly based on clinical parameters to determine peri-implant mucosal inflammation (e.g., redness, bleeding on probing—BOP, suppuration—Supp) along with a loss of the supporting tissues (e.g., increases in probing depths—PDs, progressive radiographic bone loss) (Sanz & Chapple, 2012). However, arbitrary threshold levels for PD scores and radiographic bone levels may be misleading and not allow for a proper differentiation between peri-implant mucositis and peri-implantitis (Schwarz et al., 2018). Indeed, the definition of a physiological PD at implant sites is difficult, as the vertical mucosal thickness (i.e., measured from the mucosal margin

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ORIGINAL ARTICLE

Suppuration as diagnostic criterium of peri-implantitis

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Abstract

Background: Suppuration (SUP) as a diagnostic parameter for monitoring dental implants is not yet well understood. The retrospective clinical and radiographic study was therefore performed to investigate the patient, implant, and site characteristics among individuals exhibiting SUP.

Methods: Demographic characteristics and clinical parameters were recorded. Radiographic features were analyzed using cone-beam computed tomography. Peri-implantitis was defined based on the consensus report of Workgroup 4 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions: probing depth (PD) ≥6 mm, presence of bleeding and/or SUP on gentle probing, and radiographic marginal bone loss (MBL) ≥3 mm. SUP was graded according to profuseness (dot versus line/drop) and time after probing (≥15 seconds versus <15 seconds after probing versus spontaneous). Simple binary logistic regression models were estimated using generalized estimation equations to explain the probability of SUP based on demographic, clinical, and radiographic variables.

Results: A total of 111 eligible patients ($n_{implants}$ = 501) were assessed. Of them, 57 ($n_{implants}$ = 334) were diagnosed with peri-implantitis according to the established case definition, and of these individuals, 31 ($n_{implants}$ = 96) presented SUP. Therefore, the prevalence of SUP was 27.92% in the total sample size and 54.38% in peri-implantitis patients. Overall, 28.74% implants displayed SUP within patients with peri-implantitis. SUP was more frequently found at buccal sites (51%) and proved less prevalent at mesio-lingual sites (16.7%). Defect morphology (OR = 6.59; P = 0.004), PD (OR = 1.63; P = 0.024), and MBL (OR = 1.35; P = 0.010) were significantly associated with the presence of SUP. Likewise, defect morphology (P = 0.02), PD (P = 0.003), and MBL (P = 0.01) were significantly correlated with the grade of SUP.

Conclusion: The presence and grade of SUP are associated with peri-implant bone loss, probing depth, and defect morphology in patients with peri-implantitis.

KEYWORDS
dental implants, dental prosthesis, endosseous implantation, peri-implantitis, periodontitis, tooth mobility

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Modern implant dentistry based on osseointegration: 50 years of progress, current trends and open questions

Daniel Buser, Lars Sennerby & Hugo De Bruyn

In the past 50 years, implant dentistry has evolved from an experimental treatment to a highly predictable option to replace missing teeth with implant-supported prostheses. It is a treatment modality widely used in daily practice for fully and partially edentulous patients because modern implant therapy offers not only significant functional and biologic advantages for many patients when compared with conventional fixed or removable prostheses, but also yields excellent long-term results, as documented by numerous 10-year studies with success and survival rates above 95% (46, 80, 89, 98). This breakthrough in oral rehabilitation was initiated 50 years ago by the discovery that implants made of commercially pure titanium could achieve anchorage in the bone with direct bone-to-implant contact. The most important pioneer of modern implant dentistry was Professor P. I. Brånemark from the University of Gothenburg (Sweden) who performed the first preclinical and clinical studies in the 1960s (33). Later, he termed this phenomenon osseointegration (32), which is today a widely accepted term. In the late 1960s, the second pioneer, Professor André Schroeder from the University of Bern (Switzerland), started to examine the tissue integration of various implant materials, and his group was the first to document direct bone-to-implant contact for titanium implants in nondecalcified histologic sections (177). A few years later, he also reported as the first one about the soft tissue reactions to titanium implants (179). Both pioneers were leading a team that performed numerous preclinical and clinical studies to establish the scientific basis for modern implant dentistry. The group in Sweden became known as the Brånemark team, with high-profile team members such as Tomas Albrektsson, Ragnar Adell, Ulf Lekholm and Torsten Jemt; whereas André Schroeder established, in 1980 in Switzerland, the International Team for Implantology, which has become, in the intervening 35 years, the world's largest association in implant dentistry, with more than 15,000 members and fellows in approximately 100 countries worldwide. Initially, the research teams in Sweden and Switzerland did not know about each other as they published their early studies only in local journals in their respective countries and they worked independently of each other.

1965 to 1985: the scientific quest for osseointegration and its clinical application

Until the mid-1980s, only basic surgical guidelines had been established for the predictable achievement of osseointegration. These guidelines included a low-trauma surgical technique for implant bed preparation to avoid overheating of the bone during preparation, implant insertion with sufficient primary stability and a healing period of 3–6 months without functional loading (3, 32, 179). Both research teams agreed on these basic principles of implant surgery. However, there were differences concerning two other important aspects – the healing modality and the implant surface. The Brånemark team used titanium screw-type implants with a machined surface, which was rather smooth, whereas the Schroeder International Team for Implantology used titanium implants of various shapes with a titanium

Diagnostic Principles of Peri-Implantitis: a Systematic Review and Guidelines for Peri-Implantitis Diagnosis Proposal

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ABSTRACT

Objectives: To review and summarize the literature concerning peri-implantitis diagnostic parameters and to propose guidelines for peri-implantitis diagnosis.
Material and Methods: An electronic literature search was conducted of the MEDLINE (Ovid) and EMBASE databases for articles published between 2011 and 2016. Sequential screening at the title/abstract and full-text levels was performed. Systematic reviews/guidelines of consensus conferences proposing classification or suggesting diagnostic parameters for peri-implantitis in the English language were included. The review was recorded on PROSPERO system with the code CRD42016033287.
Results: The search resulted in 10 articles that met the inclusion criteria. Four were papers from consensus conferences, two recommended diagnostic guidelines, three proposed classification of peri-implantitis, and one suggested an index for implant success. The following parameters were suggested to be used for peri-implantitis diagnosis: pain, mobility, bleeding on probing, probing depth, suppuration/exudate, and radiographic bone loss. In all of the papers, different definitions of peri-implantitis or implant success, as well as different thresholds for the above mentioned clinical and radiographical parameters, were used. Current evidence rationale for the diagnosis of peri-implantitis and classification based on consecutive evaluation of soft-tissue conditions and the amount of bone loss were suggested.
Conclusions: Currently there is no single uniform definition of peri-implantitis or the parameters that should be used. Rationale for diagnosis and prognosis of peri-implantitis as well as classification of the disease is proposed.

Keywords: dental implant; diagnosis; endosseous dental implantation; peri-implantitis.

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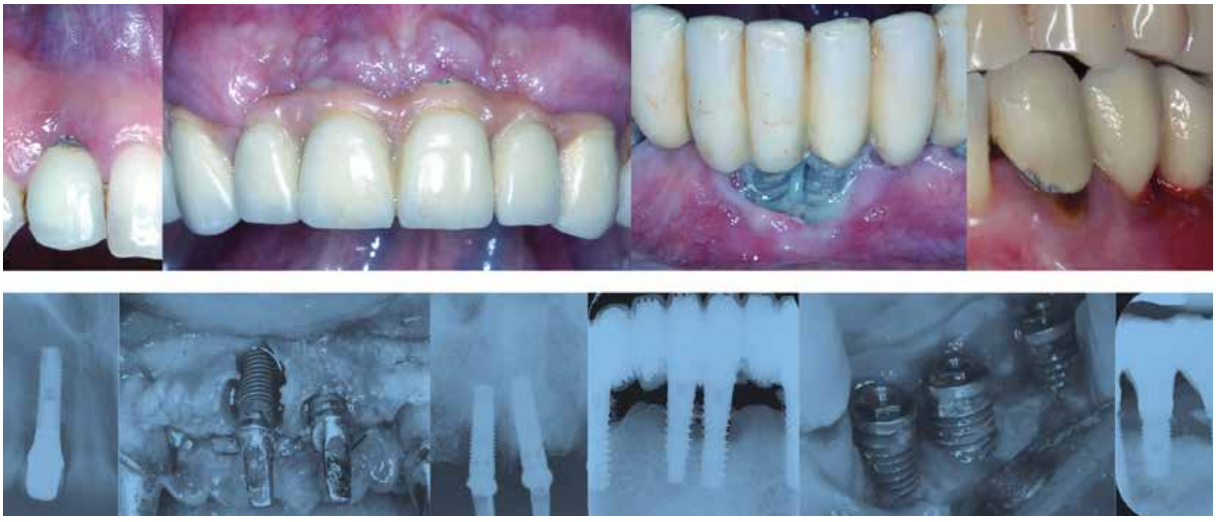

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Inside this issue:

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CLINICAL ORAL IMPLANTS RESEARCH

Anti-infective treatment of peri-implant mucositis: a randomised controlled clinical trial

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Key words: anti-infective treatment, chlorhexidine, non-surgical debridement, oral hygiene, peri-implant mucositis, RCT

Abstract

Aim: To compare the effectiveness of two anti-infective protocols for the treatment of peri-implant mucositis.

Materials and methods: Twenty-nine patients with one implant diagnosed with peri-implant mucositis (bleeding on probing [BOP] with no loss of supporting bone) were randomly assigned to a control or test group. Following an assessment of baseline parameters (probing depth, BOP, suppuration, presence of plaque), all patients received non-surgical mechanical debridement at the implant sites and were instructed to brush around the implant twice daily using a gel provided for a period of 4 weeks. The test group (15 patients) received a chlorhexidine gel (0.5%), and the control group (14 patients) received a placebo gel. The study was performed double blind. After 4 weeks, patients were instructed to discontinue using the gel and to continue with routine oral hygiene at the implant sites. Baseline parameters were repeated at 1 and 3 months.

Results: At 1 month, there was a statistically significant reduction in the mean number of sites with BOP and mean probing depth measurements at implants in both groups. There were also some statistically significant changes in these parameters from 1 to 3 months. However, there were no statistically significant differences between test and control groups. One month following treatment, 76% of implants had a reduction in BOP. Complete resolution of BOP at 3 months was achieved in 38% of the treated implants. The presence of a submucosal restoration margin resulted in significantly lower reductions in probing depth following treatment.

Conclusions: Non-surgical debridement and oral hygiene were effective in reducing peri-implant mucositis, but did not always result in complete resolution of inflammation. Adjunctive chlorhexidine gel application did not enhance the results compared with mechanical cleansing alone. Implants with supramucosal restoration margins showed greater therapeutic improvement compared with those with submucosal restoration margins.

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Biological complications affecting the supporting tissues at dental implants include peri-implant mucositis and peri-implantitis. Peri-implant mucositis is defined as inflammation of the peri-implant soft tissues without loss of supporting bone and has been reported to occur in up to 80% of patients with implants (Zitzmann & Berglundh 2008), most frequently in smokers (S. Rinke, S. Ohl, D. Ziebolz, K. Lange, P. Eickholz, unpublished data). A clinical diagnosis of peri-implant mucositis is made when there is bleeding following probing of the peri-implant sulcus, in the absence of radiographic bone loss. In contrast, when there is bone loss around an implant in addition to bleeding on probing (BOP), the diagnosis is peri-implantitis (Zitzmann & Berglundh 2008).

The peri-implant soft tissues are similar in composition to their gingival counterparts around teeth and respond in a similar way to biofilm formation, with an inflammatory cell infiltrate (Berglundh et al. 1991). Experimental studies in humans have demonstrated that a 3-week period of plaque accumulation has a similar cause-and-effect relationship at teeth (gingivitis) and implants

CLINICAL REVIEW

Success Criteria in Implant Dentistry: A Systematic Review

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ABSTRACT

The purpose of this study was to examine the most frequently used criteria to define treatment success in implant dentistry. An electronic MEDLINE/PubMED search was conducted to identify randomized controlled trials and prospective studies reporting on outcomes of implant dentistry. Only studies conducted with roughened surface implants and at least five-year follow-up were included. Data were analyzed for success at the implant level, peri-implant soft tissue, prosthetics, and patient satisfaction. Most frequently reported criteria for success at the implant level were mobility, pain, radiolucency, and peri-implant bone loss (> 1.5 mm), and for success at the peri-implant soft-tissue level, suppuration, and bleeding. The criteria for success at the prosthetic level were the occurrence of technical complications/prosthetic maintenance, adequate function, and esthetics during the five-year period. The criteria at patient satisfaction level were discomfort and paresthesia, satisfaction with appearance, and ability to chew/taste. Success in implant dentistry should ideally evaluate a long-term primary outcome of an implant-prosthetic complex as a whole.

KEY WORDS: success, survival, criteria, dental implants, implant complications, dental prostheses.

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INTRODUCTION

The commonly accepted criteria for the assessment of implant success were proposed by Albrektsson and colleagues (Albrektsson *et al*., 1986), to identify clinical evidence of successful osseointegration and survival of implants. Over the past three decades, implant success has been assessed by survival rates, continuous prosthesis stability, radiographic bone loss, and absence of infection in the peri-implant soft tissues (Albrektsson *et al*., 1986; Smith and Zarb, 1989; Buser *et al*., 1990; Albrektsson and Zarb, 1998; Misch *et al*., 2008; Annibali *et al*., 2009).

Since then, new parameters have been introduced to assess success in the achieving of lifelike implant restorations. These include health status and natural-looking peri-implant soft tissues, as well as prosthodontic parameters, esthetics, and patient satisfaction. However, osseointegration remains the predominant parameter in implant dentistry. It seems logical that the current definition of success criteria should be comprehensive, to include these additional factors (Furhauser *et al*., 2005; Meijer *et al*., 2005; Annibali *et al*., 2009; Belser *et al*., 2009).

There is still a lack of homogeneity in the dental literature on reporting complications at both implant and prosthetic levels. A previous systematic review has shown that as much as 38.7% of all implant-supported fixed partial dentures (FPD) for partially edentulous patients had some type of complication during the observation period of 5 yrs (Pjetursson *et al*., 2007). This finding highlights the importance of including prosthesis success in analyses of the overall success of dental implants.

The aim of this systematic review was to examine the most frequently used criteria to define treatment success in implant dentistry.

MATERIALS & METHODS

Search Strategy

An electronic search in the MEDLINE/PubMED database was performed for studies published in English from January 1980 until October 2010. The search strategy included the following key word combinations: *'success criteria* AND '*implant', 'success rates'* AND *'implant', 'survival rates'* AND *'implant',* and *'outcomes'* AND *'implant dentistry'.*

The electronic search was supplemented by a manual search of the bibliographies of all articles and related reviews that were selected for full-text reading. Reference manager software (Endnotes, Thomson Reuters, New York, NY, USA) was used to sort selected references and to discard duplicates.

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Comparison of naturally occurring and ligature-induced peri-implantitis bone defects in humans and dogs

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Key words: animal study, dental implant, ligature-induced, naturally occurring, peri-implantitis

Abstract

Objectives: The aim of the present study was to evaluate and compare naturally occuring and ligature-induced peri-implantitis bone defects in humans and dogs.

Material and Methods: Twenty-four partially and fully edentulous patients undergoing peri-implant bone augmentation procedures due to advanced peri-implant infections were included in this study ($n = 40$ implants). Furthermore, peri-implantitis was induced by ligature placement and plaque accumulation in five beagle dogs for three months following implant insertion ($n = 15$ implants). The ligatures were removed when about 30% of the initial bone was lost. During open flap surgery, configuration and defect characteristics of the peri-implant bone loss were recorded in both humans and dogs.

Results: Open flap surgery generally revealed two different classes of peri-implant bone defects. While Class I defects featured well-defined intrabony components, Class II defects were characterized by consistent horizontal bone loss. The allocation of intrabony components of Class I defects regarding the implant body allowed a subdivision of five different configurations (Classes Ia–e). In particular, human defects were most frequently Class Ie (55.3%), followed by Ib (15.8%), Ic (13.3%), Id (10.2%), and Ia (5.4%). Similarly, bone defects in dogs were also most frequently Class Ie (86.6%), while merely two out of 15 defects were Classes Ia and Ic (6.7%, respectively).

