TRABAJO DE FIN DE GRADO

Grado en Odontología

NON-SURGICAL TREATMENT OF PERI-IMPLANTITIS

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1 SUMMARY

La periimplantitis es una enfermedad multifactorial que presenta un origen infeccioso modulado por la respuesta del huésped y que afecta a los tejidos del implante. Su manejo consiste en disminuir la carga de patógenos periodontales para restablecer el equilibrio favorable entre el huésped y las bacterias para lograr la curación periodontal. En la literatura científica se han propuesto varias alternativas de tratamiento para lograr este resultado, y la terapia no quirúrgica debería ser siempre la opción de tratamiento inicial, independientemente del grado de periimplantitis. De hecho, esta última proporciona más tiempo para que el clínico evalúe la evolución de la enfermedad, cómo están curando los tejidos y compruebe si hay una regresión de la inflamación.

Para ello, exploraremos diversos estudios entre los tratamientos no quirúrgicos, y evaluaremos su eficacia y limitaciones. La investigación bibliográfica se realizó a través de las siguientes bases de datos bibliográficas PubMed, Medline, Cochrane y revisiones; y se seleccionaron artículos centrados en el desbridamiento mecánico, la terapia antiséptica coadyuvante, la terapia antibiótica coadyuvante y la terapia asistida por láser. Se utilizaron noventa artículos en total. Se llegó a la conclusión de que, dependiendo del grado de la enfermedad, la terapia no quirúrgica asociada al cumplimiento por parte del paciente podría dar lugar a una mejora significativa. El raspado de los implantes dentales con o sin la aplicación de material complementario, como antisépticos, antibióticos o láser, ha mostrado resultados positivos, como la reducción del número de focos de sangrado, el nivel de fijación clínica y la disminución del número de bolsas periodontales. El uso de antisépticos como coadyuvantes sigue siendo controvertido. En combinación con el desbridamiento mecánico, la administración local de antibióticos, a diferencia de la ingestión sistémica de los mismos, ha tenido un impacto positivo en los parámetros

clínicos y microbiológicos. Algunos láseres también tienen un futuro prometedor en la resolución de la periimplantitis; de hecho, conducen a una reducción bacteriana eficaz y tienen una menor tendencia a dañar la superficie del implante.

Sin embargo, el tratamiento no quirúrgico parece ser eficaz sólo a corto plazo y puede dañar la micromorfología del implante. También presenta algunas debilidades, especialmente en el caso de lesiones avanzadas. También necesitamos más estudios para conocer la mejor opción adyuvante, según el caso. Seguimos luchando por determinar el remedio óptimo para tratar esta enfermedad, ya que la mayoría de los tratamientos presentan similitudes en su grado de eficacia. Por desgracia, aún no se ha encontrado una terapia que conduzca a la resolución completa de la enfermedad.

Palabras clave: periimplantitis, tratamiento no quirúrgico, efectividad, limitaciones.

2 ABSTRACT

Peri-implantitis is a multifactorial disease that presents an infectious origin modulated by the host response and affects the implant's tissues. Its management consists of decreasing periodontal pathogens' charge to restore a host/bacteria's favorable balance to achieve periodontal healing. Several treatment alternatives have been proposed in the scientific literature to achieve this result, and non-surgical therapy should constantly be the initial treatment option, no matter the grade of peri-implantitis. Indeed, the latter provides more time for the clinician to evaluate the disease's evolution, how the tissues are healing and check if there is a regression of the inflammation.

For this purpose, we will explore various studies among non-surgical treatments, and we will evaluate its effectiveness and limitations. Literature research was conducted through the following bibliographic databases: PubMed, Medline, Cochrane and reviews; and we selected articles that focused on mechanical debridement, adjunctive antiseptic therapy, adjunctive antibiotic therapy and laser-assisted therapy. Ninety articles were utilized in total. We concluded that depending on the disease's degree, non-surgical therapy associated with patient compliance might result in a significant improvement. Dental implant scaling with or without applying adjunctive material such as antiseptics, antibiotics or lasers has shown positive results, such as reducing the number of bleeding sites, clinical attachment level, and a decrease in the number of periodontal pockets. The use of antiseptic as an adjuvant remains controversial. In combination with mechanical debridement, the local administration of antibiotics, contrary to the antibiotics' systemic ingestion, has positively impacted clinical and microbiological parameters. Some lasers also have a promising future in resolving peri-implantitis; indeed, they lead to effective bacterial reduction and have a lower tendency to damage the implant's surface.

However, the non-surgical treatment seems to be effective only in a short term and can damage the implant micromorphology. It also presents some weakness, especially in the case of advanced lesions. We also need further studies to understand the best adjuvant option, depending on the case. We are still struggling to determine the optimal remedy for treating this disease because most of the treatments have similarities in their degree of effectiveness. Unfortunately, a therapy that will lead to the disease's complete resolution has not been found yet.

Key words: peri-implantitis, non-surgical treatment, effectiveness, limitations

3 INTRODUCTION

While oral implantology is booming, peri-implant diseases are also following an exponential curve, and they are not considered an unusual complication anymore. Oral implantology has shifted into one of the fastest-growing sectors in the dental industry. Every year, more than 800,000 individuals are getting dental implants in the United States and more than 1,8 million in the European Union. (1) (2) It has turned into an incredible alternative for tooth replacement since the discovery of osseointegration with Branemark in the late fifties. According to him, we have an increased chance of success of the implant when we have 90% of bone-implant contact. (3)

Nowadays, the successfulness of dental implants presents very high success rates, around 95% to 98%, but unfortunately, those results are not representative of the future of the implants in the long term. Indeed, peri-implantitis is becoming the principal factor of morbidity of implants. (2) (4) It is an infectious disease that infects tissues around the implants following dental implant placement. Inflammation, bleeding, suppuration and bone loss around the implant are characteristic of peri-implantitis. Those factors are unquestionably related to the failure of the dental implant. In literature, we can see that the definition of peri-implantitis varies depending on the view of the authors, which poses a source of contention and research. The primary difference in research is due to factors like the number of people included in the study, time, type of research, method and the additional criteria of evaluation.

We can differentiate several types peri-implant diseases:

- Peri-implant mucositis is reported as a reversible tissue inflammation around the dental implant without attachment or bone loss (**Figure 1.**). (5) It is very similar to gingivitis. Indeed, peri-implant mucositis is the antecedent of peri-implantitis, similar

to how gingivitis precedes periodontitis. Similarities are found such as redness, bleeding on probing, periodontal pockets of less than 4mm and no radiographically visible bone loss. (6) The resolution of the inflammation is the base of the therapy of peri-implant mucositis. The early treatment of peri-implant mucositis, in parallel with patient motivation can lead to very successful results. (7)

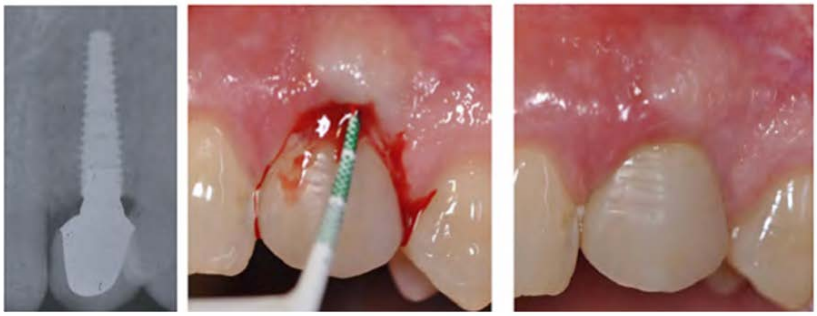

Figure 1. Radiographic and clinical picture of peri-implant mucositis.

- Retrograde peri-implantitis was first defined in 2003 by Quirynen. He defines it as a radiolucent lesion located on the apical part of the implant; the coronal part presents "normal" osseointegration. (8) It usually appears following the first months after the implant placement. It has been provoked by rest of granulomatous or scar tissues apically. Those lesions can be both, inactive and asymptomatic, or active and characterized by symptoms such as pain or swelling. (8)
- During the 2017 European workshop of periodontology, a new definition of peri-implantitis came out. It was defined as an inflammatory process of infectious origin that alters hard and soft tissues neighboring the osseointegrated dental implant, which lead to a loss of bone support. (9) During this workshop, they explained some characteristics of peri-implantitis such as probing depth of > 6 mm and bone levels > 3 mm apically, in addition to bleeding and suppuration on general probing (**Figure 2.**). (5) (7) (10) This infection can be divided into two different stages: early and late. The early infection is most commonly caused after the placement of the implant, due to an infection during the surgery or the following few weeks. In the contrary, late

infections take place after the osseointegration, when the implant is properly restored. This is closely related to general or local factors such as dental plaque accumulation or host susceptibility. (7) Unfortunately, the treatment outcome of peri-implantitis is usually unpredictable.

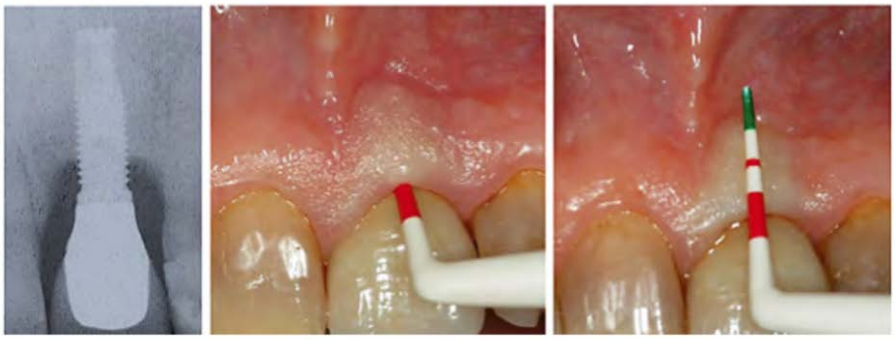

Figure 2. Radiographic and clinical picture of peri-implantitis.

To be able to choose the most appropriate treatment, we need to understand the different etiological factors involved in peri-implantitis.

In 1998, Monbelli and Lang demonstrated across few points the role of anaerobic plaque bacteria related to peri-implant infections: (11)

- The accumulation of bacterial plaque induces inflammation of the tissues around the implant. To increase the life expectancy of the implant, the control of plaque is primordial. We have a cause-effect relationship among dental plaque and peri-implantitis. Bacteria is the principal etiological factors of peri-implantitis. The microbial flora present around implants is the same as the one present around natural teeth. The presence of anaerobic species such as *Prophyromonas gingival* or *Prevotella intermedia* are highly common in tissues surrounding the implant. These bacteria are easily bound to the surface of the implant, increasing the risk of acquiring peri-implantitis
- We have a difference in the microflora between successful and failing implants. Indeed, *gram-positive cocci* are present in successful implants, unlike failing implants

that are colonized by *gram-negative anaerobic* bacteria. In general, the amount of bacterias is always low in a successful implant. Bacterial removal deposits are vital in the treatment of peri-implantitis.

- Peri-implantitis decreases with the help of an antimicrobial treatment.
- The successfulness of the implant is positively correlated to long term oral hygiene. (11)

Through the different diagnostic parameters that can be used to diagnose peri-implantitis, we can find:

- Radiographic examination: It is complementary to the clinical study and helps to measure the amount of bone loss. Less than 0,2 mm vertical bone loss per year following the primary year of implant arrangement corresponds to a primary criterion for the success of the implant. The presence of radiolucency around the implant is familiar with fibrous tissues which increase the risk of peri-implantitis. Usually, when a radiolucent line is encircling the implant and the latter is tender to percussion or present mobility, the only option will be the removal of the implant. (7)

  The disadvantage of the X-ray use is that we can only detect a problem once 30% of the bone has been lost; therefore, it is not an optimal approach for the early diagnosis of peri-implantitis. (4) (12)
- Microbiologic exam: The future of the implant might be predicted thanks to microbiological markers. The presence of high level of *Porphyromonas gingivalis, Prevotella intermedia* and *Actinobacillus actinomycetemcomitans,* and other bacteria, increases the risk peri-implantitis, as aforementioned. The treatment of peri-implantitis might include microbiological tests to make a differential diagnosis of the disease.

- Histologically, the tissues enveloping the dental implant presents features similar to gingival tissues surrounding the natural tooth, except for periodontal ligament and cement. The deficiency in cells, the high presence of collagen and the parallel organization of fibers justify the severity and rapidity of peri-implantitis. (3).
- Peri-implant probing: We are using a periodontal probe to measure the probing depth. A 3 mm probing depth are indicative of physiological probing. Pockets more or less of 5 mm are conventional of peri-implantitis.
- Bleeding after probing: The non-appearance of bleeding defines periodontal stability; however, bleeding may not necessarily relate with peri-implantitis.
- Suppuration: It is a distinctive sign of peri-implantitis. The pus is the result of an infectious lesion, associated with the damage of mucosal tissues.
- Mobility: It is a characteristic of a decrease of osseointegration. Depending on the level of mobility, we will decide on the removal of the implant or not. In 2008, Heitz-Mayfield explained that the implant should be removed as soon as mobility start. (13)
- Swelling and redness are also present in peri-implantitis
- Aspect of the tissues and clinical indices: The plaque index is a useful tool to measure the amount of plaque present around the implant.

Several general risk factors are related to the progress of peri-implantitis:

- One of the principal factors is poor plaque control. Indeed, it is considered as the leading risk factor for the advancement of the peri-implantitis. A proportional relation exists within the level of plaque and the rise of peri-implantitis. We also have a strong association linking bad oral hygiene and bone loss around the implant. Poor oral hygiene and plaque control increases the chance of catching peri-implantitis by a factor of four. (8) Therefore, one of the first things that we need to teach to the patient,

following the implant placement is the importance of oral hygiene. The removal of the dental biofilm is essential for the effectiveness of the treatment. (14)

- The presence of a previous periodontal disease or an existing one, is a decisive risk factor. The development of peri-implantitis is more frequent and faster in periodontal patients. There is a strong relationship between those patients and the failure of the implant. Not well treated periodontal patients have a higher risk to lose the implant. (15)
- A robust relation between diabetes and periodontal disease has already been established. (16) Diabetic patients present a higher chance of failure of the implant, and therefore, well-controlled patients present less risk of peri-implantitis than an uncontrolled patient. Several meta-analysis studies have demonstrated that peri-implantitis is 50% higher in diabetic patients. (16)
- Cholesterol can lead to lack of osseointegration. (17) (18)
- The lack of vitamin D impedes the osseous regeneration. Supplements of Vitamin D might be beneficial in several cases. (17) (19)
- Tobacco plays a crucial role in the apparition of periodontitis. The consumption of tobacco and bone loss are closely related. Smokers present a greater chance of deep periodontal pocket, plaque accumulation and bleeding on probing. For some practitioners, tobacco is a relative contra-indication for the placement of implants. Studies have also shown that we have a regression of the disease when the consumption of tobacco is reduced.(9) (20) (21)
- Alcohol is also acknowledged as a risk factor because it affects blood coagulation and decreases bone metabolism. (21)

- There is no scientific evidence of a direct link between stress and the appearance of peri-implantitis. However, stress, anxiety and depression can lead to lifestyle changes such as the increase consumption of alcohol or tobacco. (21) (4) (22)

Other local factors that raise the chance of peri-implantitis:

- The surface of the implant additionally influences the apparition of the peri-implantitis. (23) The majority of implants available in the market present a moderately rough surface, between 1.0 to 2.0 microns. Studies have proved that implants surface close to 1.0 μm presents a lower risk of peri-implantitis than implants with 2.0 μm surfaces. The probability of peri-implantitis is intimately associated to the roughness of the implant surface. Indeed, rough implant surfaces promote the osseointegration of the bone, but at the same time, we have an increase in the amount of plaque. (24) Also, rough surfaces are more challenging to clean. The mucous tissues that envelope smooth implant surface have less likelihood of presenting problems.
- We have the occupation of a micro-gap between the abutment implant interface. This micro-gap is considered acceptable when it is less than 10.0 μm. Some studies have demonstrated that internal implant connection presents less risk for bacterial accumulation than external ones. (25)
- Cement excess over the implant can lead to an inflammation of the tissues surrounding the implant. The removal of the cement improves the status of the periimplantitis. The removal of the cement may be difficult and require surgical intervention. (7)
- Lack of keratinized tissues, less than 2 mm, can lead to gum recession. The lack of keratinized tissues increases the probability of loss of insertion. It also leads to an increase in the amount of dental plaque due to discomfort and pain during oral hygiene. (14)