Conclusions: Within the limits of the present study, it might be concluded that configurations and sizes of ligature-induced peri-implantitis bone defects in dogs seemed to resemble naturally occurring lesions in humans.

Nowadays, there is considerable evidence supporting the view that microbial colonization plays a major role in the etiology of peri-implant infections (Mombelli et al. 1988; Becker et al. 1990; Alcoforado et al. 1991). The host response to biofilm formation on implant surfaces includes a series of inflammatory reactions that initially occur in the soft tissue (Hultin et al. 2002). Subsequently, peri-implant mucositis is a term used to describe reversible inflammatory reactions in the mucosa adjacent to an implant, whereas peri-implantitis is defined as an inflammatory process that affects the tissues around an osseointegrated implant in function, resulting in a loss of supporting alveolar bone (Albrektsson & Isidor 1994). The prevalence of peri-implantitis is difficult to estimate but may vary between 2% and 10% of all implants inserted (Esposito et al. 1998; Mombelli & Lang 1998). In recent years, an experimental peri-implantitis model was developed and used in both dogs and monkeys in order to study the pathogenesis of peri-implantitis. In this model, peri-implantitis

Peri-implant Diseases

A Review of Treatment Interventions

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KEYWORDS

• Guided bone regeneration • Laser • Nonsurgical • Peri-implantitis
• Peri-implant mucositis • Surgical • Treatment

KEY POINTS

- Risk factors of peri-implant mucositis and peri-implantitis are comparable to those of gingivitis and periodontitis.
- The ideal management of peri-implant diseases focuses on infection control, detoxification of implant surfaces, regeneration of lost tissues, and plaque control regimens via mechanical debridement.
- Implantoplasty (modification in implant surface topography), when used in combination with resective surgery, has been reported to significantly reduce the clinical parameters of peri-implantitis.
- A new technique, laser-assisted peri-implantitis protocol, is under investigation.
- There is lack of standardized treatment protocols for peri-implant disease.

Several studies[1–6] have reported that dental implants are functionally stable and have long-term success rates, and are therefore increasingly being used in the oral rehabilitation of partially and completely edentulous individuals. However, with the increasing number of patients receiving dental implants, the prevalence of inflammatory conditions around a dental implant has also escalated.[7] The consensus report from the 6th European Workshop on Periodontology has defined peri-implantitis as the presence of inflammation of the peri-implant mucosa and simultaneously loss of supporting bone.[8] In addition, it has also been described as a site-specific infection that

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ORIGINAL ARTICLE

WILEY

Morphology and severity of peri-implantitis bone defects

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Abstract

Background: Peri-implant defect morphology has shown to potentially impact upon the reconstructive outcomes for the management of peri-implantitis. Given the role that defect morphology plays upon the decision-making in the treatment of peri-implantitis, the present study aimed at assessing the morphology and severity of peri-implantitis bone defects and to insight on the patient-, implant- and site-related variables associated to these.

Material and Methods: A cone-beam computed tomography study was carried out to classify peri-implantitis defects according to the type of defect, number of remaining bony walls and severity according to the extension of vertical bone loss. Three major defect categories were proposed: class I—infraosseous; class II—horizontal; class III—combined of class I and II. These were then subclassified into: (a) dehiscence; (b) 2/3-wall; and (c) circumferential—type defect. According to the severity the defects were further subclassified into: A: advanced; M: moderate; and S: slight. In addition, 20 site-, implant-, and patient-related variables were analyzed by generalized estimating equations (GEEs) of multilevel logistic regression models.

Results: Based on an a priori power calculation, 332 implants were screened in 47 peri-implantitis patients. Of these, 158 peri-implantitis implants were eligible. The most prevalent defect morphology type was class Ib (55%) followed by class Ia (16.5%), and class IIIb (13.9%). On the contrary, the less frequent defect was class II (1.9%). The most frequent degree of severity was M (50.6%) with S (10.1%) being the least prevalent. Buccal bone loss was significantly greater compared to the other bony walls in class I and class III defects. Age was associated with the type of defect. Age and smoking habit were associated with the morphology of the defects, while smoking habit, type of prosthesis and distance to adjacent implant were associated with the severity of the defects (vertical bone loss).

Conclusion: Peri-implantitis defects frequently course with an infraosseous component and often with buccal bone loss. Certain patient-, implant-, and site-specific variables are related with defect morphology and severity. However, morphological patterns for peri-implantitis bone defects could not be proven (NCT NCT03777449).

KEYWORDS
alveolar bone, dental implants, diagnostic, implant stability, peri-implantitis, peri-implant mucositis

Non-Surgical Therapy for Peri-Implant Diseases: a Systematic Review

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ABSTRACT

Objectives: The purpose of this paper was to systematically evaluate the effectiveness of non-surgical therapy for the treatment of peri-implant diseases including both, mucositis and peri-implantitis lesions.
Material and Methods: An electronic search in two different databases was performed including MEDLINE (PubMed) and EMBASE from 2011 to 2016. Human studies reporting non-surgical treatment of peri-implant mucositis and peri-implantitis with more than 10 implants and at least 6 months follow up published in English language were evaluated. A systematic review was performed to evaluate the effectiveness of the different methods of decontamination employed in the included investigations. Risk of bias assessment was elaborated for included investigations.
Results: Twenty-five articles were identified of which 14 were further evaluated and included in the analysis. Due to significant heterogeneity in between included studies, a meta-analysis could not be performed. Instead, a systematic descriptive review was performed. Included investigations reported the used of different methods for implant decontamination, including self-performed cleaning techniques, and professionally delivered treatment such as laser, photodynamic therapy, supra-/sub-mucosal mechanical debridement, and air-abrasive devices. Follow-up periods ranged from 6 to 60 months.
Conclusions: Non-surgical treatment for peri-implant mucositis seems to be effective while modest and not-predictable outcomes are expected for peri-implantitis lesions. Limitations include different peri-implant diseases definitions, treatment approaches, as well as different implant designs/surfaces and defect characteristics.

Keywords: antibiotic prophylaxis; dental scaling; local anti-infective agents; peri-implantitis.

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ORIGINAL ARTICLE

Non-surgical therapeutic outcomes of peri-implantitis: 12-month results

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Abstract

Objectives To assess the clinical and radiographic outcomes of implants treated by means of non-surgical debridement with systemic antibiotic therapy.

Materials and methods A prospective case series study evaluating the 12-month clinical and radiographic outcomes of peri-implantitis lesions treated with ultrasonic scaler debridement, a glycine air abrasive, and metronidazole followed by supportive maintenance. Clinical and radiographic variables and success criteria were defined a priori.

Results Overall, 21 patients were included. One implant failed during the study period (implant survival rate 95.24%). Substantial changes occurred at 12 months in all the clinical and radiographic variables, reaching strong statistical significance in the majority of them. According to the success criteria applied, 40.90% of the peri-implantitis were arrested and resolved, while 59.1% presented with at least one probed site with bleeding on probing (BoP). Moreover, 95.45% exhibited peri-implant pocket depth (PPD) < 5 mm at the end of the study. None of the implants presented with progressive bone loss.

Conclusion Non-surgical therapy of peri-implantitis is effective to arrest progressive bone loss, reduce PPD and suppuration, and achieve radiographic bone fill in the majority of cases. Nevertheless, it failed to be completely efficacious in the achievement of successful therapeutic outcomes as BoP remained frequently present.

Clinical relevance Non-surgical therapy achieved significant clinical and radiological improvements.

Keywords Dental implants · Infection · Peri-implant bone loss · Peri-implant infection · Peri-implantitis · Non-surgical intervention

Introduction

The non-linear accelerative progressive pattern of bone loss in peri-implantitis leads to implant failure if the given infection is not proficiently arrested [1]. A variety of different interventions have been proposed for the treatment of peri-implantitis. Namely, non-surgical or surgical management by means of access flap debridement with numerous variants such as the use of lasers to detoxify the implant surface, implantoplasty to smooth the surface, resective procedures, and regenerative approaches [2–4]. The predictability of these interventions regarding clinical (i.e., pocket depth reduction and resolution of inflammation) and radiographic (i.e., bone fill) outcomes still remains controversial [2, 3, 5]. In fact, the therapy of peri-implantitis has been regarded as challenging and unsustainable in the long term [6–9]. Nevertheless, the treatment of peri-implantitis is essential to upgrade the implant prognosis [10, 11].

Consequently, the primary goal of peri-implantitis treatment must be the resolution of peri-implant soft tissue inflammation (i.e., no bleeding on probing, no suppuration) and the maintenance/stability of the supporting bone [9]. This desirable environment should be populated by bacteria compatible with peri-implant health [12]. This, in combination with the adherence of adequate personal-/professional-administered oral hygiene measures to eliminate biofilm deposits, should be conducive to the long-term stability of the peri-implant tissues [13].

While the non-surgical therapy for mucositis has demonstrated to be successful, predictable, and suitable for the

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Air-abrasive debridement with glycine powder versus manual debridement and chlorhexidine administration for the maintenance of peri-implant health status: a six-month randomized clinical trial

Abstract: *Study design:* This single-masked, randomized and six-month clinical intervention trial including two study groups was planned to evaluate the efficacy of maintenance treatment with glycine powder on the periodontal health of peri-implant tissues. *Methods:* A total of 46 patients with partial or total edentulism, carrying a total of 88 implants, were assigned either to an air abrasive with the glycine powder treatment group (AAD) or to a manual debridement and clorexidine administration treatment group (MDA). Clinical data were collected before treatment and at 3 and 6 months after the treatment. Plaque index (PI), bleeding index (BOP), probing depth (PD), clinical attachment level (CAL) and bleeding score (BS) were analysed. *Results:* After 3 months, AAD treatment statistically significantly improved BS ($P < 0.05$); at 6 months, AAD treatment statistically significantly improved indexes PD, PI, BOP and BS ($P < 0.05$). In addition, the AAD treatment proved to be more effective than MDA in maintaining the peri-implant health of PD at three and 6 months, and of PI at 6 months ($P < 0.05$). There were no significant changes of CAL in both groups, and all the indexes remained within the physiological levels. *Conclusions:* Within the limits of the study, treatment with glycine seems appropriate in the maintenance of peri-implant health and more effective than the traditional treatment with plastic curette and chlorhexidine.

Key words: dental implants; glycine air polishing; glycine powder; supportive periodontal therapy

Introduction

The implant-prosthetic therapy has achieved very high success rate (1, 2). In the long term, one of the main causes of failure is an infection around the implant (3).

A reversible inflammation around the implants is called peri-implant mucositis, while peri-implantitis occurs when the disease involves the loss of peri-implant bone, thus causing irreversible injury (4–10). Peri-implant mucositis can progress to peri-implantitis (11), which might finally lead to implant loss (3, 12, 13). The relation between these diseases and plaque accumulation is well established (14–28), and the problem is worryingly

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REVIEW ARTICLE

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Mechanical and biological complications after implantoplasty—A systematic review

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Abstract

Objectives: Implantoplasty, that is, the mechanical modification of the implant, including thread removal and surface smoothening, has been proposed during surgical peri-implantitis treatment. Currently, there is no information about any potential mechanical and/or biological complications after this approach. The aim of the current review was to systematically assess the literature to answer the focused question "Are there any mechanical and/or biological complications due to implantoplasty?".

Materials and methods: A systematic literature search was performed in three databases until 23/09/2018 to assess potential mechanical and/or biological complications after implantoplasty. All laboratory, preclinical in vivo, and clinical studies involving implantoplasty were included, and any complication potentially related to implantoplasty was recorded and summarized.

Results: Out of 386 titles, 26 publications were included in the present review (six laboratory, two preclinical in vivo, and 18 clinical studies). Laboratory studies have shown that implantoplasty does not result in temperature increase, provided proper cooling is used, but leads in reduced implant strength in "standard" dimension implants; further, preclinical studies have shown titanium particle deposition in the surrounding tissues. Nevertheless, no clinical study has reported any remarkable complication due to implantoplasty; among 217-291 implants subjected to implantoplasty, no implant fracture was reported during a follow-up of 3–126 months, while only a single case of mucosal discoloration, likely due to titanium particle deposition, has been reported.

Conclusions: Based on all currently available, yet limited, preclinical in vivo and clinical evidence, implantoplasty seems not associated with any remarkable mechanical or biological complications on the short- to medium-term.

KEYWORDS
complication, implant threads, implantoplasty, peri-implantitis, systematic review

1 | INTRODUCTION

It is currently accepted that treatment of peri-implantitis regularly requires surgical intervention to get adequate access to the contaminated implant surface (Klinge, Klinge, Bertl, & Stavropoulos, 2018; Renvert & Polyzois, 2018). Indeed, a variety of protocols, including mechanical or chemical means, or combinations thereof, aiming at implant surface decontamination have been proposed.

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Decontamination of dental implant surface in peri-implantitis treatment: A literature review

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Abstract

Etiological treatment of peri-implantitis aims to reduce the bacterial load within the peri-implant pocket and decontaminate the implant surface in order to promote osseointegration. The aim of this literature review was to evaluate the efficacy of different methods of implant surface decontamination. A search was conducted using the PubMed (Medline) database, which identified 36 articles including *in vivo* and i*n vitro* studies, and reviews of different decontamination systems (chemical, mechanical, laser and photodynamic therapies). There is sufficient consensus that, for the treatment of peri-implant infections, the mechanical removal of biofilm from the implant surface should be supplemented by chemical decontamination with surgical access. However, more long-term research is needed to confirm this and to establish treatment protocols responding to different implant characterics.

Key words: *Peri-implantitis, treatment, decontamination, implant surface, laser.*

Introduction

Treatments using dental implants to replace missing teeth are effective and predictable and show good long-term success rates (1,2). However, with the ever-growing popularity of implant treatments and the increasing number performed in recent years, the incidence of short-term and long-term complications has increased. One of these complications, which may lead to loss of the implant in the long term, is peri-implantitis (2).

Peri-implantitis has been defined as an inflammatory lesion of the tissues surrounding the implant subjected to functional loading, with a loss of supporting bone.
When affectation is limited to the mucosa and does not involve bone loss, it is known as mucositis (3).
The literature provides widespread evidence of peri-implantitis's microbial etiology (4), with a microbiota that is very similar to advanced periodontitis, with high levels of spirochetes and non-motile anaerobic Gram-neg-

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BEST EVIDENCE CONSENSUS

JOURNAL OF Periodontology

Laser therapy for treatment of peri-implant mucositis and peri-implantitis: An American Academy of Periodontology best evidence review

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Abstract

Background: Peri-implant diseases are prevalent, with numerous therapies studied in an attempt to combat this condition. The present review aims to systematically evaluate the effectiveness of laser therapy with non-surgical or surgical therapy in managing peri-implant mucositis and peri-implantitis.

Methods: An electronic search of three databases and a hand search of peer-reviewed journals for relevant articles published (in English) from January 1980 to June 2016 were performed. Human clinical trials of ≥ 10 patients with peri-implant diseases, treated with surgical or non-surgical approaches and laser therapy, and a follow-up period of ≥ 6 months, were included. Random-effects meta-analyses were performed to analyze weighted mean difference (WMD) and confidence interval for the recorded variables according to PRISMA guidelines. Risk of bias assessment was also performed for randomized controlled trials included.

Results: From 22 articles selected, 11 were included in the meta-analyses. The outcomes of using lasers as a monotherapy could not be evaluated since no controlled studies were identified. Therefore, all reported results were the outcomes of applying lasers as an adjunct to surgical/non-surgical treatment. For the non-surgical approach, WMD of probing depth (PD), clinical attachment level (CAL), bleeding on probing (BOP), plaque index (PI), marginal bone level (MBL) and recession (REC) was 0.15 mm ($P = 0.50$), −0.10 mm ($P = 0.32$), 21.08% ($P = 0.02$), −0.07 ($P = 0.002$), −0.22 mm ($P = 0.04$) and −0.11 mm ($P = 0.34$), respectively. For the surgical approach with a long-term follow up, WMD of PD, CAL, BOP, and PI was 0.45 mm ($P = 0.11$), 0.22 mm ($P = 0.56$), 7.26% ($P = 0.76$) and −0.09 ($P = 0.84$), respectively.