- Lack of access for cleaning due to the prosthesis conception lead to plaque accumulation. The need for a new implant prosthesis or the complete removal of the implant might be the only option for the proper cleaning and the impediment of plaque accumulation. (14) (24)
- Periodontal disease present in some teeth that can affect the microbial flora that surround the dental implant. It is primordial to stabilize the periodontal disease before placing the implant. The bacterial colonization usually occurs 30 minutes after the placement of the dental implant. (4)
- The presence of an infection in adjacent endodontic teeth can lead to an infection of the implant. (8)
- The quality of the bone during implant placement also plays an important role for the implant stability. (26)

In the first place, implants are clinically stable without any pathological signs of mobility. However, in the absence of effective care, loss of osseointegration can occur, which can lead to the failure of the failure. (**Figure 3.**) (27)

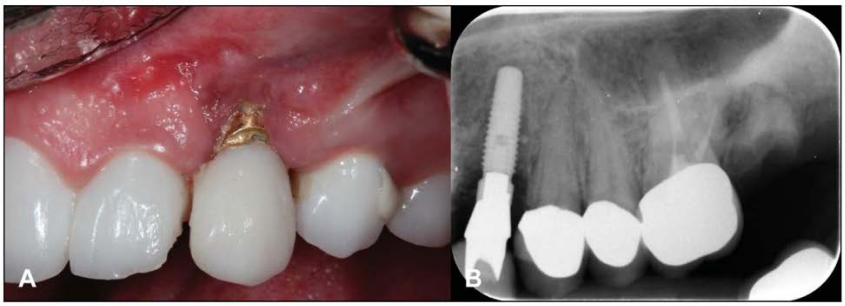

Figure 3. Dental implant with an established periimplantitis lesion (a and b). Periimplantitis with multiple contributing factors, including unseated crown, residual cement, poor emergency profile, buccally-placed implant, potential trauma from occlusion, poor peri-implant tissue quality, and generalized periodontal disease; all of which needs to be analyzed and addressed as part of the nonsurgical treatment. Radiographic and clinical picture of peri-implantitis.

The importance of prevention and the need for an effective protocol was highlighted in the 11th European Workshop for Periodontology. An effective supportive care to prevent the recurrence of peri-implantitis is primordial over the long term. (28) In 1998, Mombelli proposed a protocol for the treatment of peri-implantitis: depending on the probing depth, bacterial biofilm, BOP, suppuration and bone loss on Xray, the management of peri-implantitis varies from simple, non-surgical therapy, to complex surgeries (especially in case of deep probing depth >5mm). (12) (29) (27) However, the data on which therapy is most effective is inconclusive. Although, non-surgical remedy should be the leading choice, no matter the stage of the periimplantitis, but it has some limitations. Some studies have illustrated how the non-surgical procedure of peri-implantitis is an ideal choice in the aesthetic zone. (**Figure 4a -b)** (24)

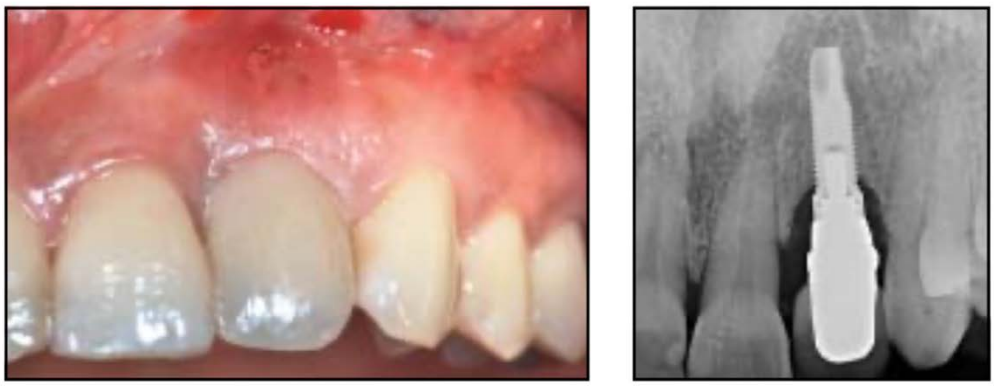

Figure 4a (left) Clinical photograph of early peri-implantitis at an implant at the maxillary left lateral incisor position. Note the inflamed tissue and exudate.

Figure 4b (right) Radiograph of maxillary lateral incisor with bone loss < 25%of the implant length, depicting early peri-implantitis. (32)

Non-surgical therapy should precede any surgical therapy; indeed, the latter provides more time for the clinician to evaluate the disease's evolution, adjust the treatment if necessary, evaluate how the tissues are healing and check if we have a regression of the inflammation. (7) The earlier the detection of peri-implantitis and the better the outcome;

the more we wait, the more ineffective the non-surgical treatment will be. A supportive maintenance program should always follow the non-surgical therapy. In cases of progressive bone loss or persistent periimplantitis, despite several non-surgical treatments, surgical treatments will be the optimal option to decontaminate the micro-implant surface. (4) The last therapeutical option should be the removal of the implant. (27)

The treatment planning should be based on local and general factors, but we should also take into account the patient consideration and allow some adaptability due to the unknown outcome of the treatment. (30)

Our goal is to explore various non-surgical therapies for the treatment of peri-implantitis.

4 OBJECTIVES

Peri-implantitis is considered one of the most challenging complications in implantology. Over the years, the realization of the problem pushes clinicians to imagine different therapeutic approaches to prolong the implant's life and stop peri-implantitis. Indeed, it is a rapidly progressive pathology of bacterial aetiology that progress towards the bone due to the absence of connective tissues to protect it. (27) The change and progression from mucositis to peri-implantitis is challenging to manage. Therefore, it is important to treat early signs of inflammation to prevent or reduce marginal bone loss. The removal of the oral biofilm from the implant is the primary goal in the therapy of peri-implantitis. (27) (30) Currently, we have a significant body of clinical reports and studies that show that it is possible to stop the progression of the disease and repair the destroyed tissues. Studies have proved that peri-implant mucositis is reversible; the quick diagnosis and treatment of mucositis will prevent the progression into peri-implantitis, which is more laborious to

treat and present an unpredictable outcome. (7) (31) The properties of implant surfaces also impact the disease's progression and resolution; therefore, a technical modality that can effectively detoxify the implant without modifying its surface is needed. (32) We will analyze and focus on these studies to find the best non-surgical options to treat peri-implantitis.

Our objective is to conduct an empirical study on the best non-surgical therapeutical options to remedy peri-implantitis and analyze its effectiveness and limitations.

5 METHODOLOGY

5.1 DATABASE SELECTION

For this study, a literature search was performed through the following bibliographic database: PubMed, Medline, Cochrane and Bibliographic reviews.

Some of the later journals have been distinguished as being conceivably significant for the outcome of this review, such as the journal of:

- Prosthetic Dentistry
- Oral Implantology
- Clinical periodontology
- Clinical and Experimental Dentistry
- Oral and Maxillofacial implants
- Clinical Laser Medicine and Surgery
- Periodontal & Implant Science
- Oral Implantology
- Periodontics & Restorative Dentistry
- Photochemistry and Photobiology B: Biology

- Scientific world journal
- British dental journal
- Clinical Oral investigations
- Prosthodontics

5.2 ELIGIBILITY CRITERIA

➢ Inclusion criteria

The following articles have been pre-selected depending on the content of the titles and the abstracts, based on the criteria:

- Dental articles related to the objectives.
- Types of studies: randomized clinical trials, meta-analysis, clinical studies (human, animal, in vitro and in vivo studies) evaluating the treatments of peri-implantitis.
- Chosen population: a human or animal population with a dental implant. Subject who have at least one dental implant touched by mucositis or peri-implantitis.
- Target time: most of the studies presenting results over six months to more than one year, except one study that showed results after 12h.
- Pathology studied: peri-implantitis (peri-implant mucositis and mild to moderate peri-implantitis).
- Treatment studied: non-surgical procedure, including the utilization of local or systemic therapeutic agents to recover peri-implant oral health. It excludes all types of treatment approaches with surgical procedures, such as open flap.
- Bleeding or Suppuration is considered when it is present in at least one of the four sites per implant explored.

- Purpose: Description of the different non-surgical treatment option, their effectiveness and limitation for the treatment of peri-implantitis.

➢ Exclusion criteria:

Articles containing the following criteria were excluded from the study:

- Topic not relevant to the focus question
- Articles without analytical objectives
- Very severe case of peri-implantitis
- Articles before 1992

➢ Limitations of the researches

- Languages limits: English, Spanish and French
- Publication year limit: from 1992 to 2020

5.3 STRATEGY FOR THE RESEARCH

Through the articles, we decided to assess the changes related to bleeding on probing (BOP), probing depth (PD) and also, in some cases, the clinical attachment level (CAL) / probing attachment level and suppuration.

Depending on the studies, we can find a few variations between peri-implant mucositis and periimplantitis. Indeed, some studies might consider a bone loss up to 3 mm as peri-implant mucositis, while others will define this condition as periimplantitis. (6)

5.4 FINAL SELECTION – DATA COLLECTION

The pre-selected articles have been subjected to critical reading to retain only the most relevant. In total, ninety articles were used, indexed between 1992 and 2020.

Keywords: dental implant, peri-implantitis, periodontal diseases, non-surgical treatment, laser, mechanical debridement, antibiotics, antiseptics, periodontal maintenance, supportive periodontal therapy, decontamination, biological complication, anti-infectious therapy, peri-implant complications.

6 RESULTS

After several trials to identify the most powerful interventions for managing peri-implantitis, we understood that there is no conclusive evidence suggesting what could be the best protocol to manage peri-implantitis. (33) The variation in the definitions of peri-implantitis, the lack of clarity regarding the status of the disease, and the contrast between the inclusions and exclusions of the criteria of each study was very challenging. (1) In the contemporary body of work, the ideal treatment of peri-implantitis varies among authors. A study by Cochrane conducted over one year demonstrated the ineffectiveness of existing treatment and recurrence of peri-implantitis by up to 100%. (34) Nevertheless, other studies demonstrated that proper treatment planning and early detection of the disease presents a positive outcome; and even if the disease's complete resolution is not reached, a modification in the inflammation is still achievable in the short term. (1) Concerning the treatment's effectiveness, in most of the studies, we could observe a higher impact and reduction on bleeding on probing compared to probing depth and clinical attachment. (24) (29) (27) Mechanical debridement presents successful outcomes despite the peaks and troughs of threads that are a tactile challenge. Accessing the pockets may pause a difficulty even for the most qualified laborer; with the procedure highly contingent on the operator's skills and training. While performing this treatment, it is

imperative not to change the implant micromorphology, and to not interfere with the biocompatibility. (35) (36) In general, mechanical debridement appears to be especially effective in pockets less than 3 mm and may succeed in some recovery in the peri-implant bleeding tendency. Despite better results when using metallic curettes and ultrasonic, we can observe a greater surface damage compared to nonmetallic instruments. Indeed, some authors do not recommend using metal curettes to treat smooth-surfaced implants because of the alterations they can cause. Non-metallic instruments on the other hand, such as plastic curettes and abrasive spray systems were found to cause minimal or no damage to the implant surface. (7) The new copper metal tips have potential because they are as effective as metal tips, but they have the advantage of producing minimal harm to the implant surface, similar to the plastic tip. (37) Several studies have demonstrated that the supplementation of mechanical therapy with topical antimicrobials presented better results in the BOP and PD. (7) However, some studies demonstrate that mucositis can be resolved with mechanical debridement without antiseptic treatment. Citric acid and sodium hypochlorite were the antiseptics that presented the most significant results than the other commercially available antiseptics. (24) (38) The antibacterial therapy presents better results when it is locally applicated than systemically ingested for the treatment of peri-implantitis. Indeed, patients that experienced local antibiotic adjunctive therapy presented a higher probability of a successful outcome. (39) Laser therapy has become a good alternative in the treatment of peri-implantitis because it allows a good decontamination of the site without altering the surface of the implant. However, a major problem with laser application, is limited visibility. (27) Some lasers, such as the Er: YAG laser, presented inspiring results. Nevertheless, we also have Er, Cr, YSGG (WaterlaseTM) that have significant potential in the field because it presents a technical amelioration over the Er: YAG's. (4) (40)

The issue that remains is whether the condition's recurrence after a year represents a failure of the first treatment or the establishment of a new disease. (1)

7 DISCUSSION

7.1 MECHANICAL DEBRIDMENT

Mechanical therapy is the treatment of election when inflammation is observed around the implant. It still sounds unusual that the devices used for the debridement of implants are the same as the one used to treat teeth that present a flat surface. Several studies have demonstrated the improvement of implant surface thanks to mechanical debridement. This technique offers some advantages, such as increased tactile sensation and minimal risk of aerosol contamination. However, it also presents disadvantages such as difficult access to deep pockets, iatrogenic risk, and it is highly dependent on the practitioner's dexterity and experience. (14) (41) (42) We are trying to make the implant surface biologically compatible with periodontal healing by removing tartar, bacterial biofilm, and endotoxins through mechanical action. (41) (42) While performing this treatment, it is imperative not to change the implant micromorphology, to not interfere with the biocompatibility. (36) Indeed, numerous in vitro studies have been conducted to evaluate different systems for the mechanical debridement of implants, assessing their efficacy and the damage they may create on the implant surface. (43)

During many years, mechanical debridement was achieved thanks to titanium (**Figure 5.**) or carbon-fiber scalers (**Figure 6.**). (44)

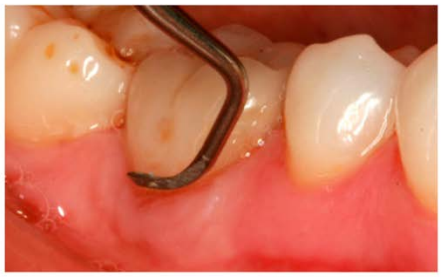

Figure 5. Debridement of implant biofilm using a titanium curette.

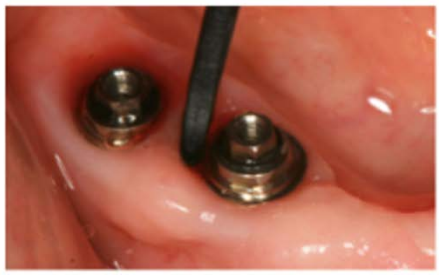

Figure 6. Debridement of peri-implant biofilm using a carbon-fiber curette.

Standard metallic scalers typically used for root surfaces cleaning develop injuries in the implant's titanium oxide surface and corrosion. Furthermore, these metallic scalers can lead to microscopic groove development and in parallel, more plaque accumulation (**Figure 7**). (43)

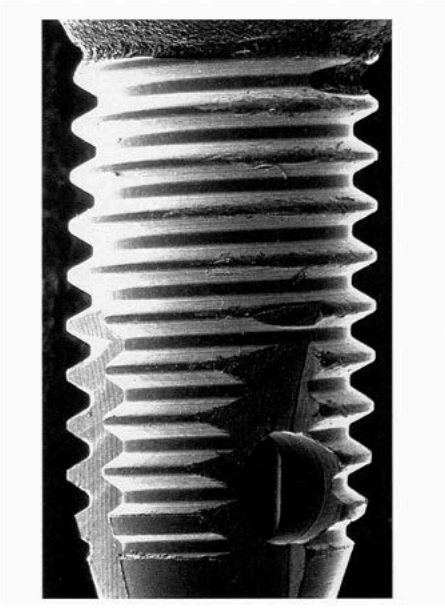

Figure 7. Surface of a smooth titanium implant after treatment with a metal curette for 60 seconds (original magnification 15X).

According to Lang et al. in 2000, mechanical debridement is very effective in cases with calculus, bleeding, absence of pus and pockets of less than 3 mm. He proposes using carbon fiber curettes to remove calculus and the use of abrasive paste to remove plaque. The carbon fiber curettes are sharp and strong enough to remove light to moderate calculus deposits. (45)

During the last 100 years, periodontal instruments were always in progress. Plastic scalers have been developed to limit more significant damage to the implant surface. (25) The Teflon coated scalers are more rigid than the plastic ones. Compare to stainless steel curette; they produce less harm to the implant. (10)

More recently, the development of ultrasonic devices with plastic (**Figure 8.**) or Teflon-coated curettes (**Figure 9.**) have demonstrated a reduction in the alteration of the surface of the implant but those tips can leaved some bacterial rests on the implant surface. (9)

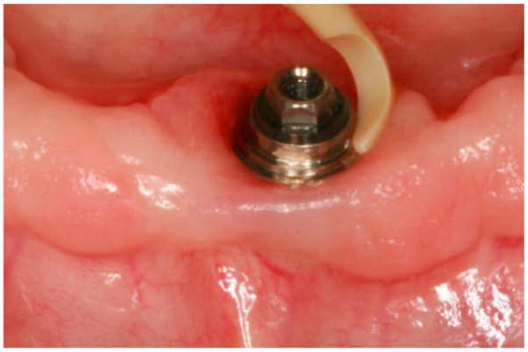

Figure 8. Debridement of peri-implant biofilm using a plastic curette.