Conclusions: Current evidence shows laser therapy in combination with surgical/non-surgical therapy provided minimal benefit in PD reduction, CAL gain, amount of REC improvement, and PI reduction in the treatment of peri-implant diseases. Lasers when used as an adjunct to non-surgical therapy might result in more BOP reduction in the short term. However, current evidence allowed for analysis of only Er:YAG, CO_2, and diode lasers. Studies on others failed to have controlled evidence supporting their evaluation.

KEYWORDS

Decontamination, dental implants, lasers, meta-analyses, peri-implantitis, systematic review

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Management of peri-implant mucositis and peri-implantitis

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The use of dental implants for supporting prosthetic rehabilitations has shown highly satisfactory results regarding restoration of the patient's function and esthetics, as well as in terms of long-term survival (2). However, dental implants can lose supportive bone, even in cases of successful osseointegration. The main cause of this loss of crestal bone surrounding an implant is local inflammation during the course of peri-implant diseases. These diseases are defined as inflammatory lesions of the surrounding peri-implant tissues and include two different entities: peri-implant mucositis and peri-implantitis (7). Peri-implant mucositis is defined as an inflammatory lesion limited to the surrounding mucosa of an implant, whereas peri-implantitis is an inflammatory lesion of the mucosa that affects the supporting bone with loss of osseointegration (19).

Both peri-implant diseases are infectious in nature and are caused by bacteria from dental biofilms (18). A recent review concluded that the microbiota associated with peri-implant diseases is a mixed anaerobic infection, with a composition similar to that of the subgingival microbiota of chronic periodontitis, although some cases of peri-implant disease may be specifically associated with other bacterial species, such as *Peptostreptococcus* spp. or *Staphylococcus* spp. (22). Although bacterial pathogens represent the initial step of the disease process, the ensuing local inflammatory response and the misbalance in the host–parasite interaction seem key in the pathogenesis of the tissue destruction defining these diseases. Different risk indicators that may influence the pathogenesis in favor of tissue destruction include poor oral hygiene, a history of periodontitis and cigarette smoking. Less evidence has been demonstrated for the role of diabetes and alcohol consumption (13). The possible role of other factors, such as genetic traits, the implant surface or the lack of keratinized mucosa, are also under investigation (63).

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-implant microbiota 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-implant tissues, whilst radiographs should be used to confirm peri-implant bone loss (13, 57).

Peri-implant diseases are important disease entities as a result of their high prevalence and the lack of a standard mode of therapy (7, 35). Although the current epidemiological data are limited, peri-implant mucositis has been reported to affect 80% of the subjects with dental implants and 50% of the implants, whilst peri-implantitis affects 28–56% of the subjects and 12–43% of the implants. This reviews aims to describe the different approaches to treat peri-implant diseases and to evaluate critically the evidence available to support the different proposed therapies. With this purpose we used a recently published systematic review from our research group in which only controlled studies were considered (11). In addition, relevant recently published studies were included.

Case definitions for peri-implant diseases

Table 1 depicts the different diagnostic criteria used to define peri-implant mucositis. Although the definitions are heterogeneous, all but one (28) of the selected studies included bleeding on probing of the peri-implant mucosa. Peri-implantitis definition also varied across studies (see Table 2) but normally included the presence of bleeding on probing, deep probing depth (Fig. 1) and bone loss, although using

The Effects of Anti-infective Preventive Measures on the Occurrence of Biologic Implant Complications and Implant Loss: A Systematic Review

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Purpose: *To systematically appraise whether anti-infective protocols are effective in preventing biologic implant complications and implant loss after a mean observation period ≥ 10 years after loading.* ***Materials and Methods****: An electronic search of Medline via PubMed and Embase via Ovid databases complemented by manual search was conducted up to October 31, 2012. Studies were included provided that they were published in English, German, French, or Italian, and conducted on ≥ 20 partially and fully edentulous patients with dental implants and regular (≥ 1×/year) supportive periodontal therapy (SPT) over a mean observation period ≥ 10 years. Assessment of the identified studies and data extraction were performed independently by two reviewers. Authors were contacted if required. Collected data were reported by descriptive methods.* ***Results****: The initial electronic search resulted in the identification of 994 titles from Medline via PubMed and 531 titles from Embase via Ovid databases, respectively. After elimination of duplicate titles and exclusion of 60 full-text articles, 143 articles were analyzed, resulting in 15 studies eligible for qualitative analysis. The implant survival rate ranged from 85.7% to 99.2% after a mean observation period ≥ 10 years. One comparative study assessed the effects of regular SPT on the occurrence of biologic complications and implant loss. Overall, regular diagnosis and implementation of anti-infective therapeutic protocols were effective in the management of biological complications and prevention of implant loss. Residual probing depths at the end of active periodontal therapy and development of reinfection during supportive periodontal therapy (SPT) represented a significant risk for the onset of peri-implantitis and implant loss. Comparative studies indicated that implant survival and success rates were lower in periodontally compromised vs noncompromised patients.* ***Conclusions****: In order to achieve high long-term survival and success rates of dental implants and their restorations, enrollment in regular SPT including anti-infective preventive measures should be implemented. Therapy of peri-implant mucositis should be considered as a preventive measure for the onset of peri-implantitis. Completion of active periodontal therapy should precede implant placement in periodontally compromised patients.* Int J Oral Maxillofac Implants 2014;29(Suppl):292–307. doi: 10.11607/jomi.2014suppl.g5.1

Key words: *bone loss, complication, dental implants, implant loss, implant survival, peri-implantitis, prevention, prophylaxis, supportive periodontal therapy*

Outcomes from long-term clinical studies demonstrated that supportive periodontal therapy (SPT) after completion of active therapy is an essential component for the prevention of disease recurrence (eg, caries and periodontitis) and tooth loss.[1–5] Patients treated for advanced periodontitis and subsequently enrolled in a regular SPT program experienced a mean incidence of tooth loss ranging between 2% and 5% over an observation period of 10 years.[1,4,6–8] On the other hand, lack of enrollment in or adherence to a regular SPT program was associated with disease progression and higher rates of tooth loss.[5,9,10] In the majority of patients complying with SPT, periodontal disease progression and tooth loss occurred rarely.[10] In patients not adhering to SPT, however, a sevenfold increase in tooth loss due to periodontitis was reported compared with patients adhering to SPT over a mean period of 10 years following active periodontal therapy.[10] Despite the evident benefits of SPT following active periodontal therapy, only a minority of patients comply with the recommended recall intervals.[11–13]

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Primary prevention of peri-implantitis: Managing peri-implant mucositis

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Abstract

Aims: Over the past decades, the placement of dental implants has become a routine procedure in the oral rehabilitation of fully and partially edentulous patients. However, the number of patients/implants affected by peri-implant diseases is increasing. As there are – in contrast to periodontitis – at present no established and predictable concepts for the treatment of peri-implantitis, primary prevention is of key importance. The management of peri-implant mucositis is considered as a preventive measure for the onset of peri-implantitis. Therefore, the remit of this working group was to assess the prevalence of peri-implant diseases, as well as risks for peri-implant mucositis and to evaluate measures for the management of peri-implant mucositis.

Methods: Discussions were informed by four systematic reviews on the current epidemiology of peri-implant diseases, on potential risks contributing to the development of peri-implant mucositis, and on the effect of patient and of professionally administered measures to manage peri-implant mucositis. This consensus report is based on the outcomes of these systematic reviews and on the expert opinion of the participants.

Results: Key findings included: (i) meta-analysis estimated a weighted mean prevalence for peri-implant mucositis of 43% (CI: 32–54%) and for peri-implantitis of 22% (CI: 14–30%); (ii) bleeding on probing is considered as key clinical measure to distinguish between peri-implant health and disease; (iii) lack of regular supportive therapy in patients with peri-implant mucositis was associated with increased risk for onset of peri-implantitis; (iv) whereas plaque accumulation has been established as aetiological factor, smoking was identified as modifiable patient-related and excess cement as local risk indicator for the development of peri-implant mucositis; (v) patient-administered mechanical plaque control (with manual or powered toothbrushes) has been shown to be an effective preventive measure; (vi) professional intervention comprising oral hygiene instructions and mechanical debridement revealed a reduction in clinical signs of inflammation; (vii) adjunctive measures (antiseptics, local and systemic antibiotics, air-abrasive

Key words: chemical plaque control; mechanical plaque control; meta-analysis; peri-implant mucositis; peri-implantitis; primary prevention; secondary prevention; systematic review

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Critical Review
Implantodontology

The impact of maintenance on peri-implant health

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Abstract: Most of the literature evaluating dental implants focuses on implant survival, which is a limited proxy for the successful rehabilitation of patients with missing teeth. Success should include not only survival but also lack of mechanical, biological, and esthetics problems. A comprehensive review of local and systemic risk factors prior to implant placement will allow the tailoring of treatment planning and maintenance protocols to the patient's profile in order to achieve longitudinal success of the therapy. This review discusses the role of controlling different risk factors and prevention/treatment of peri-implant mucositis in order to avoid peri-implantitis. Although the literature addressing the topic is still scarce, the existing evidence shows that performing optimal plaque control and regular visits to the dentist seem to be adequate to prevent peri-implant lesions. Due to impossibility of defining a probing depth associate with peri-implant health, radiographic evaluations may be considered in the daily practice. So far, there is a strong evidence linking a past history of periodontal disease to peri-implant lesions, but this is not so evident for other factors including smoking and diabetes. The prevention of biological complications starts even before implant placement and include a broader analysis of the patient risk profile and tailoring the rehabilitation and maintenance protocols accordingly. It should be highlighted that the installation of implants does not modify the patient profile, since it does not modify genetics, microbiology or behavioral habits of any individual.

Keywords: Peri-Implantitis; Maintenance; Dental Implants.

Introduction

Since the discovery of osseointegration by professor Per-Ingvar Branemark in the middle 1960's, several surgical, prosthetic, and technological developments have dramatically changed implant dentistry. Recently, lower implant therapy costs have popularized the rehabilitation of fully and partially edentulous patients with the direct implication that an increasing number of individuals at greater risk of mechanical and biological failures/complications receive implants. Some of these failures can be observed in shorter periods of time, but most take place after years of function.

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Supportive peri-implant therapy following anti-infective surgical peri-implantitis treatment: 5-year survival and success

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Key words: maintenance care, peri-implantitis, success, supportive therapy, survival

Abstract

Objectives: To evaluate clinical outcomes of supportive peri-implant therapy (SPIT) following surgical treatment of peri-implantitis.

Materials and methods: Twenty-four partially dentate patients with 36 dental implants diagnosed with peri-implantitis were treated by an anti-infective surgical protocol followed by regular supportive therapy. SPIT included removal of supra- and submucosal biofilm at the treated implants using titanium or carbon fibre curettes, or ultrasonic devices. In addition, professional prophylaxis (calculus/biofilm removal) at other implants/teeth and oral hygiene reinforcement was provided. Clinical measurements and radiographs were obtained at 1, 3 and 5 years. A successful treatment outcome was defined as implant survival with the absence of peri-implant probing depths (PD) $\geq$ 5 mm with concomitant bleeding/suppuration and absence of progression of peri-implant bone loss.

Results: Twelve months after treatment, there was 100% survival of the treated implants and 79% of patients (19 of 24) had a successful treatment outcome according to the defined success criteria. At 3 years, 75% of the patients (18 of 24) had a successful treatment outcome, two patients (8%) were lost to follow-up (LTF), while 8% lost an implant, and two patients had recurrence of peri-implantitis. Between 3 and 5 years, an additional two patients were LTF, and an additional two patients each lost one implant. Thus, at 5 years 63% of patients (15 of 24) had a successful treatment outcome. Complete resolution of peri-implantitis, defined as absence of bleeding at all sites, was achieved in 42% of implants (N = 15) at 5 years.

Conclusion: Five years following regular supportive therapy, the peri-implant conditions established following peri-implantitis surgery were maintained in the majority of patients and implants. Some patients had recurrence of peri-implantitis and some lost implants over the 5-year period.

The effectiveness of peri-implantitis treatment is the subject of much debate in the recent literature. Numerous and varied non-surgical and surgical protocols have been documented in case reports and comparative studies (Heitz-Mayfield & Mombelli 2014). While some treatment protocols focus on the resolution of peri-implant infection/inflammation, others aim to achieve regeneration of the peri-implant bony defect. There are however few studies which provide evidence for the long-term outcomes following peri-implantitis treatment. Furthermore, the details of the supportive care provided following treatment are not well documented.

The role of supportive periodontal therapy in the long-term success of periodontal treatment is well established. Clinical attachment level gains have been shown to remain stable over 10 or more years following non-surgical, surgical and regenerative treatment protocols, provided maintenance care is provided on a regular basis and adequate plaque control is maintained (full mouth plaque score [FMPS] < 25%; Hirschfeld & Wasserman 1978; Axelsson & Lindhe 1981; Lindhe & Nyman 1984; Axelsson et al. 2004).

While it seems logical that similar stability might be expected following establishment of healthy peri-implant conditions, there are

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REVIEW ARTICLE

WILEY CLINICAL ORAL IMPLANTS RESEARCH

Clinical outcomes of peri-implantitis treatment and supportive care: A systematic review

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Abstract

Objectives: To report the clinical outcomes for patients with implants treated for peri-implantitis who subsequently received supportive care (supportive peri-implant/periodontal therapy) for at least 3 years.

Material and methods: A systematic search of multiple electronic databases, grey literature and hand searching, without language restriction, to identify studies including ≥10 patients was constructed. Data and risk of bias were explored qualitatively. Estimated cumulative survival at the implant- and patient-level was pooled with random-effects meta-analysis and explored for publication bias (funnel plot) at different time intervals.

Results: The search identified 5,761 studies. Of 83 records selected during screening, 65 were excluded through independent review (kappa = 0.94), with 18 retained for qualitative and 13 of those for quantitative assessments. On average, studies included 26 patients (median, IQR 21–32), with 36 implants (median, IQR 26–45). Study designs (case definitions of peri-implantitis, peri-implantitis treatment, supportive care) and population characteristics (patient, implant and prosthesis characteristics) varied markedly. Data extraction was affected by reduced reporting quality, but over 75% of studies had low risk of bias. Implant survival was 81.73%–100% at 3 years (seven studies), 74.09%–100% at 4 years (three studies), 76.03%–100% at 5 years (four studies) and 69.63%–98.72% at 7 years (two studies). Success and recurrence definitions were reported in five and two studies respectively, were heterogeneous, and those outcomes were unable to be explored quantitatively.

Conclusion: Therapy of peri-implantitis followed by regular supportive care resulted in high patient- and implant-level survival in the medium to long term. Favourable results were reported, with clinical improvements and stable peri-implant bone levels in the majority of patients.

KEYWORDS
dental implants, dental restoration failure, long-term care, meta-analysis, peri-implantitis, periodontal maintenance, supportive periodontal therapy, surgical treatment, survival, systematic review

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REVIEW ARTICLE

CLINICAL ORAL IMPLANTS RESEARCH WILEY

The effect of supportive care in preventing peri-implant diseases and implant loss: A systematic review and meta-analysis

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Abstract

Objective: To evaluate the influence of supportive treatment (SPT) during a maintenance period after implant placement on implant survival rate (SR) and incidence of peri-implant diseases.

Material and methods: A systemic literature search for studies published up to June 2018 was conducted by two independent reviewers using Pubmed/MEDLINE, EMBASE, and Cochrane Central databases. Clinical controlled trials (CCT) involved in SPT protocol with more than 1-year follow-up were included. Quantitative meta-analyses were carried out to analyze the risk ratio (RR) of SR, the incidence of peri-implantitis, and peri-implant mucositis between SPT and non-SPT groups. Any potential confounding factors were investigated using meta-regression.

Results: Nine CCTs fulfilled the criteria. To evaluate the influence of SPT on SR, peri-implantitis, and peri-implant mucositis, six of nine, three of nine, and three of nine articles were included in further meta-analysis, respectively. SPT group significantly showed higher SR (RR: 1.10; $p < 0.001$), lower prevalence of peri-implantitis (RR: 0.25; $p < 0.001$) and peri-implant mucositis (RR: 0.57; $p < 0.001$) than the non-SPT group. Meta-regression of the selected studies failed to find an association between SR, peri-implantitis, and peri-implant mucositis and confounding factors: application of chemical agents and the frequency of SPT.

Conclusion: SPT can potentially improve peri-implant health in terms of SR, peri-implantitis, and peri-implant mucositis. Additionally, the correlation in recall interval and adjunctive use of chemical agents during SPT to peri-implant diseases and implant loss could not be found.

KEYWORDS
maintenance, peri-implantitis, supportive treatment, survival rate, systematic review and meta-analysis

1 | INTRODUCTION

Peri-implant diseases such as peri-implantitis (PI) have recently gained much attention due to uprising prevalence. Recent consensus has concluded plaque as the main cause of peri-implant mucositis and PI (Berglundh et al., 2018). Similar to the process from gingivitis to periodontitis, peri-implant mucositis was regarded as the precursor for peri-implantitis (Jepsen et al., 2015). It should be noted that in spite of the reversibility of peri-implant mucositis, longer healing time compared to gingivitis was still required for complete disease

Outcome of supportive peri-implant therapy on the rates of peri-implant diseases and marginal bone loss: a systematic review and meta-analysis

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Objective: The aim of this systematic review and meta-analysis was to evaluate the impact of supportive peri-implant therapy (SPIT) on the rates of peri-implant diseases and peri-implant marginal bone loss. **Data sources:** The guidelines of PRISMA statement were followed in searching for randomized controlled trials, controlled clinical trials, and retrospective studies in several electronic databases and reference lists. The Cochrane Collaboration's Risk of Bias tools for nonrandomized studies were used to assess the risk of bias. Data were analyzed using statistical software. A total of 159 studies were identified. Five trials, with 1,570 implants in 617 patients, met the inclusion criteria. Overall meta-analysis showed significantly reduced rates of peri-implantitis with SPIT compared with non-SPIT at implant and patient levels. Peri-implant mucositis was significantly reduced with SPIT at implant level only. Peri-implant marginal bone loss was significantly reduced in patients with SPIT compared to those who did not attend SPIT. **Conclusion:** SPIT can significantly reduce the rate of peri-implantitis and marginal bone loss. The evidence on the role of SPIT in reducing the rate of peri-implant mucositis, on the other hand, remains limited. Further well-designed studies on the impact of SPIT on implant treatment outcome are still needed. **Clinical significance:** There is a need to adopt a SPIT regimen for patients receiving implant therapy to reduce the rate of peri-implant diseases and marginal bone loss. This need should be stipulated in the patient information and consent forms prior to implant therapy. *(Quintessence Int 2021;52:122–131; doi: 10.3290/j.qi.a45428)*

Key words: dental implants, meta-analysis, peri-implant marginal bone loss, review, supportive peri-implant therapy

Throughout recent decades, dental implants have dominated the prosthetic options in the replacement of missing teeth in partially and completely edentulous patients. The long-term success and predictability of dental implant therapy is well documented.[1–3] However, an increase in the reporting of associated peri-implant diseases has been observed in recent years.[4–8] These complications at their current incidence rates could be alarming considering the massive number of dental implants placed worldwide. Peri-implant diseases can occur in two forms: peri-implant mucositis and peri-implantitis. Peri-implant mucositis is a reversible condition where the inflammatory process is restricted to the soft tissues surrounding a functionally osseointegrated dental implant without any sign of bone loss. On the other hand, peri-implantitis is defined as an inflammation around a functionally osseointegrated dental implant involving both the soft tissues and surrounding bone. It is characterized by progressive bone loss beyond the initial healing phase of bone remodeling.[9] The prevalences of peri-implant diseases in patients receiving dental implant therapy were estimated at 63% for peri-implant mucositis and up to 19% for peri-implantitis.[4]

Among the potential risk factors for peri-implant diseases is the lack of supportive peri-implant therapy (SPIT).[10,11] SPIT is an essential phase of implant treatment and often follows the completion of the rehabilitation phase of treatment. The aim of SPIT is to maintain healthy peri-implant tissues around the implant prosthesis and to control risk factors/indicators. Patient

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Impact of Maintenance Therapy for the Prevention of Peri-implant Diseases: A Systematic Review and Meta-analysis

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Abstract

At the present time, peri-implantitis has become a global burden that occurs with a frequency from 1% to 47% at implant level. Therefore, we aimed herein at assessing the impact of peri-implant maintenance therapy (PIMT) on the prevention of peri-implant diseases. Electronic and manual literature searches were conducted by 3 independent reviewers using several databases, including MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, and Cochrane Oral Health Group Trials Register, for articles up to June 2015 without language restriction. Articles were included if they were clinical trials aimed at demonstrating the incidence of peri-implant diseases under a strict regime or not of PIMT. Implant survival and failure rate were studied as secondary outcomes. A meta-analysis was conducted to evaluate the influence of PIMT and other reported variables upon peri-implant diseases. Thirteen and 10 clinical trials were included in the qualitative and quantitative analysis, respectively. Mucositis was affected by history of periodontitis and mean PIMT at implant and patient levels, respectively. Similarly, significant effects of history of periodontal disease were obtained for peri-implantitis for both implant and patient levels. Furthermore, mean PIMT interval was demonstrated to influence the incidence of peri-implantitis at implant but not patient level. PIMT interval showed significance at both levels. For implant survival, implants under PIMT have 0.958 the incident event than those with no PIMT. Within the limitations of the present systematic review, it can be concluded that implant therapy must not be limited to the placement and restoration of dental implants but to the implementation of PIMT to potentially prevent biologic complications and hence to heighten the long-term success rate. Although it must be tailored to a patient's risk profiling, our findings suggest reason to claim a minimum recall PIMT interval of 5 to 6 mo. Additionally, it must be stressed that even in the establishment of PIMT, biologic complications might occur. Thus, patient-, clinical-, and implant-related factors must be thoroughly explored.

Keywords: peri-implantitis, periodontitis, mucositis, risk factors, dental implants, evidence-based dentistry

Introduction

Over the past decades, the utilization of dental implants for oral rehabilitation has been considered the standard treatment alternative in a broad variety of scenarios due to its apparent predictability (Jung et al. 2008). Nonetheless, the steady increases of biologic complications (i.e., mucositis and peri-implantitis) involving implants are triggering a shift in clinicians' decision making of saving questionable natural dentition (Rasperini et al. 2014). While mucositis is defined as the presence of reversible inflammatory soft tissue infiltrate, peri-implantitis involves the loss of bone beyond the physiologic crestal bone remodeling (Zitzmann and Berglundh 2008). Presently, peri-implantitis constitutes a global burden that occurs at a frequency from 1% to 47% at implant level (Zitzmann and Berglundh 2008; Atieh et al. 2013; Derks and Tomasi 2015; Jepsen et al. 2015). This fact may be due in part to the lack of consensus in terminology, etiology, and diagnostic criteria (Salvi and Lang 2004; Zitzmann and Berglundh 2008; Atieh et al. 2013). First, Mombelli et al. (1987) described it as an infectious disease that shares features with chronic periodontitis. Currently, although the hypothesis of bacterial infection due to plaque accumulation as the etiologic factor is still accepted (Jepsen et al. 2015), it does not appear to be a unifactorial disease, where patient-, surgical-, and prosthetic-related indicators may contribute to its development

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A supplemental appendix to this article is published electronically only at http://jdr.sagepub.com/supplemental.

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Peri-implantitis. Part 2: Prevention and maintenance of peri-implant health

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IN BRIEF

- Reviews potential modifiable and non-modifiable risk factors for per-implantitis development.
- Details strategies for the prevention of peri-implantitis.
- Proposes an implant maintenance protocol and schematic for maintenance visits.

PRACTICE

The prevention of any disease process should be the cornerstone of any healthcare provision. This ethos is well established in dentistry with plaque associated disease such as periodontitis and caries but is at the current time less developed for peri-implantitis. The current review identities potential modifiable and non-modifiable risk factors for per-implantitis development and details strategies for the prevention of the disease. These include poor oral hygiene, previous history of periodontitis, smoking, genetic factors, occlusal overload and foreign body reactions. Local factors include soft tissue and bone quality, implant positioning, restoration design and the implant-abutment interface. An implant maintenance protocol is proposed and a schematic for maintenance visits is also detailed.

INTRODUCTION

Preventing the occurrence of future disease is a fundamental component of dental practice; indeed, the prevention of plaque-associated diseases such as caries and periodontitis is a central feature of dental public health strategies across the world.[1]

Part one of this series of highlighted the importance a preventive ethos has to play when planning implant therapy due to the adverse consequences that result from peri-implantitis and the lack of established or predictably effective treatments for the condition.[2,3]

The preventive approach should begin at the outset, with appropriate case selection, and early, effective education of the patient about their role in preventive and maintenance strategies. Clinicians need to be aware of risk factors associated with the development of peri-implantitis and communicate these to the patient before implant placement. The need for ongoing maintenance following implant placement and the acceptance of the time required and costs for the necessary professional support should be outlined and documented during the consent process. Patient awareness and commitment should occur well in advance of any implant placement.

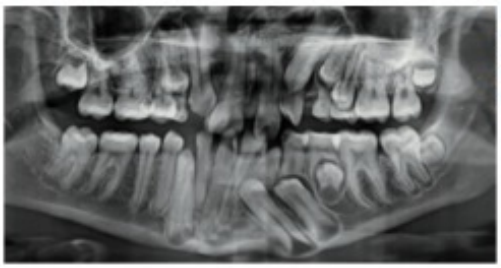

Fig. 1a This patient presented complaining of a crowded dentition and commonly managed plaque associated diseases

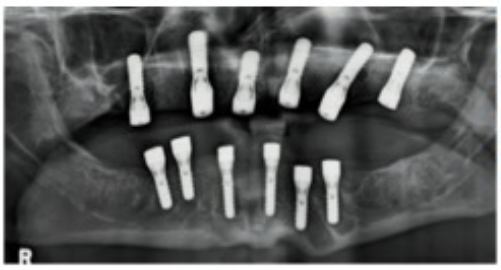

Fig. 1b Unfortunately in favour of management of the orthodontic issues and carious lesions the patient was edentulated and provided with a number of implants the majority of which had compromised angulations

CASE SELECTION

The implication of possible implant failure needs to be a major consideration when choosing between methods of tooth replacement. In addition, when comparing treatment options there needs to be a full and objective appreciation of the advantages and disadvantages of all treatment options including providing no treatment. The best interests of the patient in the short and long term must be paramount. The clinician has a professional responsibility to work within his/her competencies, ensure the patient is fully informed and provide the most appropriate care.

The patient will also require comparative information between conventional and implant prostheses, as well as what would be the sequelae if no treatment is provided. The clinician must be able to provide unbiased and robust information about all the treatment options. This is essential to make the consent more robust and the whole process transparent for both the providing clinician and the patient (Fig. 1).

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Society For Biomaterials

Review Article

Current state-of-the-art and future perspectives of the three main modern implant-dentistry concerns: Aesthetic requirements, mechanical properties, and peri-implantitis prevention

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Abstract: The idea of permanent tooth replacement goes back to the year 2000 BC at least, when carved bamboo pegs were used to replace missing teeth in ancient China. The phenomenon of osseointegration, however, was not verified until the mid-1960s, when Branemark discovered that titanium could integrate to bone. Since then, the osseointegration capacity of implants has been profoundly investigated and implants as such have evolved enormously in all possible aspects, from material selection and processing to specific surface engineering, among many others. This review article, in particular, focuses on dental implants and aims to introduce the main concerns involved in modern dentistry, concentrating especially on the importance of finding an effective way to prevent peri-implantitis. In this sense, strategies such as shifting from metal to ceramic implant components and applying novel antimicrobial antibiotic-free coatings seem to be taking the lead. © 2019 Wiley Periodicals, Inc. J Biomed Mater Res Part A: 107A: 1466–1475, 2019.

Key Words: dental implant, peri-implantitis, bactericidal glasses, aesthetic, mechanical properties

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INTRODUCTION

In recent years, technological and scientific development alongside the evolution of patient demand have led to advanced concerns in dentistry regarding the need to improve and guarantee a specific combination of aesthetic, mechanical, and biological properties. More specifically, in modern dentistry, features such as color matching aesthetics, platform switching, fast osseointegration and healing, hard and soft tissue long-term stability, and peri-implantitis prophylaxis are crucial, among many others.

In terms of the dental implant durability and success, the reliability and the stability of the implant–abutment and implant–bone interfaces play an essential role. In general, the treatment success depends on many interface-related factors. The implant-abutment connection design seems to be an important factor in modulating bone level changes around implant-supported reconstructions. Micromotion between implants and abutments depends on the design of the corresponding connection.[1] Marginal bone changes around implants with different connection types have been attributed to several etiological factors, such as biomechanical factors that increase the stress around marginal bone and potentially contribute to alveolar bone resorption. Moreover, biological factors such as peri-implant accumulation of inflammatory cells at the implant-abutment interface may contribute to marginal bone loss. The main cause of peri-implant disease is considered to be bacterial leakage at the implant-abutment connection of a two-piece implant system.[2] Microgaps at the implant-abutment interface play a significant role in the bacterial colonization of peri-implant sulcus, even in modern two-piece implant systems. The constant flux of microbiota between implant and abutment is an important factor for chronic inflammatory infiltration and marginal bone resorption. Prevention and control of bacterial

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IMPLANT DENTISTRY

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Association of prosthetic features and peri-implantitis: A cross-sectional study

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Abstract

Objective: To identify the influence of prosthetic features through a comprehensive analysis with other known risk factors.

Materials and methods: A total of 169 patients (*n* = implants: 349) was retrospectively included in the present study. Peri-implantitis was diagnosed based on peri-implant bone loss and probing depth. Using radiographs taken 1 and 5 years following prosthesis insertion, the following features were determined: peri-implant marginal bone loss (MBL), emergence angle (EA), emergence profile (EP) and crown/implant ratio (CIR). The splinted position of prosthesis was also recorded. Multivariable generalized estimating equation was used to analyse the influence of each feature on the prevalence of peri-implantitis. The final prediction model was constructed by Cox proportional hazard regression analysis.

Results: The EA showed a significant correlation with MBL. A statistically greater prevalence of peri-implantitis was observed if EA ≥ 30 degrees, when EP is convex and in middle implant splinted with both mesial and distal adjacent implants in bone-level implant. A similar correlation was not observed in tissue-level implants. CIR had no significant effect on the prevalence of peri-implantitis.

Conclusion: Over-contoured implant prosthesis is a critical local confounder for peri-implantitis. The implant splinted to both mesial and distal adjacent implant has a higher risk of peri-implantitis.

KEYWORDS
emergence angle, emergence profile, Peri-implantitis, restoration contour, splinted

1 | INTRODUCTION

Peri-implantitis is defined as a plaque-associated pathological condition occurring in tissues around dental implants, characterized by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting bone (Berglundh et al., 2018). Risk factors for peri-implantitis have been reported in numerous studies. Irregular maintenance visits, poor oral hygiene and a history of periodontitis were found to increase the risk of peri-implantitis (Derks et al., 2016; Roccuzzo, Bonino, Aglietta, & Dalmasso, 2012; Roos-Jansåker, Lindahl, Renvert, & Renvert, 2006; Roos-Jansåker, Renvert, Lindahl, & Renvert, 2006). Smoking (Degidi, Nardi, & Piattelli, 2016; Wada et al., 2019) and systemic diseases, such as diabetes (Daubert, Weinstein, Bordin, Leroux, & Flemmig, 2015) had been identified to be associated with a higher prevalence of peri-implantitis. Some studies have reported a relationship between prosthetic factors and peri-implantitis. Dalago, Schuldt Filho, Rodrigues, Renvert, and Bianchini (2017) reported that cement-retained prostheses result in an increased risk of bone loss around implants, which was likely due to the presence of residual cement in the sulcus.