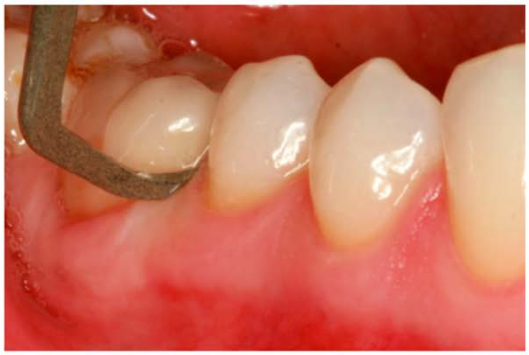

Figure 9. Debridement of peri-implant biofilm using a Teflon curette (polytetrafluoroethylene-e).

Ultrasonic scalers have the particularity to transform electrical current into mechanical energy in the form of high-frequency vibrations at the instrument tip. The vibration frequencies usually range from 18 000 to 45 000 Hz. (44) The use of sonic or ultrasonic instruments is a good alternative to the use of manual curettes. The vibrations are created by a generator-transducer system that defines frequency and amplitude. They offer some advantages, such as integrated irrigation, an increase of time, and are easier and more comfortable to use. However, they are very noisy, need lots of maintenance, and have a high aerosol contamination risk. (41) (42)

In 1996, Matarasso et al., in an in vitro study, explained the modifications of titanium implant surface following the use of different prophylaxis procedures. They analyze ten

prophylaxis systems (conventional ultrasound, ultrasonic with plastic tip, stainless steel curette, titanium curettes, Teflon curette, air-powered system, abrasive rubber cups, polishing rubber cup and brush) and compared it with untreated controls implants. It concludes that conventional stainless-steel curettes and metal ultrasonic tips can damage the implant surface and promote future plaque accumulation. (46)

Augthun et al. in 1998 carried out a similar study to the previous one, testing different systems for the mechanical debridement of implants, excluding ultrasonic devices. The first part of the study showed that the abrasive powder system, the plastic curettes, and irrigation with 0.1% chlorhexidine did not damage the implants' surfaces. In the second part of the study, the three methods are clinically tested, and it is shown that the abrasive powder system achieves higher efficiency in removing deposits (**Figure 10)**. (43)

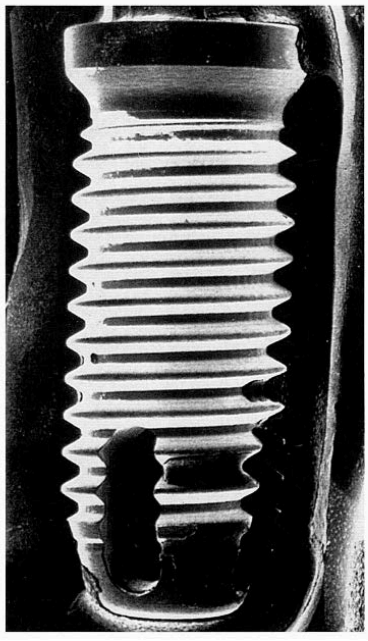

Figure 10. Surface of a smooth titanium implant after intraoral plaque deposition and treatment with the air-powder-abrasive system (original magnification I2X).

A double-blind randomized longitudinal clinical study, over a period of 6 months, contrasting titanium curettes and ultrasonic device, failed to demonstrate any specific differences in the treatment outcomes. This study only showed a reduction concerning the bleeding of the dental implant but didn’t show any specific improvement concerning the probing. (47)

A randomized controlled clinical trial (RCT) illustrated the effectiveness of the Carbone curette combine with an antiseptic therapy of chlorhexidine gluconate, for the mechanical debridement, compared to an air abrasive device of amino acid glycine powder. After 6 months, both techniques will lead to a relative improvement in the clinical attachment level (CAL), but the improvement of the BOP is highly superior with the air abrasive device. (48)

Another study demonstrated the effectiveness of powder abrasive device applying glycine powder instead of debridement with ultrasonic or manual instruments. One of its most essential features is to prevent surface alteration on rough and smooth surfaces of threaded, screw-shaped implant. (36)

Sato et al. in 2004 conducted an in vitro study testing the efficacy of a new piezoelectric ultrasound system with a carbon tip (**Figure 11.**) that performs a horizontal movement that moves parallel to the implant surface. This new system is compared with a conventional ultrasound system (**Figure 12.**) and a plastic scaler (**Figure 13.**). The results showed that the two ultrasonic systems are equally effective in their removal capacity, and no differences in the surface disturbance were found. However, this study was performed in vitro and cannot be directly applied to the clinical situation. We need further in vivo studies to examine the potency of those instrument in the plaque and calculus removal from the implant surface. (49)

Figure 11. New ultrasonic scaler (VR)

Figure 12. Conventional ultrasonic scaler (SP)

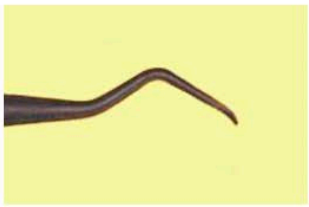

Figure 13. Plastic scaler (PS)

In 2007, Kawashima et al. carried out the same study but in vivo, comparing piezoelectric ultrasound scalers with a carbon tip, ultrasound with a plastic tip, and a metal tip. The results show that all three systems remove similar amounts of plaque and calculus; while the piezoelectric carbon-tipped ultrasound and the conventional plastic-tipped ultrasound leave a smooth surface, the conventional metal-tipped ultrasound produces surface damage. (50)

Mechanical therapy alone presented restricted clinical changes with the use of designed carbon-fiber curettes, ultrasonic devices and titanium instruments. Moreover, the use of the Vector system (an ultrasound with a carbon fiber tip accompanied by an abrasive fluid with hydroxyapatite microparticles). (**Figure 14.**) delivered unimportant differences in BOP and PD after six months. (35) The use of carbon fiber tip manually or with vector system produced only few improvements in bleeding on probing (BOP) but no signifiable corrections in the deepness of the pocket (PD). (35) The Vector system is another type of ultrasonic instrument, that uses an operating frequency of 25 000 Hz and a coupling at the head of the handpiece to transfer energy indirectly to the working tip. These instruments are cooled by a water-based medium containing polishing particles of various sizes depending on the therapeutic indication. One of his advantages is that the amount of contaminated aerosol is reduced compared to that produced by other ultrasonic or sonic devices.

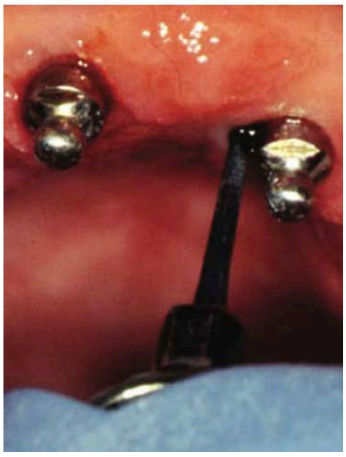

Figure 14. Photograph showing treatment of a peri-im- plant pocket with the Vectors system with a special carbon fiber tip.

A study carried out by Schwarz et al. in 2003 compared two methods for the mechanical debridement of implants: Er: YAG laser and the Vector system. According to this in vitro study results, the Vector method should not be used in the mechanical treatment of implants because all the surfaces treated with this method showed damage to their surface. (51)

Duarte et al. in 2009 carried out an in vitro study comparing four methods for mechanical debridement on smooth and rough titanium implant surface (Er: YAG laser, plastic curettes, metal curettes and abrasive air-powder systems) and assessing the adhesion of Str. Sanguinis after treatment. For smooth-surfaced implants, metal curettes produced more surface scratching. For rough-surfaced implants, the surface was not altered by any of the methods studied. Although, those rough-surfaced implants treated with metal curettes and abrasive powder spray presented less bacterial adhesion. The authors do not recommend using metal curettes to treat smooth-surfaced implants because of the alterations they can cause, but they also conclude that the use of metal curettes and abrasive air spray rough-surfaced implants results in fewer bacterial adhesion. (52)

In 2009, Máximo et al. performed cases series and treated patients with Teflon curettes and abrasive sodium carbonate air powder. They went to the conclusion that "mechanical therapies alone were effective in treating mucositis". (31) (53)

In an RCTs, Sahm et al. judged manual debridement with submucosal chlorhexidine instead of debridement using an air-powder abrasive device. After six months, there was no implant disaster and no significant difficulties. Both studies presented some similarity in the reduction in the bacterial biofilm. The significant difference is that the air-powder abrasive device demonstrated better BOP decreases than the mechanical debridement. (1) (54)