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Chapter 9

Biological complications with dental implants: their prevention, diagnosis and treatment

Lang NP, Wilson TG, Corbet EF. Biological complications with dental implants: their prevention, diagnosis and treatment.
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Key words: prevention – diagnosis – treatment – microbiology – supportive therapy – mucositis – peri-implantitis

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Biofilms form on all hard non-shedding surfaces in a fluid system, i.e. both on teeth and oral implants. As a result of the bacterial challenge, the host responds by mounting a defence mechanism leading to inflammation of the soft tissues. In the dento-gingival unit, this results in the well-described lesion of gingivitis. In the implanto-mucosal unit, this inflammation is termed "mucositis". If plaque is allowed to accumulate for prolonged periods of time, experimental research has demonstrated that "mucositis" may develop into "periimplantitis" affecting the periimplant supporting bone circumferentially. Although the bony support may be lost coronally, the implant still remains osseointegrated and hence, clinically stable. This is the reason why mobility represents an insensitive, but specific diagnostic feature of "periimplantitis". More sensitive and more reliable parameters of developing and existing periimplant infections are "bleeding on probing", "probing depths" and radiographic interpretation of conventional or subtraction radiographs. Depending on the diagnosis made continuously during recall visits, a maintenance system termed Cummulative Interceptive Supportive Therapy (CIST) has been proposed.

Rationale

All implants may be subject to mechanical complications. Since these are dependent on technical rather than biological factors, they will be dealt with in a separate report. Although the possibility of the loss of osseointegration due to traumatic forces from occlusal overload is not disregarded (Isidor 1996), the scientific evidence for such processes has not yet been established (Tonetti & Schmid 1994). An analysis of the clinical trials of the ITI® system revealed a very small proportion of failures which seem to be associated with occlusal overload.

Many retrospective and prospective studies on the survival of ITI® dental implants have noted late (defined as occurring following successful prosthetic reconstruction) failures (Buser et al. 1990; Mericske-Stern 1990; ten Bruggenkate et al. 1990; Buser et al. 1991; Mericske-Stern et al. 1994; Versteegh et al. 1995; Buser et al. 1997; Ellegaard et al. 1997).

Consensus Statements and Recommended Clinical Procedures Regarding Implant Survival and Complications

Primary authors: Niklaus P. Lang, Tord Berglundh, Lisa J. Heitz-Mayfield, Bjarni E. Pjetursson, Giovanni E. Salvi, Mariano Sanz

INTRODUCTORY REMARKS

The working group based its discussion on 2 systematic reviews published in 2002, 2 systematic reviews published in 2004 on related topics, and 3 traditional reviews prepared specifically for this consensus workshop (see reference list).

After extensive discussion, the previously unpublished reviews were amended where indicated, and consensus was reached that the reviews were both comprehensive and complete in covering the available published literature up to August of 2003. Hence, the papers were accepted and formed the basis for the consensus report on implant survival and complications. Subsequent to the consensus meeting, the quoted literature was updated up to December 2003.

For the purpose of clarification and understanding of the evaluated literature, the working group adopted a glossary of terms.

GLOSSARY OF TERMS

- *Survival:* The element (implant or reconstruction) is present at the follow-up examination but its condition is not specified.
- *Success:* The element (implant or reconstruction) is present at the follow-up examination, and complications are absent.
- *Loss:* The element (implant or reconstruction) is no longer present at the time of the follow-up examination.
- *Complications:* Chair time is required after incorporation of the prosthesis.
- *Failure:* Either the element (implant or reconstruction) is lost or a complication is present at the follow-up examination. Hence, this term will generally be avoided and replaced by the above-mentioned terms.
- *FPD:* Fixed partial denture

Terms related to biologic complications/peri-implant disease:

- Mucositis: Localized lesion without bone loss around an osseointegrated implant
- Peri-implantitis: Localized lesion including bone loss around an osseointegrated implant
- Soft tissue complications: Fistula, excessive swelling, hyperplasia, etc

Terms related to technical complications:

- Implant-related: Fracture
- Connection-related: Loosening, fractures
- Suprastructure-related: Framework, veneer, loss of retention (fracture of the cement seal)

CONSENSUS STATEMENTS

Single Crowns and Overdentures

A recently published systematic review addressed the incidence of implant loss and complications of oral implants supporting single crowns over at least 5 years.[1] The analysis was based on 8 studies and yielded an early loss of 0.8% before prosthetic placement and an incidence of 2% to 2.5% loss during 5 years of function. The same systematic review reported 2.5% implant loss prior to the placement of overdentures and nearly 6% implant loss during 5 years of function.

Fixed Partial Dentures

The systematic reviews prepared for this consensus workshop reported exclusively on complica-tion and survival rates of fixed partial dentures (FPDs), either implant-supported or implant/ tooth-supported.

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Decision Tree for the Management of Periimplant Diseases

Kozue Okayasu, DDS,* and Hom-Lay Wang, DDS, MSD, PhD†

The development of implants reflects one of the foremost breakthroughs of dentistry. As the market keeps growing exponentially, the implantologist faces an unavoidable challenge, that is, how to deal with the complications associated with implants. Literature published so far has focused in dealing with the technical and surgical aspects of implant therapy. Information regarding the management of periimplant diseases is rather lacking. Hence, the purpose of this article is to provide an overview and description of periimplant diseases, along with treatment recommendations. (Implant Dent 2011;20:256–261)

Key Words: periimplant diseases, implant, periimplantitis, periimplant mucositis, complications

It is not too much to say that the development of implants is the foremost breakthrough of modern dentistry. Since Dr. Brånemark identified the principles of osseointegration in 1969 between pure titanium and human bone,[1] this tooth replacement technique keeps growing exponentially as evidenced by the extensive implant systems available in the market. With the evolution of implant dentistry, the idea to replace missing teeth became more appealing to patients. The mission of the implantologist is to maintain a patient's oral health while restoring a functional dentition with enhanced esthetics. As a result of a better ability to masticate, the quality of life is improved.[2] However, are implantologists ready to carry out the mission while maintaining high quality of treatments that meet the standard of care? How reliable are the current data with regard to the quality of implant care that is provided by implantologists worldwide?

The current evidence has demonstrated high implant success rates.[3–9] Nonetheless, implant complications do arise and clinicians will have to face these challenges in their daily practice; despite the improvement of technology and science, the human body is still vulnerable to diseases. Bacterial plaque with concomitant occlusal overload are well-established causes of implant failures.[10] The bacterial plaque-associated implant complications are inflammatory processes referred to as periimplant mucositis and periimplantitis. As these represent a new challenge for clinicians, the goal of this article is to provide an overview and description of periimplant diseases, along with treatment recommendations.

WHAT ARE PERIIMPLANT DISEASES?

Periimplant diseases comprise nonspecific inflammatory reactions that occur in the host tissues.[11–14] Inflammation that occurs within the periimplant soft tissues is defined as periimplant mucositis and is often considered as a reversible reaction. Clinical features of periimplant mucositis include, but are not limited to, the presence of bleeding on probing (BOP), swelling of the periimplant mucosa, increase of probing depth (mainly pseudopockets), and/or erythema of the surrounding tissues. On the other hand, when the inflammatory lesion reaches to the bone, it is referred to as periimplantitis.[15] Periimplantitis, an irreversible process, is characterized by radiographic bone loss, bleeding or suppuration upon probing, increased pocket depth, pain, swelling, or fistula.[16]

When an implant presents with clinical mobility, it is defined as a failed implant.[16] However, a failing implant usually refers to a progressive bone loss without implant mobility. Implants can fail at several stages: an early implant failure refers to the lack of initial osseointegration due to an inability to establish an intimate bone-to-implant contact (BIC). Factors that may contribute to early implant failures include, but are not limited to, premature loading, surgical trauma, or impaired healing response (eg, medically compromised and AIDS).[17,18] Late failure, on the other hand, occurs after initial integration, physiological remodeling, and loading. Occlusal overload and bacterial infection are among some of the causes of late failures.[19] It is uncommon to see failures after the first year of loading.[5,20] In contrast, "ailing implants," also

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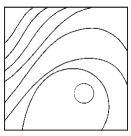
Guidelines for the Diagnosis and Treatment of Peri-implant Diseases



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Although some risk factors of peri-implant disease are well defined, the lack of efficient and predictable approaches to treat peri-implantitis has created difficulty in the management of those complications. The aim of this review was to evaluate the reliability of the diagnosis methods and to provide a set of guidelines to treat peri-implant diseases. A search of PubMed and a hand search of articles related to peri-implant diseases were conducted up to August 2013. A summary of the current methods for the diagnosis of peri-implantitis, its potential risk factors, and a flow chart to guide the clinical management of these conditions are presented.
(Int J Periodontics Restorative Dent 2014;34:e102–e111. doi: 10.11607/prd.1994)

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Implant therapy is a predominant and useful armamentarium for patients with missing teeth. An increased number of procedures with no clear etiology of complications has led to an increase in cases of peri-implant disease. Peri-implant diseases may occur in two forms, peri-implant mucositis and peri-implantitis.[1] *Peri-implant mucositis* is an inflammatory lesion that resides in the soft tissue surrounding a dental implant without signs of bone loss following the initial bone remodeling. In contrast, *peri-implantitis* also affects the supporting bone, causing progressive bone loss beyond the normal biologic remodeling.[2] Peri-implantitis appears in combination with marginal bone loss (MBL) greater than 3 mm, bleeding on probing (BOP) or purulence, or both.[3] It has been estimated that 12% to 43% of implants have bone loss in combination with BOP,[4] with a prevalence of approximately 10% for implant-supported single crowns.[5]

Different cross-sectional studies have investigated potential risk indicators for peri-implant diseases, including poor oral hygiene, smoking, pre- or coexisting periodontitis,

The Therapy of Peri-implantitis: A Systematic Review

Lisa J. A. Heitz-Mayfield, BDS, MDSc, Odont Dr[1]/Andrea Mombelli, Prof Dr Med Dent[2]

Purpose: *To evaluate the success of treatments aimed at the resolution of peri-implantitis in patients with osseointegrated implants.* **Materials and Methods:** *The potentially relevant literature was assessed independently by two reviewers to identify case series and comparative studies describing the treatment of peri-implantitis with a follow-up of at least 3 months. Medline, Embase, and The Cochrane Library were searched. For the purposes of this review, a composite criterion for successful treatment outcome was used which comprised implant survival with mean probing depth < 5 mm and no further bone loss.* ***Results:*** *A total of 43 publications were included: 4 papers describing 3 nonsurgical case series, 13 papers describing 10 comparative studies of nonsurgical interventions, 15 papers describing 14 surgical case series, and 11 papers describing 6 comparative studies of surgical interventions. No trials comparing nonsurgical with surgical interventions were found. The length of follow-up varied from 3 months to 7.5 years. Due to the heterogeneity of study designs, peri-implantitis case definitions, outcome variables, and reporting, no meta-analysis was performed. Eleven studies could be evaluated according to a composite success criterion. Successful treatment outcomes at 12 months were reported in 0% to 100% of patients treated in 9 studies and in 75% to 93% of implants treated in 2 studies. Commonalities in treatment approaches between studies included* (1) *a pretreatment phase,* (2) *cause-related therapy, and* (3) *a maintenance care phase.* ***Conclusions:*** *While the available evidence does not allow any specific recommendations for the therapy of peri-implantitis, successful treatment outcomes at 12 months were reported in a majority of patients in 7 studies. Although favorable short-term outcomes were reported in many studies, lack of disease resolution as well as progression or recurrence of disease and implant loss despite treatment were also reported. The reported outcomes must be viewed in the context of the varied peri-implantitis case definitions and severity of disease included as well as the heterogeneity in study design, length of follow-up, and exclusion/inclusion criteria.* Int J Oral Maxillofac Implants 2014;29(Suppl):325–345. doi: 10.11607/jomi.2014suppl.g5.3

Key words: *peri-implantitis, systematic review, treatment, therapy*

Peri-implantitis—an infectious condition of the tissues around osseointegrated implants with loss of supporting bone and clinical signs of inflammation (bleeding and/or suppuration on probing)—has a prevalence on the order of 10% of implants and 20% of patients 5 to 10 years after implant placement.[1] The numbers of patients with a history of periodontitis and those who are smokers in a cohort, as well as the type and frequency of aftercare, are factors that influence these prevalence data. Furthermore, the prevalence of peri-implantitis will vary depending on the bone loss threshold and/or probing depth threshold used for case definition. Various clinical protocols for prevention and treatment of peri-implantitis have been proposed, including mechanical debridement, the use of antiseptics and local or systemic antibiotics, as well as surgical access and regenerative procedures. Several attempts to combine the data of the available literature in a meta-analysis have failed in the past due to insufficient data.[2–6] In a recent review on a part of this literature,[7] it was noted that almost all reports on the treatment of naturally occurring peri-implantitis in humans do in fact not satisfy the strict criteria for a randomized controlled trial (RCT). The absence of a true control group (no treatment or placebo) was a common limitation. Trials at the highest level of evidence compared test procedures, both of which had an unclear outcome. As it is difficult to recruit sufficient numbers of patients with peri-implantitis to take part in a true randomized trial, some studies may have

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Periodontology 2000

Treatment of pathologic peri-implant pockets

Stefan Renvert & Ioannis Polyzois

The peri-implant mucosa has a number of features similar to the gingival tissues surrounding teeth. It is a well-keratinized oral epithelium and creates a cuff-like barrier that has been proven to adhere to the implant's collar by a hemidesmosomal attachment originating from the junctional epithelium cells (80, 83) (Fig. 1). The collagen fibers, originating at the level of the crestal bone, are parallel to the implant surface and as they cannot insert into the body of the implant, this makes them more susceptible to trauma. After the installation of titanium fixtures, a predominantly gram-negative subgingival anaerobic microflora is established on their surface (36). This bacterial aggregation in contact with the peri-implant mucosa leads to inflammation and bone loss. Similarly to the process seen around natural teeth, inflammation and bone loss will eventually lead to increased probing depths (48).

It has been demonstrated that an inflammatory lesion develops in the mucosa around teeth and implants as a reaction to *de novo* plaque formation (4). These lesions are localized in the marginal portion of the soft tissue between the keratinized oral epithelium and the junctional epithelium (4). If no treatment is provided and the lesion progresses, a large B-cell lymphocyte infiltrate develops. A number of studies demonstrated similarities in the host-cell response at implants diagnosed with peri-implantitis and at teeth with periodontitis (5, 6, 47). However, differences exist, and elastase-producing cells have been reported to be more common in peri-implantitis. This finding suggests that peri-implantitis is a more acute type of inflammation (23).

Peri-implant lesions progress in an apical direction and do not seem to be encapsulated by collagen fibers, as are periodontitis lesions (1, 37) (Fig. 2). Histology data acquired from human biopsy specimens have identified an inflammatory infiltrate consisting of plasma cells, lymphocytes, macrophages and numerous polymorphonuclear leukocytes in approximately 65% of the connective tissue around implants with peri-implantitis. This finding could explain the increased amounts of elastase found in peri-implantitis lesions compared with the lesions around teeth. Further observations suggest that the inflammatory infiltrate in peri-implantits lesions is in direct contact with the alveolar bone and can extend into the alveolar bone marrow spaces (37, 82). In periodontal lesions the inflammatory infiltrate does not spread to the bone but is separated from it by noninflamed connective tissue, the thickness of which is about 1 mm. Finally, the cytokine profile differs somewhat between peri-implant and periodontal sites. Cytokines with the potential to activate osteoclasts have been found in both sites but their profile differs in that interleukin-1alpha appears to be the most prevalent cytokine in peri-implantitis, whereas tumor necrosis factor-alpha is the most common cytokine in chronic periodontitis (33).

The majority of diagnostic methods conventionally used in periodontics have been adopted by clinicians and researchers to diagnose peri-implant diseases as well as to assess the health status of peri-implant tissues. These methods include clinical, radiographic and laboratory examinations. The periodontal probe has been an invaluable tool over the years in assessing the clinical status and depth of the periodontal pocket and the level of the marginal crest of the mucosa. Additionally, bleeding on probing or suppuration following probing have been considered as standard clinical evaluations (Fig. 3). Concerns about the accuracy of probing around implants as a result of the design of the supragingival implant components and the position of the implants has led the periodontal community to recommend a more flexible plastic probe for examination of the peri-implant pockets (Fig. 4). Another reason why it would be prudent to question the ability of the periodontal probe to lend its

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Journal of Clinical Periodontology

Impact of defect configuration on the clinical outcome following surgical regenerative therapy of peri-implantitis

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Schwarz F, Sahm N, Schwarz K, Becker J. Impact of defect configuration on the clinical outcome following surgical regenerative therapy of peri-implantitis. J Clin Periodontol 2010; 37: 449–455. doi: 10.1111/j.1600-051X.2010.01540.x.

Abstract

Objectives: The present study aimed at investigating the impact of defect configuration on the clinical outcome of surgical regenerative therapy of peri-implantitis lesions using a natural bone mineral in combination with a collagen membrane (NBM+CM).

Materials and Methods: Twenty-seven patients ($n = 27$ defects) exhibited three different types of peri-implantitis lesions including either Class Ib (buccal dehiscence+semicircumferential), Class Ic (buccal dehiscence+circumferential), or Class Ie (circumferential) intra-bony defects ($n = 9$ defects per group). All defects were treated with access flap surgery and the application of NBM+CM.

Results: At 6 and 12 months, Class Ie defects tended to reveal higher changes in the mean probing depth (PD) and clinical attachment level (CAL) values when compared with Class Ib and Class Ic groups. However, significant differences were only observed at 6 months (PD: 2.9 ± 0.3 *versus* 1.4 ± 0.5 *versus* 1.3 ± 0.7 mm; CAL: 2.5 ± 0.5 *versus* 0.9 ± 0.8 *versus* 0.9 ± 0.7 mm). Site-level analysis has pointed to lowest PD and CAL changes at the midbuccal aspect of Class Ib and Class Ic groups.

Conclusion: Defect configuration may have an impact on the clinical outcome following surgical regenerative therapy of peri-implantitis lesions. While Class Ie defects seem to be promising in conjunction with NBM+CM, Class Ib and Class Ic may be considered as unfavourable.

Key words: bone graft; collagen membrane; defect configuration; peri-implantitis; surgical regenerative therapy

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Previous results from controlled clinical studies have pointed out that non-surgical treatment of peri-implantitis appears to be unpredictable and potential beneficial clinical outcomes may be limited to a period of 6–12 months (Schwarz et al. 2005, 2006a, d, Renvert et al. 2006, 2008, 2009a). This strong tendency towards a re-infection of the peri-implant pocket may primarily be explained by the limited efficacy of a non-surgical surface debridement procedure to completely remove bacterial contaminants from exposed structured titanium implant surfaces, thus impeding the establishment of a new bone-to-implant contact (BIC) (Schwarz et al. 2006c). In contrast, surgical treatment of peri-implantitis lesions using open flap debridement and a submerged healing procedure was proven to be more effective in promoting bone regeneration and BIC in animals (Schwarz et al. 2006c, Renvert et al. 2009b). Consequently, numerous experimental studies have focused on the potential improvement of surgical protocols including implant surface debridement and decontamination as well as a combination with bone augmentation procedures and the principle of guided bone regeneration (GBR) (Claffey et al. 2008). Limited clinical data suggest that the clinical outcome obtained following surgical regenerative therapy of peri-implantitis appears to be more predictable than any

Conflict of interest and source of funding statement

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CLINICAL ORAL IMPLANTS RESEARCH

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Outcome of surgical treatment of peri-implantitis: results from a 2-year prospective clinical study in humans

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Key words: peri-implantitis, peri-implant bone loss, peri-implant surgery, surgery outcome

Abstract

Aim: The aim of the present study was to evaluate the outcome of a surgical procedure based on pocket elimination and bone re-contouring for the treatment of peri-implantitis.

Material and methods: The 31 subjects involved in this study presented clinical signs of peri-implantitis at one or more dental implants (i.e. ≥ 6 mm pockets, bleeding on probing and/or suppuration and radiographic evidence of ≥ 2 mm bone loss). The patients were treated with a surgical procedure based on pocket elimination and bone re-contouring and plaque control before and following the surgery. At the time of surgery, the amount of bone loss at implants was recorded.

Results: Two years following treatment, 15 (48%) subjects had no signs of peri-implant disease; 24 patients (77%) had no implants with a probing pocket depth of ≥ 6 mm associated with bleeding and/or suppuration following probing. A total of 36 implants (42%) out of the 86 with initial diagnosis of peri-implantitis presented peri-implant disease despite treatment. The proportion of implants that became healthy following treatment was higher for those with minor initial bone loss (2–4 mm bone loss as assessed during surgery) compared with the implants with a bone loss of ≥ 5 mm (74% vs. 40%). Among the 18 implants with bone loss of ≥ 7 mm, seven were extracted. Between the 6-month and the 2-year examination, healthy implants following treatment tended to remain stable, while deepening of pockets was observed for those implants with residual pockets.

Conclusion: The results of this study indicated that a surgical procedure based on pocket elimination and bone re-contouring and plaque control before and following surgery was an effective therapy for treatment of peri-implantitis for the majority of subjects and implants. However, complete disease resolution at the site level seems to depend on the initial bone loss at implants. Implants with no signs of peri-implantitis following treatment tended to remain healthy during the 2-year period, while a tendency for disease progression was observed for the implants that still showed signs of peri-implant disease following treatment.

Bleeding and/or suppuration following probing has been proposed as a valuable clinical sign for the diagnosis of both peri-implant mucositis and peri-implantitis while the concomitant detection of marginal peri-implant bone loss in radiographs will distinguish a peri-implantitis from a mucositis (Zitzmann & Berglundh 2008).

Bacteria play a major role in the aetiology of peri-implant mucositis and peri-implantitis (Pontoriero et al. 1994; Augthun & Conrads 1997; Mombelli & Lang 1998; Leonhardt et al. 1999; Quirynen et al. 2002, 2006). Animal experiments have shown that plaque accumulation on the implant surfaces seems to be critical to the development of peri-implant diseases (Berglundh et al. 1992; Ericsson et al. 1992; Lang et al. 1994) and may be responsible for altering the biocompatibility of the implant surfaces. Thus, the treatment of both mucositis and peri-implantitis in human is based on plaque removal from the implant surfaces. With this type of treatment two questions arise:

(1) Is it possible to re-establish healthy condition for the tissues of an implant affected by peri-implant disease? Regarding this question, plaque removal using a non-surgical debridement/decontamination of the implant surfaces seems to be effective in the treatment of peri-implant mucositis, while limited effect of this procedure has been reported for the treatment of peri-implantitis (for review see Renvert et al. 2008a, 2008b); experimental studies have shown resolution of peri-implantitis following the surgical exposure of the implants and the mechanical debridement/decontamination of the implant surfaces (for review see Claffey et al. 2008).

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Journal of Clinical Periodontology

A single-centre randomized controlled clinical trial on the adjunct treatment of intra-bony defects with autogenous bone or a xenograft: results after 12 months

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Aghazadeh A, Persson GR, Renvert S. A single-centre randomized controlled clinical trial on the adjunct treatment of intra-bony defects with autogenous bone or a xenograft: results after 12 months. J Clin Periodontol 2012; 39: 666–673. doi: 10.1111/j.1600-051X.2012.01880.x.

Abstract

Background: Limited evidence exists on the efficacy of regenerative treatment of peri-implantitis.

Material and Methods: Subjects receiving antibiotics and surgical debridement were randomly assigned to placement of autogenous bone (AB) or bovine-derived xenograft (BDX) and with placement of a collagen membrane. The primary outcome was evidence of radiographic bone fill and the secondary outcomes included reductions of probing depth (PD) bleeding on probing (BOP) and suppuration.

Results: Twenty-two subjects were included in the AB and 23 subjects in the BDX group. Statistical analysis failed to demonstrate differences for 38/39 variables assessed at baseline. At 12 months, significant better results were obtained in the BDX group for bone levels ($p < 0.001$), BOP ($p = 0.004$), PI ($p = 0.003$) and suppuration ($p < 0.01$). When adjusting for number of implants treated per subject, a successful treatment outcome PD $\leq$ 5.0 mm, no pus, no bone loss and BOP at 1/4 or less sites the likelihood of defect fill was higher in the BDX group (LR: 3.2, 95% CI: 1.0–10.6, $p < 0.05$).

Conclusions: Bovine xenograft provided more radiographic bone fill than AB. The success for both surgical regenerative procedures was limited. Decreases in PD, BOP, and suppuration were observed.

Key words: antibiotics; bone grafting; peri-implant disease; peri-implantitis; surgical therapy

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Peri-implantitis resulting in bone loss around implants is difficult to treat. In studies evaluating the effects of different non-surgical therapies of peri-implantitis, decreases in (BOP and some reductions in PD have been reported (Schwarz et al. 2006a,b, Renvert et al. 2009, Persson et al. 2010, Sahm et al. 2011). In cases with bone loss exposing parts of the implant surface to microbial colonization, either an osseous surgery approach, open flap debridement, or a regenerative procedure may be

Cochrane Library

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Interventions for replacing missing teeth: treatment of peri-implantitis (Review)

Esposito M, Grusovin MG, Worthington HV

Esposito M, Grusovin MG, Worthington HV.
Interventions for replacing missing teeth: treatment of peri-implantitis.
Cochrane Database of Systematic Reviews 2012, Issue 1. Art. No.: CD004970.
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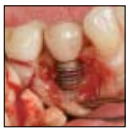
www.cochranelibrary.com

Successful Management of Peri-Implantitis with a Regenerative Approach: A Consecutive Series of 51 Treated Implants with 3- to 7.5-Year Follow-up



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The results of a case series of 51 consecutively treated, peri-implantitis–affected implants in 38 patients with follow-up measurements from 3 to 7.5 years are presented. Each implant displayed bleeding on probing, probing depths ≥ 6 mm, and bone loss ≥ 4 mm prior to surgery. A successful regenerative approach including surface decontamination, use of enamel matrix derivative, a combination of platelet-derived growth factor with anorganic bovine bone or mineralized freeze-dried bone, and coverage with a collagen membrane or a subepithelial connective tissue graft was employed in all cases. Patients were divided into two groups. Group 1 included patients in which the greatest defect depth was visible on radiographs; group 2 included patients in which the greatest loss of bone was on the facial or oral aspect of the implant. Bone level changes in patients in group 2 were determined by probe sounding under local anesthesia. Probing depth reductions at 3 to 7.5 years of follow-up were 5.4 and 5.1 mm in groups 1 and 2, respectively. Concomitant bone level gain was 3.75 mm in group 1 and 3.0 mm in group 2. No implant in either group lost bone throughout the duration of the study. The results to date with this regenerative approach for the treatment of peri-implantitis appear to be encouraging. (Int J Periodontics Restorative Dent 2012;32:11–20.)

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Peri-implantitis has been defined as an inflammatory process affecting the hard and soft tissues surrounding an implant in function.[1] This term was first introduced in the late 1980s,[2] and since, there have been a number of articles discussing its diagnosis and etiology. More recently, there have been six systematic reviews regarding the treatment of peri-implantitis.[3–8] The authors concluded that while many different treatment algorithms have been offered, including nonsurgical mechanical debridement[9,10] with or without the use of local or systemic antibiotics,[11–13] the addition of lasers to these treatments,[14,15] the use of access flaps combined with antimicrobial therapy, and regenerative procedures,[16–23] none of these approaches have evidence corroborating their long-term predictability. At best, a 5-year clinical follow-up study using systemic antibiotics and access surgery demonstrated a 58% success rate in resolution of the peri-implant disease.[18]

Bacterial plaque typically has been implicated as the cause of peri-implantitis, and as such, treatment

CLINICAL ORAL IMPLANTS RESEARCH

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Anti-infective surgical therapy of peri-implantitis. A 12-month prospective clinical study

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Key words: anti-infective treatment, chlorhexidine, implant surface, peri-implantitis, surgical debridement, systemic antimicrobials

Abstract

Aim: The aim of this prospective cohort study was to evaluate an anti-infective surgical protocol for the treatment of peri-implantitis.

Materials and methods: Thirty-six implants in 24 partially dentate patients with moderate to advanced peri-implantitis were treated using an anti-infective surgical protocol incorporating open flap debridement and implant surface decontamination, with adjunctive systemic amoxicillin and metronidazole. Treatment outcomes were assessed at 3, 6 and 12 months. Patient-based statistical analyses using multiple regression analyses were performed.

Results: There was 100% survival of treated implants at 12 months. At 3 months, there were statistically significant ($P < 0.01$) reductions in mean probing depths (PD), Bleeding on Probing (BoP) and suppuration. The greater the mean PD at baseline, the greater the PD reduction at 3 months. At 3 months, there was also a significant mean facial mucosal recession of 1 mm ($P < 0.001$). All these changes were maintained at 6 and 12 months. At 12 months, all treated implants had a mean PD < 5 mm, while 47% of the implants had complete resolution of inflammation (BoP negative). At 12 months, 92% of implants had stable crestal bone levels or bone gain. There were no significant effects of smoking on any of the treatment outcomes.

Conclusions: For the treatment of peri-implantitis, an anti-infective protocol incorporating surgical access, implant surface decontamination and systemic antimicrobials followed by a strict postoperative protocol was effective at 3 months with the results maintained for up to 12 months after treatment.

Peri-implantitis is defined as an inflammatory lesion in the surrounding peri-implant tissues with loss of supporting bone (Zitzmann & Berglundh 2008). Peri-implantitis is diagnosed when there is Bleeding on Probing (BoP) in addition to radiographic evidence of loss of supporting bone (i.e. crestal bone loss exceeding that which is expected following crestal remodelling after implant placement and insertion of the reconstruction). Additional clinical findings, including suppuration, deep probing depths (PD) (>5 mm) or mucosal recession are frequently observed (Heitz-Mayfield 2008; Lang & Berglundh 2011).

The prevalence of peri-implant disease has been documented in three cross-sectional studies from Scandinavia, reporting that peri-implantitis is a common complication in implant therapy with 28% of subjects affected in one Swedish study (Fransson et al. 2008), 47% in another study in Norway (Koldsland et al. 2010) and $\geq$56% of patients affected in another study in Sweden (Roos-Jansaker et al. 2006; Zitzmann & Berglundh 2008).

The primary goals of peri-implantitis therapy are to resolve inflammation and to arrest the progression of disease. As the aetiology of peri-implantitis is similar to that of periodontitis, anti-infective protocols comparable to those used to treat periodontitis have been adopted to treat peri-implantitis (Lang et al. 2000; Heitz-Mayfield & Lang 2010). However, few clinical studies are available evaluating

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Network Meta-Analysis for Evaluating Interventions in Implant Dentistry: The Case of Peri-Implantitis Treatment

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ABSTRACT

Background/Aim: Evidence from head-to-head comparison trials on peri-implantitis treatment is limited, and it is therefore impossible to conduct a direct meta-analysis. We propose an alternative statistical method, network meta-analysis, for evidence synthesis, which enables to compare the results of multiple treatments.

Methods: We searched, in triplicate, for randomized controlled trials (RCTs) and controlled trials in the PubMed, Cochrane Central Register of Controlled Trials, Clinicaltrials.gov, and Latin American and Caribbean Health Sciences Literature databases up to and including August 2010. We also conducted a manual search of the reference lists regarding published systematic reviews and searched for gray literature in OpenSIGLE. We assessed changes in clinical attachment level (CAL) and pocket probing depth (PPD) after nonsurgical and surgical treatments of peri-implantitis. The risk of bias of selected studies was determined by the use of specific criteria, and it was performed in triplicate and independently. We used multilevel mixed modeling to perform the network meta-analysis and Markov Chain Monte Carlo simulation to obtain confidence intervals for the fixed and random effects.

Results: Eleven studies were included in the review. All RCTs are at unclear or high risk of bias. Surgical therapy in conjunction with bone grafts and non-resorbable membranes achieved 3.52 mm greater PPD reduction than nonsurgical therapy alone, 95% high-probability density (HPD) intervals: –0.19, 6.81. Surgical treatment in conjunction with bone grafts and resorbable membranes achieved 2.80 mm greater CAL gain than nonsurgical therapy alone, 95% HPD intervals: –0.18, 5.59.