Schwarz et al. in 2009 conducted a study on titanium plates to evaluate the influence of two decontamination methods with abrasive spray devices on cell viability. This study obtained intraoral biofilm samples cultured on titanium discs and later sprayed with glycine spray or bicarbonate spray. Both types of devices were shown to be equally effective in biofilm removal. On the other hand, bicarbonate spray was shown to achieve higher cell activity than glycine spray. The authors conclude that these results are because particle size influences cell viability on implant surfaces. (55)

Baek et al. in 2012 evaluated a new metal tip for ultrasonic instrumentation made of copper alloy. They performed an in vitro study comparing it with conventional stainless-steel tips and plastic tips on titanium surfaces. We could observe similar results concerning implant surface scratching; however, the conventional steel tip produced more surface scratching. Regarding removal efficiency, the stainless-steel tip is twice as efficient as the new copper metal tips. These new tips also produce minimal harm to the implant surface, the same as the plastic tip. (56)

After looking at the different studies' conclusions, Louropoulou et al. in 2012, in a systematic review, presented some guidelines on the effect of mechanical debridement on the implant surface. In the case of smooth-surfaced implants, non-metallic instruments and rubber cups are the methods of choice. For rough-surfaced implants, non-metallic instruments and abrasive spray systems were the best instruments of options if we want to preserve the surface integrity. Non-metallic instruments were found to cause minimal or no damage to the implant surface. (57)

Regrettably, a lack of proof concerning the most powerful instrumentation modality is still present. Besides, the design of implant-supported prosthetic restorations sometimes makes mechanical decontamination challenging to achieve on the implants' surface. (1)

(58) Mechanical debridement remains the gold standard in treating peri-implantitis, but we need further studies to achieve the best results. (36)

You can find in the Annexes 11.1 one a table that compares all the different studies.

7.2 ADJUNCTIVE ANTISEPTIC THERAPY

The addition of adjunctive measures to the mechanical debridement may lead to a better outcome in the treatment of periimplantitis. (7) The choice of antiseptic molecule varies according to the patient, his or her pathology, and the treatment plan stage. (42) (41)

In 1995, Ciancio et al., in a double-blind, randomized clinical trial, manifested the profitable outcomes of rinsing with Listerine, an antiseptic mouth rinse, for the treatment of patients with mucositis. Twenty patients with at least two implants with mucositis signs were randomly assigned to two groups: one with twice-daily Listerine rinses and one with a placebo of 5% hydro alcohol after prophylactic treatment. At three months follow-up, the Listerine group showed a significant increase in plaque, gingival index and bleeding rate compared to the placebo group. The rinse as an adjuvant did not produce improvements in probing depth or insertion level for either group. (31) (59)

A randomized, double-blind clinical investigation illustrated the effectiveness of two anti-infective protocols for handling peri-implant mucositis. First of all, all patients underwent mechanical debridement. Then, they were directed to clean around the implant with a manual toothbrush. They were instructed for four weeks, to clean twice a day using a gel at the implant location. Those patients were subdivided into two groups: one group received a 0.5% chlorhexidine gel, and the other received a placebo gel. (**Figure 15.**) (44)

After the four weeks, patients were required to end the utilization of the gel and followed with usual oral hygiene. After the first month, both groups demonstrated an essential reduction of BOP as well as PD. (58)

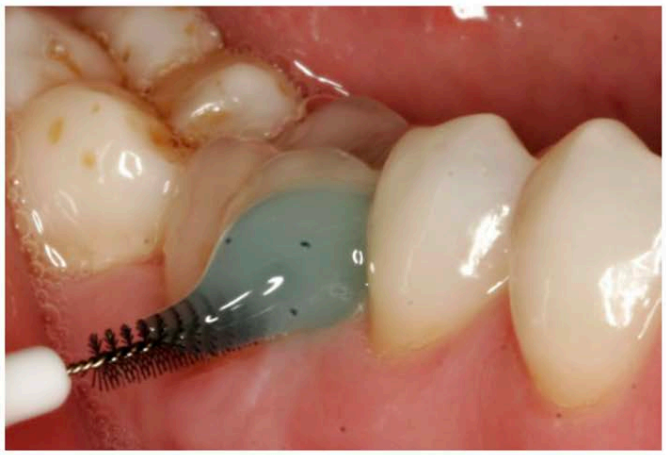

Figure 15. Peri-implant oral-hygiene procedure with an inter- dental brush and chlorhexidine gel.

In 2006, Trejo et al. carried out a study to demonstrate the effectiveness of chlorhexidine gel. They induced mucositis in monkeys and tested two treatment modalities: mechanical debridement and mechanical debridement with chlorhexidine irrigation and a 0.2% chlorhexidine gel. These two protocols are compared with a control group that does not receive any treatment. Both treatment modalities presented similar improvement without any specific distinctions concerning the probing depth, gingival and plaque index. However, we could observe variations between the treatment groups and the control group. Histologically, we could observe an absence of inflammation in the treatment groups, contrary to the control group. This study demonstrates that mucositis can be resolved with mechanical treatment without the need for antiseptic treatment. (60)

Porras et al. in 2002 performed a similar study to the previous one but on 16 patients, comparing only mechanical debridement with mechanical debridement combined with chlorhexidine irrigation and the application of chlorhexidine gel, without a control group. The conclusions point that both treatments presented improvement at the gingival index,

a reduction of the probing depth, and destruction of pathogenic bacteria associated with mucositis. However, no differences have been observed between both groups. (60)

In 2010, Heitz. Mayfield et al. conducted a clinical study on 29 patients diagnosed with mucositis. All patients received mechanical debridement and were then divided into two groups: one group received 0.2% chlorhexidine gel twice a day for a month, and the other group utilized a placebo. After one month, both groups presented a reduction of the gingival index and probing depth but with no significant differences. This study concludes that chlorhexidine as an adjuvant antiseptic does not improve the results of mechanical treatment. (58)

During the same year, Thöne-Mühling et al. carried out a study to evaluate a treatment protocol for mucositis with a "full-mouth" procedure. This "full-mouth" procedure include mechanical debridement with or without the application of chlorhexidine gel and rinse. After eight months of follow-up, both treatment modalities improved clinical parameters with no differences between them. The bacterial count at 24 hours after treatment decreased for both groups, without being higher for the group decontaminated with chlorhexidine. At eight months, the reduction of bacterial quantity is not significant for any of both groups. (61) These studies on chlorhexidine as an adjuvant in mucositis's therapy concluded that the results are similar with or without its use. (58) (60) (61)

In 2010, in an in vivo human study, Gosau y cols. assessed six antimicrobial agents' effectiveness on titanium implants surface oral biofilm. They performed acrylic upper jaw splints (14 specimens in every splint) fixed on titanium specimens for this study. Those splints were worn for 12 hours at night by four patients. Various antimicrobial agents such as Sodium hypochlorite 1%, Hydrogen peroxide 3%, Chlorhexidine gluconate 0.2%, triclosan 0,3%, Listerine, citric acid 40% were used for 1 min on the titanium implants and used as control saline solution. Afterwards, the bacterial biofilm

was measured thanks to fluorescence microscopy. All the antimicrobials agents lead to a reduction in the bacterial biofilm, with higher results for Sodium hypochlorite, Hydrogen peroxide 3%, Listerine, Chlorhexidine gluconate 0.2% compared to citric acid and triclosan 0,3%. (62)

Strooker et al. in 1998 carried out a study to compare the effects of mechanical debridement with chemical therapy, using orthophosphoric acid at 35%. Two implants in each hemiarch were treated with: orthophosphoric acid at 35% for one minute and rinse for 15 seconds or mechanical debridement with plastic curettes. This treatment is repeated monthly for five months. At the end of the following period, a reduction in the gingival index and probing depth was observed in both groups, with a better outcome in the group receiving chemical treatment. Indeed, a more significant reduction in the gingival index and the number of bacterial colony-forming units was achieved thanks to the chemical therapy. (60)

Ntrouka et al. in 2010, conducted an in vitro study to evaluate the antibacterial capacity of different products. In this study, titanium discs were incubated with Str. Mutants on one side and with patient saliva on the other side to obtain polymicrobial samples. In this case, the antimicrobial agents were: EDTA 24%, citric acid 40%, hydrogen peroxide 10%, Ardox-x (bleach and antiseptic rinse combination), cetyl pyridinium chloride (CPC), chlorhexidine 0.2% and water as control. The results of the destruction of Str. Mutants show a significant reduction when using hydrogen peroxide, Ardox-X and the best outcome were obtained with citric acid, compared to the other antimicrobial agents. The results show that citric acid or combinations of citric acid achieve a significant reduction in removing multispecies from the salivary culture. (63) However, the extended administration of citric acid solution is not recommended since it could alter the implant's quality of the titanium bony. (4)