Conclusion: Surgical procedures in peri-implantitis treatment achieve more PPD reduction and CAL gain than nonsurgical approaches. Nevertheless, these results should be interpreted with caution because of the limited number of studies included and their low methodological quality. Network meta-analysis is a useful statistical methodology for evidence synthesis and to summarize the strength and limitation in the current evidence.

KEY WORDS: network meta-analysis, nonsurgical treatment, peri-implantitis, surgical treatment

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INTRODUCTION

Peri-implantitis is an inflammatory reaction in the tissues surrounding a dental implant and is characterized by loss of supporting bone.[1] Depending on its severity, implant failure can occur as a consequence of loss of bone around the implants. In recent decades, a variety of therapies has been proposed for treatment and control of the disease. Conservative approaches, for example, dental implant surface scaling with/without application of adjunctive materials, such as irrigation substance[2,3] or antibiotics,[2] have resulted in improved outcomes, such as clinical attachment level (CAL) gain and pocket probing depth (PPD) reduction. Furthermore, there is some evidence that surgical procedures with or without

CLINICAL ORAL IMPLANTS RESEARCH

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Combined surgical therapy of advanced peri-implantitis lesions with concomitant soft tissue volume augmentation. A case series

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Key words: bone graft, collagen membrane, connective tissue, implantoplasty, peri-implantitis, surgical regenerative therapy

Abstract

Objectives: Mucosal recessions are a common finding following surgical treatment of peri-implantitis, thus compromising the overall esthetic outcome of implant therapy. This case series aimed at evaluating the clinical outcome of a combined surgical therapy of advanced peri-implantitis lesions with concomitant soft tissue volume augmentation.

Material and methods: Ten patients (n = 13 implants exhibiting combined supra- and intrabony defects) underwent access flap surgery, implantoplasty at bucally and supracrestally exposed implant parts, and augmentation of the intrabony components using a natural bone mineral and a native collagen membrane after surface decontamination. A subepithelial connective tissue graft was harvested from the palate and adapted to the wound area to support transmucosal healing. Clinical parameters (i.e. bleeding on probing – BOP; probing depths – PD; mucosal recession – MR; clinical attachment level – CAL) were recorded at baseline and after 6 months.

Results: At 6 months, the combined surgical procedure was associated with a significant reduction in mean BOP (74.39 ± 28.52%), PD (2.53 ± 1.80 mm), and CAL (2.07 ± 1.93 mm) values. Site-level analysis has pointed to a slight increase in mean mucosal height (0.07 ± 0.5 mm) at the buccal aspects (i.e. mb, b, db).

Conclusion: The combined surgical procedure investigated may be effective in controlling advanced peri-implantitis lesions without compromising the overall esthetic outcome in the short term.

Previous studies have indicated that surgical treatment of peri-implantitis with concomitant placement of autogenous bone or various types of bone substitutes may be associated with clinical and radiographic improvements on both short- and long-term periods of up to 4 years (Schwarz et al. 2009; Roos-Jansaker et al. 2011; Aghazadeh et al. 2012). While the beneficial effect of a barrier membrane is still in question, some evidence suggests that defect configuration, implant surface characteristics as well as the method of surface debridement and decontamination may have an impact on the clinical outcome following surgical regenerative therapy of peri-implantitis (Schwarz et al. 2010, 2012a; Roccuzzo et al. 2011).

Recently, a combined surgical resective and regenerative treatment procedure was introduced for the management of advanced peri-implantitis defects (Schwarz et al. 2011a). In particular, this approach combined a smoothening of buccally and supracrestally exposed implant parts by rotating burrs (i.e. implantoplasty) with the application of a natural bone mineral (NBM) and a native collagen membrane (CM) at the intrabony defect components. Despite significant improvements in re-establishing a new bone-to-implant contact at the histologic level (Schwarz et al. 2011b) and resolving infection after 6 and 24 months of healing, this specific surgical procedure was associated with an increase in mucosal recession over time (Schwarz et al. 2011a, 2012a,b). Because similar outcomes were also noted in conjunction with open flap debridement or regenerative treatment procedures alone (Schwarz et al. 2008b, 2010; Heitz-Mayfield et al. 2012), the decision to employ such approaches should consider the esthetic demands of the patient at respective implant sites.

To overcome this limitation, the aim of this case series was to evaluate the clinical

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Review

Surgical Management of Peri-Implantitis: A Systematic Review and Meta-Analysis of Treatment Outcomes

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Background: This systematic review was requested by the Task Force of the American Academy of Periodontology as a follow-up study of the 2013 report, with an aim to investigate the efficacy of different surgical approaches to treat peri-implantitis.

Methods: A search of four electronic databases from January 1990 to May 2013 was performed. Studies included were human clinical trials published in English that applied surgeries for treating peri-implantitis. Parameters evaluated included probing depth (PD) reduction, clinical attachment level gain, bleeding on probing (BOP) reduction, radiographic bone fill (RBF), and mucosal recession. The weighted mean (WM) and the 95% confidence interval of the studied parameters were estimated with the random-effect model.

Results: A total of 1,306 studies were initially identified, after reviewing titles, abstracts, and full texts, and 21 articles, 12 of which were case series, were finally included. Four treatment groups were identified: 1) access flap and debridement; 2) surgical resection; 3) application of bone grafting materials; and 4) guided bone regeneration. The mean initial PD ranged from 4.8 to 8.8 mm, with initial BOP ranging from 19.7% to 100%. Short-term follow-ups (3 to 63 months) revealed that the available surgical procedures yielded a WM PD reduction of 2.04 (group 2) to 3.16 mm (group 4), or 33.4% to 48.2% of the initial PD. The WM RBF was 2.1 mm for groups 3 and 4.

Conclusions: Within the limitation of this systematic review, the application of grafting materials and barrier membranes resulted in greater PD reduction and RBF, but there is a lack of high-quality comparative studies to support this statement. The results might be used to project treatment outcomes after surgical management of peri-implantitis. *J Periodontol 2014;85:1027-1041.*

KEY WORDS

Anti-infective agents; debridement; guided tissue regeneration; osseointegration; peri-implantitis; treatment outcome.

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† Taubman Health Sciences Library, University of Michigan.

With an increasing number of implants being placed, peri-implantitis is becoming a prevalent and notable disease, affecting 2.7% to 47.1% of implants.[1-5] Identical to periodontitis, microbial plaque is the main etiologic factor of peri-implantitis.[6] It has been shown that the infected sites harbor a higher proportion of periodontal pathogens.[7,8] Because peri-implantitis shares many features of periodontitis,[9] such as clinical presentations, etiology, and pathogenesis, strategies used to treat periodontitis were adopted for managing peri-implantitis.[10,11] These non-surgical or surgical approaches share common goals of eliminating infection and restoring lost structures and function. Although effective in treating peri-implant mucositis, non-surgical therapy is unable to eradicate peri-implantitis.[12] The surgical therapy is currently the mainstream approach for treating peri-implantitis.[13] A contained, deep defect may be amenable for regeneration, whereas a shallow defect may respond more favorably with resective surgery. With the rising prevalence of peri-implantitis, there is an urgent need to identify an effective treatment procedure.

One of the goals of surgical therapy is to gain access for effective surface decontamination. Surfaces contaminated by microbes are not conducive to bone-forming cells; therefore, surface decontamination is critical for reosseointegration. Mechanical means of

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A Regenerative Approach to the Successful Treatment of Peri-implantitis: A Consecutive Series of 170 Implants in 100 Patients with 2- to 10-Year Follow-up

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This article presents the results of a consecutive case series of 170 treated peri-implantitis–affected implants in 100 patients with follow-up measurements from 2 to 10 years. A total of 51 implants in 38 patients previously reported on were followed for an additional 2.5 years, and 119 additional implants in 62 additional patients were treated with the same protocol and monitored for at least 2 years posttreatment. The treatment consisted of flap reflection, surface decontamination, use of enamel matrix derivative (EMD) or platelet-derived growth factor (PDGF), and guided bone regeneration with mineralized freeze-dried bone and/or anorganic bovine bone combined with PDGF or EMD and covered with an absorbable membrane and/or subepithelial connective tissue graft. Maintenance and monitoring followed every 2 to 3 months. Two implants were lost 6 months posttreatment, for a 98.8% survival rate. Bleeding on probing was eliminated in 91% of the treated implants. Probing depth reduction averaged 5.10 mm, bone level gain averaged 1.77 mm, and soft tissue marginal gain averaged 0.52 mm. These outcomes were obtained with one surgical procedure on 140 implants, with two procedures on 18 implants, and with three procedures on 10 implants. The results to date with this layered/combined regenerative approach for the treatment of peri-implantitis appear to be encouraging. (Int J Periodontics Restorative Dent 2015;35:857–863. doi: 10.11607/prd.2571)

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Peri-implantitis, defined as an inflammatory condition affecting the tissues surrounding an implant and resulting in bleeding on probing (BoP) and loss of supporting bone,[1] has been reported to have a prevalence of between 6% and 36% of implants in function for more than 5 years.[2] One consensus report, in fact, stated that peri-implantitis was identified in 56% of subjects and 43% of implant sites.[3] The varying prevalence of the condition reflects the differing thresholds of bone loss used in the various studies to define its existence.[4] Two recent systematic reviews and a meta-analysis reported that peri-implantitis affected approximately 10% of implants and 20% of patients 8 to 10 years after implant placement.[5,6] By 2020, it is estimated, 2 to 4 million implants will be placed annually in North America.[7] Considering the number of implants placed or projected to be placed from 2013 to 2017 in the United States alone, this estimate would predict that over 1.2 million implants will require therapy for this disease.[8]

However, treatment strategies reported on vary significantly, and this is reflected in the comments made in recent systematic reviews.[3,9–15] One systematic review concluded that the evidence available is insufficient to allow specific recommendations for peri-implantitis

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RANDOMIZED CLINICAL TRIAL

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Open flap debridement of peri-implantitis with or without adjunctive systemic antibiotics: A randomized clinical trial

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Abstract

Aims: To investigate clinical, radiographic and microbiological outcome over 12 months following open flap debridement of peri-implantitis with or without antibiotics.

Materials and methods: Peri-implantitis was surgically treated with or without Zithromax® in 19 control and 20 test individuals. Probing pocket depth (PPD), gingival inflammation (BOP), intra-oral radiographs and microbial samples were studied. Per protocol and intent-to-treat analyses were performed.

Results: The mean difference (reduction) in PPD values between baseline and month 12 in the test and control groups was 1.7 mm (*SD* ± 1.1, 95% CI: 1.1, 2.3, $p < .001$) and 1.6 mm (*SD* ± 1.5, 95% CI: 0.8, 2,4, $p < .001$), respectively. Data analysis failed to show study group differences for BOP, PPD, radiographic bone level and microbial load. Successful treatment (per protocol: PPD ≤ 5 mm, no BOP, no suppuration and no bone loss ≥0.5 mm) at 12 months in test and control groups was 7/15 (46.7%) and 4/16 (25.0%). Bacterial load reduction was similar in study groups with a temporary reduction following treatment.

Conclusions: Surgical treatment of peri-implantitis with adjunctive systemic azithromycin did not provide 1-year clinical benefits in comparison with those only receiving open flap debridement.

KEYWORDS
antibiotics, microbiota, peri-implantitis, surgical treatment

1 | INTRODUCTION

Peri-implantitis is an inflammatory process leading to irreversible loss of implant supporting bone. The current clinical definition of peri-implantitis was established at two European Workshops (Lang & Berglundh, 2011; Sanz & Chapple, 2012). A cluster of bacteria has been associated with peri-implantitis (Charalampakis, Rabe, Leonhardt, & Dahlen, 2011; Persson & Renvert, 2014). The development of a complex infectious microbiota represents a clinical challenge in peri-implantitis management (Renvert, Roos-Jansaker, & Claffey, 2008).

Mechanical treatment of peri-implantitis alone may not resolve the disease. Two recent meta-analyses have provided evidence that adjunctive use of azithromycin improves the efficacy of non-surgical periodontal therapy (Renatus, Herrmann, Schonfelder, Schwarzenberger, & Jentsch, 2016; Zhang, Zheng, & Bian, 2016). Few studies have assessed the outcome of systemic administration of antibiotics in combination with surgical intervention of peri-implantitis (Javed et al. 2013). Stable clinical conditions through a combination of surgery combined with regenerative procedures and systemic antibiotics can be obtained (Roos-Jansaker, Lindahl, Persson, & Renvert, 2011; Roos-Jansaker, Persson, Lindahl, & Renvert, 2014). Carcuac et al. (2016) have demonstrated that adjunctive systemic antibiotics did not influence the treatment success at implants with a non-modified surface, whereas benefits were observed at implants with a modified surface. Although surgical resective and/or augmentative procedures have shown promising results in the treatment of peri-implantitis, the effect on the clinical outcome of surgical treatments needs to be further investigated (Schwarz, Schmucker, & Becker, 2015).

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RANDOMIZED CLINICAL TRIAL

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Surgical treatment of peri-implantitis: 3-year results from a randomized controlled clinical trial

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Abstract

Objectives: This study reports on the 3-year follow-up of patients enrolled in a randomized controlled clinical trial on surgical treatment of advanced peri-implantitis.

Material and Methods: A total of 100 patients with advanced peri-implantitis were randomly assigned to one of four treatment groups. Surgical therapy aiming at pocket elimination was performed and, in three test groups, supplemented by either systemic antibiotics, use of an antiseptic agent for implant surface decontamination or both. Outcomes were evaluated after 1 and 3 years by means of clinical and radiological examinations. Differences between groups were explored by regression analysis.

Results: Clinical examinations at 3 years after treatment revealed (i) improved peri-implant soft tissue health with a mean reduction in probing depth of 2.7 mm and a reduction in bleeding/suppuration on probing of 40% and (ii) stable peri-implant marginal bone levels (mean bone loss during follow-up: 0.04 mm). Implant surface characteristics had a significant impact on 3-year outcomes, in favour of implants with non-modified surfaces. Benefits of systemic antibiotics were limited to implants with modified surfaces and to the first year of follow-up.

Conclusion: It is suggested that surgical treatment of peri-implantitis is effective and that outcomes of therapy are affected by implant surface characteristics. Potential benefits of systemic antibiotics are not sustained over 3 years.

KEYWORDS
dental implant, implant surface characteristics, surgical treatment

1 | INTRODUCTION

Peri-implantitis is a common complication in patients provided with implant-supported restorative therapy (Derks et al., 2016). The disease is characterized by an extensive inflammatory lesion residing in peri-implant soft tissues (Carcuac & Berglundh, 2014) and by loss of peri-implant marginal bone (Lindhe & Meyle, 2008).

Studies evaluating treatment outcomes of peri-implantitis rarely included follow-up periods of more than 1 year. The few studies that reported on long-term results were generally characterized by limited sample sizes and lack of control groups (Froum, Froum, & Rosen, 2012; Heitz-Mayfield et al., 2016; Roccuzzo, Pittoni, Roccuzzo, Charrier, & Dalmasso, 2017; Roos-Jansåker, Persson, Lindahl, & Renvert, 2014; Schwarz, John, Schmucker, Sahm, & Becker, 2017; Serino, Turri, & Lang, 2015). The studies were not designed to evaluate treatment strategies and to identify predictors for treatment outcomes. Thus, the understanding on the effect of different treatment protocols for advanced peri-implantitis is limited.

We recently reported 1-year results of a randomized clinical trial on the surgical treatment of severe peri-implantitis including a study sample

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ORIGINAL RESEARCH

WILEY CLINICAL ORAL IMPLANTS RESEARCH

Long-term outcome of surgical treatment of peri-implantitis. A 2-11-year retrospective study

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Abstract

Objective: To assess long-term clinical and radiological outcomes of surgical treatment of peri-implantitis.

Material and methods: Files and radiographs from 50 patients who had received surgical treatment for peri-implantitis were analyzed. Data on clinical characteristics prior to surgical therapy and at latest follow-up were obtained. In each radiograph, the marginal bone level was assessed at the mesial and distal aspects of the affected implants. The treatment included oral hygiene instruction, professional supra-mucosal instrumentation, and surgical therapy aiming at pocket elimination. Following flap elevation and removal of inflamed tissue, the affected implant was cleaned using gauze soaked in saline. Calculus was removed. When indicated, osseous re-contouring was carried out to facilitate pocket elimination. Flaps were adjusted, sutured, and compressed to the crestal bone. Supportive therapy including oral hygiene control was provided with 4-month intervals.

Results: Treatment was effective in resolving the inflammatory condition as documented by marked reduction in peri-implant probing depth and bleeding on probing scores together with crestal bone level preservation. Treatment outcome was significantly better at implants with non-modified surfaces than at implants with modified surfaces. The probability of an implant to exhibit no further bone loss or bone gain after treatment was high if the peri-implant mucosa at the site presented with shallow pockets and the absence of bleeding on probing at follow-up.

Conclusions: The results of the study revealed that (i) surgical treatment of peri-implantitis was effective in the long-term, (ii) outcome was better at implants with non-modified than with modified surfaces, and (iii) preservation of crestal bone support was consistent with healthy peri-implant tissue conditions.

KEYWORDS
clinical, dental implant, modified implant surface, radiographs

1 | INTRODUCTION

Peri-implantitis is pathological condition occurring in tissues surrounding dental implants. It is characterized by inflammation in the peri-implant mucosa and loss of supporting bone (Carcuac & Berglundh, 2014). Results from a systematic review indicate that one of five patients restored with implant-supported prosthesis is likely to exhibit peri-implantitis at one or several implants (Derks & Tomasi, 2015).

Treatment of peri-implantitis has been evaluated in both pre-clinical and clinical studies (Graziani, Figuero, & Herrera, 2012; Schwarz, John, Mainusch, Sahm & Becker, 2012). Most of the clinical

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RANDOMIZED CLINICAL TRIAL

WILEY Journal of Clinical Periodontology

Surgical treatment of peri-implantitis lesions with or without the use of a bone substitute—a randomized clinical trial

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Abstract

Aim: To assess whether the treatment outcome differed between surgical debridement, with or without a bone substitute.

Materials and Methods: Forty-one adults with three- or four-wall peri-implant bone defects were enrolled in a 1-year RCT. Surgical debridement (control group), or in combination with a bone substitute (Endobon®) (test group) was performed.

Results: Radiographic evidence of defect fill (primary outcome) was only significant in the test group ($P = 0.004$). At year 1, no bleeding on probing (BOP) in the control and test groups were 7/20 (35%) and 10/21 (47.6%), respectively ($\chi^2 = 0.67$, $P = 0.41$). Plaque scores did not differ by study group at baseline ($P = 0.31$), or at year 1 ($P = 0.08$). Mid-buccal soft tissue recession changes did not differ by groups ($P = 0.76$). Successful treatment outcome (defect fill ≥1.0 mm, PPD values at implant ≤5 mm, no BOP, and no suppuration was identified in 1/20 (5.0%) control, and 9/21 (42.9%) test individuals ($F = 7, 9$, $P < 0.01$). Number needed to treat analysis identified an absolute risk reduction of 32.8% in benefit of the test procedure. ($F = 7, 9$, $P < 0.01$).

Conclusions: Successful treatment outcome using a bone substitute was more predictable when a composite therapeutic endpoint was considered.

KEYWORDS
bone grafting, peri-implantitis, radiographs, surgical treatment

1 | INTRODUCTION

Non-surgical treatment options may not effectively allow debridement of titanium dental implants (Froum et al., 2016; Heitz-Mayfield et al., 2018; Papathanasiou, Finkelman, Hanley, & Parashis, 2016; Renvert, Widén, & Persson, 2017; Schwarz, Becker, & Renvert, 2015). In a recent systematic review, the conclusion was that non-surgical debridement approach was effective in the treatment of implant mucositis, but not predictable in the treatment of peri-implantitis (Suárez-López Del Amo, Yu, & Wang, 2016).

In a recent meta-analysis, the conclusion was that there is a lack of scientific evidence regarding the superiority of the reconstructive treatment of peri-implantitis (Daugela, Cicciù, & Saulacic, 2016).

A failure rate of approximately 60% of cases treated surgically for peri-implantitis has been reported (de Waal, Raghoebar, Meijer, Winkel, & van Winkelhoff, 2016). Other studies have reported successful outcome by surgical debridement methods (Froum et al., 2016), or reconstructive surgical treatment of peri-implantitis (Ramanauskaite, Daugela, & Juodzbalys, 2016). Several studies have used combinations of grafts and barrier membranes (Aghazadeh, Persson, & Renvert,2012; Khoury & Buchmann, 2001; Roos-Jansåker, Renvert, Lindahl, & Renvert, 2007; Schwarz, Hegewald, Sahm, & Becker, 2014; Schwarz, Sahm, Bieling, & Becker, 2009). Animal research has demonstrated that it is possible to regenerate bone to achieve re-osseo-integration on a previously infected implant surface (Alhag, Renvert, Polyzois, & Claffey, 2008; Kolonidis et al., 2003; Polyzois, Renvert, Bosshardt, Lang, & Claffey, 2007; Schou et al., 2003).

The objective of the present RCT was to assess if surgical debridement of peri-implantitis defects, including chemical detoxification of

Surgical Treatment of Periimplantitis With Non–Augmentative Techniques

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Objectives: *The aim of this review was to systematically screen the literature on surgical non–regenerative treatments of periimplantitis, especially for radiologic and clinical outcomes, and to determine predictable therapeutic options for the clinical management of periimplantitis lesions.*

Material and Methods: *The potentially relevant literature was assessed independently by 2 reviewers to identify clinical studies, trials, and case series in humans describing the surgical non–regenerative treatment outcomes of periimplantitis with a follow-up of at least 6 months. MEDLINE, EMBASE, and the Cochrane Library were searched for studies reporting changes in probing depth (PD) and/or bleeding on probing (BOP) and/or radiologic marginal bone-level changes.*

Results: *A total of 10 publications were included: 6 prospective randomized controlled trials, 1 prospective cohort study, 2 retrospective controlled studies, and 1 case series. Clinical parameters can be reduced by surgical non–regenerative treatments. Concerning 3 year follow-ups, BOP and PD values decreased more efficiently after implantoplasty than using systematic administration of antibacterials. Adjunctive local chemical irrigations or diode laser have no long-term effects. The non–regenerative surgical approach in combination with implantoplasty also shows improved radiographic parameters.*

Conclusions: *Surgical non–regenerative treatment of periimplantitis can reduce the amount of inflammation in the short-term follow-up. Using implantoplasty may result in the improvement of clinical and radiographic parameters. Because of limited evidence and heterogeneity in study design, there is a need for randomized controlled studies with proper design and powerful sample size in the future. (Implant Dent 2019;28:177–186)*

Key Words: periimplant, dental implants, periodontitis, periimplant disease, CIST, resective, non–augmentative, therapy, implantoplasty

Periimplant diseases are defined as "collective term for inflammatory reactions in the tissues surrounding the implants,"[1] whereas periimplantitis was introduced as an inflammatory process on hard and soft tissue, resulting in pathological pocket formation and loss of supporting bone.[2]

The wide range in prevalence rates of 2.7% to 47.1% of implants[1,3,4] can be attributed to differences in the study population, disease dentition, and implant micro- and macrostructures. Therefore, an effective strategy for treating this disease is required, otherwise a debilitating condition around the affected implants will result in loss of function and esthetics.

The development of an adherent biofilm on the implant surface plays an important role in the etiology of periimplantitis.[2] As a result of this multifactorial, but significant role of bacteria in the initiation and progress of infection of periimplant diseases, elimination of the established biofilm from the implant surface is the main objective in the treatment of periimplant mucositis and periimplantitis.[5]

Several clinical protocols for the treatment of periimplantitis have been proposed, including mechanical debridement, the use of antiseptics and local or systemic antibiotics,[6,7] surgical access,[8–10] and regenerative[11–14] or resective surgical procedures.[15–18]

The aim of this review is to systematically screen the literature on surgical non–regenerative treatments of periimplantitis, especially for radiologic and clinical outcomes, and to determine predictable therapeutic

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WILEY

ORIGINAL ARTICLE

Two to six-year disease resolution and marginal bone stability rates of a modified resective-implantoplasty therapy in 32 peri-implantitis cases

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Abstract

Background: Different nonsurgical, antibacterial, surgical, and regenerative approaches to treat peri-implantitis have been proposed, but there is no an actual "gold" standard treatment showing the most favorable results to counteract peri-implantitis effects.

Purpose: To evaluate radiographically and clinically the disease resolution and peri-implant marginal bone stability rates of peri-implantitis cases treated through a combined resective-implantoplasty therapy in a moderate to long-term period.

Materials and Methods: Records of patients diagnosed with peri-implantitis and treated through the same protocol applying a combined resective-implantoplasty therapy with minimum 2-year follow-up were screened. Eligible patients were contacted and asked to undergo clinical and radiologic examination. Progressive marginal bone loss, bleeding on probing, suppuration, implant mobility, and implant fracture were considered to establish the disease resolution rate and peri-implant bone stability of the treated implants.

Results: Twenty-three patients with 32 treated implants fulfilled the inclusion criteria. Over the 2 to 6-year follow-up, (mean time: 3.4 ± 1.5 years), the disease resolution rate was 83% (patient level) and 87% (implant level). Four implants (13%) were lost or removed due to continuous MBL and osseointegration failure. At follow-up, peri-implant marginal bone remained stable with no further bone loss in 87% of the treated implants. BOP was absent in 89.3% (implant level), suppuration was resolved in all cases, and no pain or implant fracture was reported.

Conclusion: Implantoplasty treated cases showed high disease resolution rate and peri-implant marginal bone stability. This surgical antibiofilm strategy can counteract peri-implantitis progression providing an adequate environment for implant function and longevity over a moderate to long-term period.

KEYWORDS
implant survival, implantoplasty, peri-implantitis, peri-implant lesions

Long-Term Outcome of Surgical Regenerative Treatment of Peri-implantitis: A 2- to 21-Year Retrospective Evaluation

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Marisa Roncati, RDH, DDS[3]
Mario Aimetti, MD, DDS[2]

The aim of this retrospective study was to evaluate long-term clinical and radiologic outcomes of submerged and nonsubmerged guided bone regenerative treatments for peri-implantitis lesions. Strict methods of implant-surface decontamination and detoxification were performed. Data on clinical probing depth, soft tissue measures, and marginal bone level that were documented by comparative radiographs were obtained from 45 patients, for a total of 57 implants prior to treatment and at the latest follow-up. The average follow-up period was 6.9 years (range: 2 to 21 years). Analysis of implant-based data revealed a success rate of 70.2% for a total of 40 implants. Recurrence of peri-implantitis was observed on 9 implants, and 8 implants were removed. The regenerative procedures, under a strict periodontal control, were effective in the treatment of moderate to advanced peri-implantitis lesions. Int J Periodontics Restorative Dent 2020;40:487–496. doi: 10.11607/prd.4647

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Peri-implantitis is defined as an inflammatory process around an implant characterized by both soft tissue inflammation and progressive loss of supporting bone beyond biologic bone remodeling,[1–3] affecting considerable proportions of the dental implants that were inserted and initially osseointegrated in the oral cavity.[4–6]

Defect identification is crucial to reach a correct diagnosis, which consequently can direct adequate treatment.[7] Different surgical treatment modalities have been described with different results,[8–16] and several bone regenerative procedures, combined with concomitant soft tissue augmentation,[16] have been proposed to reduce objectionable esthetic effects; but these procedures have a limited long-term follow-up,[10,15,16] small sample size, and different treatment protocols and outcome measures.[17–23]

Long-term results on surgical regenerative treatment of peri-implantitis have been based on a few studies, and some on a reduced number of patients or with inconsistent results, which rarely included evaluations of bone level changes.[24–26]

The aim of this retrospective observational study was to evaluate the long-term clinical and radiologic outcomes following surgical regenerative treatment of peri-implant

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REVIEW ARTICLE

The effect of surgical regenerative treatment for peri-implantitis: A systematic review

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KEYWORDS

Peri-implantitis;
Peri-implant diseases;
Alveolar bone grafting;
Alveolar bone loss;
Bone regeneration

Abstract *Objectives:* The purpose of the present study was to systematically review literature on the effectiveness of surgical regenerative treatment for peri-implantitis.

Methods: Different databases were searched including the Cochrane Central Register of Controlled Trials, EMBASE and MEDLINE. Primary outcomes were changes in probing pocket depth (PPD), bleeding on probing (BOP), radiographic marginal bone level (RBL) and signs of infection. Secondary outcomes were facial marginal recession, aesthetic outcomes and cost of treatment. Only randomised controlled trials (RCTs) with a minimum of 12 months follow-up period after regenerative surgical treatment were selected according to PRISMA guidelines.

Main results: Five studies were selected. The highest mean reduction of PPD was 3.1 mm in a bovine-derived xenograft (BDX) group. The highest percentage reduction of BOP occurred in patients treated with implantoplasty and saline (a reduction of 85.2%). The highest mean defect fill of RBL was reported in the porous titanium granules group (3.6 mm). Mean reductions of PPD, RBL and facial marginal soft tissue recession were statistically insignificant (p-value > 0.05) in the studies included. However, the mean reduction in BOP was statistically significant (p-value < 0.05) in four studies as compared to the baseline (before treatment). A high heterogeneity among the studies included, regarding surgical protocols, defects morphology and selection of biomaterials, was found.

Conclusion: All studies included showed an improvement in clinical conditions after surgical regenerative treatment for peri-implantitis. However, no study has shown any statistical significance in its approach. There is a lack of scientific evidence in literature regarding which type of bone substitute has superiority in the treatment of peri-implantitis, as well as the role of barrier

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Impact of bone defect morphology on the outcome of reconstructive treatment of peri-implantitis

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Abstract

Objectives: To assess if (I) the alveolar bone defect configuration at dental implants diagnosed with peri-implantitis is related to clinical parameters at the time of surgical intervention and if (II) the outcome of surgical intervention of peri-implantitis is dependent on defect configuration at the time of treatment.

Materials and methods: In a prospective study, 45 individuals and 74 dental implants with ≥ 2 bone wall defects were treated with either an autogenous bone transplant or an exogenous bone augmentation material. Defect fill was assessed at 1 year.

Results: At baseline, no significant study group differences were identified. Most study implants (70.7%, $n = 53$) had been placed in the maxilla. Few implants were placed in molar regions. The mesial and distal crestal width at surgery was greater at 4-wall defects than at 2-wall defects ($p = 0.001$). Probing depths were also greater at 4-wall defects than at 2-wall defects ($p = 0.01$). Defect fill was correlated to initial defect depth ($p < 0.001$). Defect fill at 4-wall defects was significant ($p < 0.05$).

Conclusions: (I) The buccal-lingual width of the alveolar bone crest was explanatory to defect configuration, (II) 4-wall defects demonstrated more defect fill, and (III) deeper defects resulted in more defect fill.

Keywords: Peri-implantitis, Bone grafting, Reconstruction, Regeneration, Bone defect, Radiograph

Introduction

Peri-implantitis is a complication following replacement of teeth using dental implants. In a recent meta-analysis, the authors identified that peri-implantitis is a common disease with an estimated weighted mean prevalence of 43% [1]. According to the existing definition of peri-implantitis, the condition is always associated with bone loss exceeding the loss of bone resulting from remodelling [2]. In many cases, the loss of bone in peri-implantitis is related to the presence of intraosseous defects.

Definitions of the topography of alveolar bone lesions associated with bone defects at dental implants have been presented [3–5]. The defect morphology has been reported to influence the healing potential following reconstructive therapy of peri-implantitis [3]. From a clinical perspective, the decision to perform resective or reconstructive procedures may be affected by defect configuration. Resective surgery may be used for the elimination of peri-implant lesions, whereas reconstructive therapies may be applied to obtain defect fill [5, 6]. Reconstructive surgical treatment of peri-implantitis may be enhanced by using deproteinized bovine material or an enamel matrix derivate [7]. In a recent meta-analysis, the authors concluded that although the evidence was limited, the use of grafting material and barrier membranes may contribute to a better reduction of probing depth and more evidence of defect fill [8].

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