In 2014, Ji et al. demonstrated the effectiveness of the mechanical debridement in the treatment of peri-implantitis with or without the adjunctive use of antiseptic rinses. (64)

The efficacy of sodium hypochlorite has been highlighted through an ex vivo study. Indeed, sodium hypochlorite was the only antiseptic to present significant results compared to other commercially available antiseptics such as: hydrogen peroxide, chlorhexidine gluconate and citric acid. (24) (38) Even if hypochlorite presents exciting results, the toxicity of the latter decreases its utility. (24) (38)

In a recent study, McKenna et al. attempt to compare the effects of ozone and hydrogen peroxide in treating mucositis. They selected 20 patients who had at least four implants. Splints were made to cover the implants during brushing. The patients were divided into four treatment groups: (1) air + saline, (2) air + peroxide, (3) ozone + hydrogen peroxide and (4) ozone + saline. Patients treated with ozone + saline and ozone + hydrogen peroxide achieved a significant reduction in plaque index, modified gingival index and bleeding index, with similar results between the two groups, while patients treated with air + saline had the worst results (**Figure 16.**). From this study, it is concluded that ozone therapy has the potential for the control of mucositis. (65)

Figure 16. HealOzone handpiece with silicone cup and cannula.

Further in vivo researches are necessary to learn more about the extension and effectiveness of adjunctive antiseptic therapy.

You can find in the Annexes 11.2 one a table that compares all the different studies.

7.3 ADJUNCTIVE ANTIBACTERIAL THERAPY

Mechanical debridement can also be associated to an adjunctive local or systemic antibacterial therapy to increase the outcome of the periodontal treatment. Bacteriostatic or bactericidal products have the role of inhibiting plaque formation. Unfortunately, they present a time-limited effect, which means they must be used several times.

Positive results have been observed with local antimicrobials such as minocycline microspheres in combination with the mechanical debridement. They are bioresorbable polymeric scaffold, and the antibiotic is contained inside. The distribution of the antibiotic is produced through maintained liberation as the scaffold breaks down over time. (66)

Indeed, two RCTs conducted in 2008 and 2012 have shown the effectiveness of the minocycline microsphere at the clinical and microbiological level, as an adjunctive antibacterial treatment following the mechanical debridement. After 12 months, we can see that the minocycline microspheres result in an improvement at the BOP level and PD also. Thanks to this treatment we manage to achieve a reduction of 38% of the BOP and more or less 0,3mm of PD. In the deepest site, we couldn't observe any specific differences concerning the amount of bacterias but a reduction up to 0,6 mm in the probing depth, after 12 months. We need further studies concerning the use of minocycline microspheres as an adjunctive antibacterial therapy in peri-implant lesions. For durable success, the treatment needs to be repeated. Both systematic review by concludes that the use of systemic antibiotics produces an improvement in the clinical parameters of peri-implantitis. (67) (68) (69)

In another prospective RCT, Schär et al. highlighted the value of the minocycline microsphere in comparison with antimicrobial photodynamic therapy (PDT). All patients received mechanical treatment with curettes and glycine powder spray. After 6 months, this study shows that both therapies equally induce a reduction of the mucosal

inflammation in the initial stages of peri-implantitis. None of the treatment modalities produced a clinical attachment gain. At the end, both options does not lead to a complete resolution of the inflammation. (70) (71)

Salvi et al. showed the effectiveness of the minocycline for the treatment of peri-implantitis for a short period. (1) In 2007, they evaluated the effect of the application of minocycline microspheres (Arestin) as an adjuvant to mechanical debridement. In this study, they evaluate the clinical, radiological and microbiological results but do not compare the results with a control group. The study involved 31 implants diagnosed with peri-implantitis. Firstly, they performed mechanical debridement, then applied 0.2% chlorhexidine gel, and finally, minocycline microspheres were placed in the peri-implant pocket. Results at 12 months show a statistically significant reduction in probing depth (mean 1.6mm) and BOP. The second part of the study shows the microbiological results: a significant reduction in the bacterial count is achieved after ten days. At the end of 12 months, only *A. Actinomycetemcomitans* are lower than the initial values. (69)

Buchter et al. demonstrate the usefulness of doxycycline through a randomized RCT. Indeed, in his study he shows the advantages of the local and controlled application of Atridox, which is a solution that contains 8,5% of doxycycline in combination with the mechanical debridement. The application of the Atridox, lead to an improvement in the BOP (P=0,001), a huge amelioration in the probing attachment of 1,15mm and a reduction of the pocket depths about 1,15mm, in the short term. (72)

Mombelli et al. estimated mechanical debridement with local delivery of tetracycline fibers. 2 patients were excluded from the trial because they presented tenacious peri-implantitis and suppuration on probing. We could observe an improvement of the bone level and a reduction of the PD and BOP. The treatment of peri-implantitis by local delivery of tetracycline presented a positive impact on clinical and microbiological

parameters. However, it is noted that in cases of narrow and deep defects, the direct contact of the fibers with the entire implant surface is complicated, and therefore the desired effects may not be achieved. (1) (73) Furthermore, it seems that tetracycline excites fibroblast increase in the interested area. (4)

Schenk et al. in 1997, conducted a study to evaluate the effectiveness of tetracycline hydrochloride (HCL) fibers as an adjunct to mechanical treatment in mucositis and peri-implant hyperplasia cases (**Figure 17 a-b-c**). After mechanical debridement, tetracycline fibers were placed in the test group and not in the control group. The results show that in the group test, a reduction in mucosal hyperplasia and BOP is achieved, while in the control group, no changes were observed. However, these results were obtained only on a small sample of 8 patients. (74)

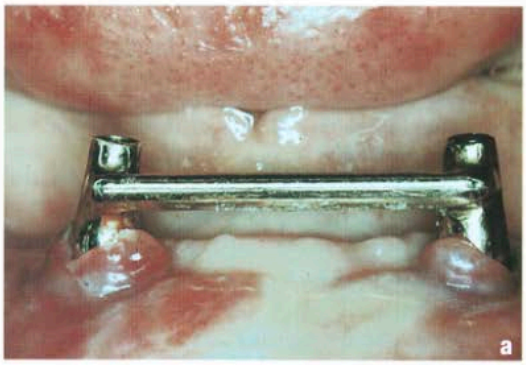

Figure 17.a. Peri implant mucosal hyperplasia at endosseous implants in left and right lower canine position

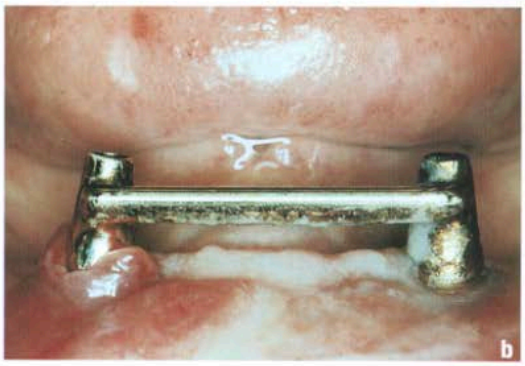

Figure 17.b. Scaling and controlled local delivery of tetracycline HCL resulted in elimination of the mucosal hyperplasia at the patient's left implant after 12 weeks (test). Scaling alone did not affect the mucosal hyperplasia at the patient's right implant (control)

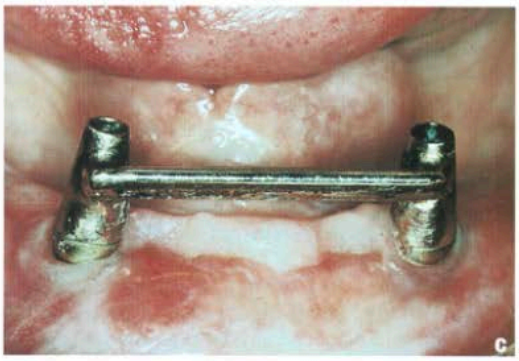

Figure 17.c. After completion of the randomized controlled trial, also the patient's right implant had received controlled local delivery of tetracycline HCL and 12 weeks later, i.e., 24 weeks after baseline, the mucosal hyperplasia was also eliminated at this implant.

Unfortunately, we have a limited knowledge concerning the use of systemic antibiotics for the remedy of peri-implantitis.

In 1992, through Mombelli et al. presented the power of antibiotics administration over the subgingival microbiota in peri-implant infections. The treatment is based on mechanical debridement, chlorhexidine irrigation and systemic antimicrobial cure (1 gr of Ornidazole for 10 days). At the end of the treatment, we can see a reduction concerning BOP and after one years, the BOP is still low. We can also observe a decrease of the PD

after one year, except in one case. We have a general improvement of the microbiota accompanied by a decrease of the subgingival bacterial mass and anaerobic bacterias. This therapy has positive outcome for patients suffering from peri-implantitis. (75)

This is in contradiction with a more recent studies (2012 and 2013), that didn't show the effectiveness of antibiotic in the treatment of periimplantitis. In the RCT of 2012, after 6 months, no improvement concerning the PD was observable, but we can observe a decrease in the BOP from 82,6% to 27,3%. Regarding the bacterial count, no difference was noticed. The BOP improvement may be credited to the enhancements in oral health. The use of systemic antibiotic in the treatment of periimplantitis does not have specific relevance. (39)

In 2013, Rams et al. conducted an in vitro study in which they cultured subgingival plaque samples from 160 implants with peri-implantitis. These cultures were tested for susceptibility to amoxicillin, doxycycline, clindamycin, metronidazole and the combination amoxicillin and metronidazole. Some of the pathogenic bacteria of the peri-implant mucosa are resistant to a single administration of clindamycin, amoxicillin, doxycycline or metronidazole, but there are few cases of resistance to the combination amoxicillin and metronidazole. (76)

A study directed by the Barcelona School of dentistry also demonstrated that the combination of amoxicillin and clavulanic acid presented the antibiogram's best results. (4)

A clinical study conducted in 2012 by Hallström et al. aims to compare the outcome of mucositis treatment with or without the use of systemic antibiotics. They evaluated 48 patients with mucositis, and after receiving mechanical debridement, half of them were given 500mg of azithromycin for four days, and the other half did not receive antibiotics. At six months follow-up, a decrease in probing depth was observed with no differences

between groups. However, concerning BOP, the control group achieved a more significant reduction than the test group, but these differences were not significant. There were also no differences in the composition of the bacterial flora between the two groups at six months. According to the results of this study, the use of systemic antibiotics does not help treat mucositis. (39)

The results of the 2013 study is that the effectiveness of an antibiotic therapy for the treatment of periimplantitis remains questionable. (66)

The combination of mechanical debridement with adjunctive local antibacterial cure may serve as a good choice for the remedy of peri-implantitis. Regarding the use of systemic antibiotics, broader studies are needed to evaluate their effectiveness.

You can find in the Annexes 11.3 one a table that compares all the different studies.

7.4 LASER-ASSITED THERAPY

The term laser means "light amplification by stimulated emission of radiation". A laser can be defined and characterized as a device that produces electromagnetic radiation at a well-defined wavelength. Laser therapy present bactericidal and detoxification effects. The laser decontamination mechanism is based on their thermal effect, which propagates cell necrosis by denaturalizing proteins. (4) It presents some advantages: extremely low mechanical stress, no formation of a smear layer, and the removal of the epithelium lining and inflammation tissues present in the periodontal pocket. (77) It is a technique that requires lots of precision. This therapy leads to the reduction of periodontal pocket and bleeding on probing. We will list different studies that tried to demonstrate both their effectiveness in surface decontamination and the effects they could produce on the implant surface. (78)

Nowadays, we have a big variety of lasers, such as CO2, Er: YAG, Nd: YAG, which are the most commonly used in dentistry. Studies explained that some lasers, due to their ineffectiveness in decreasing calculus, are only used as an adjunctive treatment to mechanical debridement. (79)

We also have the diode laser that is a non-ablative instrument directly in contact with the implant surface and does not cause deformation, melting, or cracking the implant surface. (77) Due to its high melting temperature, this laser presents a bactericidal effect that was confirmed throughout an in vivo study using DNA probes that detect periodontal pathogens. (79) Indeed, his thermal effect reduces the chemical adhesion of bacteria, helping its removal by curette or ultrasonic devices. (79) The diode laser is also said to produce bio stimulation of fibroblasts and osteoblasts that drives significant collagen creation but also improves healing in smokers, in addition to mechanical therapy.

In 2013, a case report was performed to demonstrate the 810-nm diode laser's effectiveness to treat a 7 mm pocket around an implant through a non-surgical therapy. The case of a 45 years -old male presents swelling, suppuration, and inflammation at one of his mandibular implant (Nobel Biocare). (**Figure 18. a-b.**) Due to the disease's extension, surgery was planned, but an emergency intervention was organized to decrease the pain and the inflammation using the 810-nm diode laser. (**Figure 18.c.**). The patient did not receive any anesthesia or systemic antibiotic for the treatment. The diode laser therapy was performed twice a year for three years, parallel with home care periodontal therapy (**Figure 18.d.**). We could observe a reduction of the probing depth from 7 to 3 mm and the absence of bleeding on probing. Bone level improvement can also be observed on the five-year post-operative X-ray (**Figure 18.e.**). It is also important to underline that the patient did not present postoperative ache and shown high compliance to home care procedures. (77)

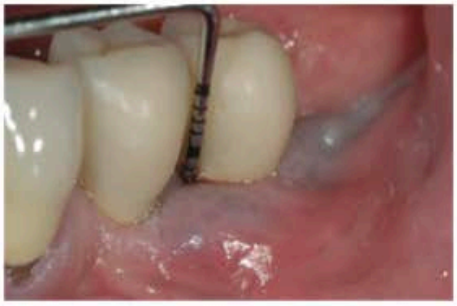

Figure 18.a. Clinical examination revealed 7-mm probing depths, circumferentially around a mandibular implant, bleeding on probing, and the presence of exudate and gingival inflammatory edema.

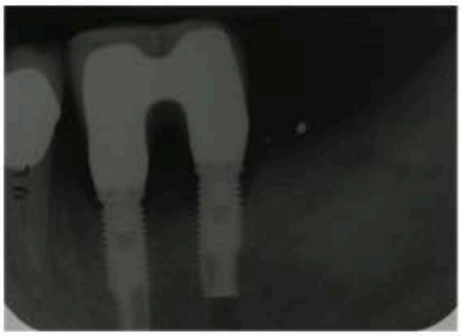

Figure 18.b. Periapical radiography shows bone loss for five-fixture threads on the most distal mandibular left implant.

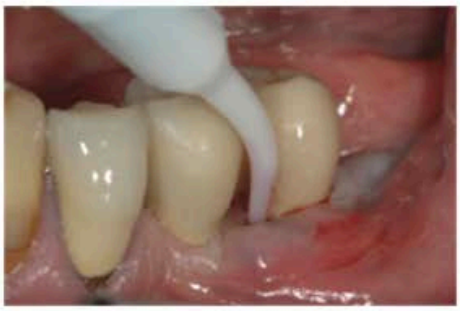

Figure 18.c. Patient treated using an 810-nm diode laser to disinfect the area and facilitate bacterial biofilm removal by mechanical and manual periodontal instrumentation.

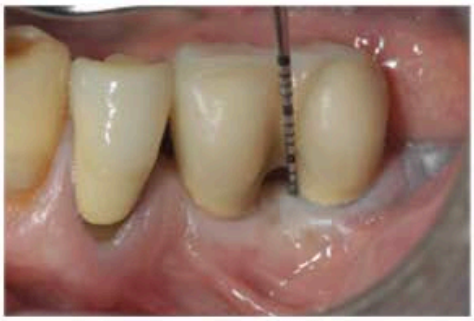

Figure 18.d. Clinical probing depth: 5-year follow-up

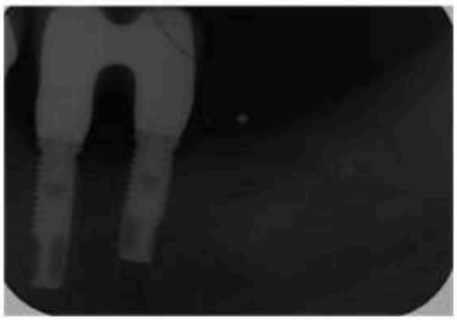

Figure 18.e. Periapical radiograph: 5-year follow-up

Kreisler et al., in an in vitro study, evaluated the damage that four types of laser can produce on various implant surfaces. They concluded that Nd: YAG and Ho: YAG lasers should not be used in the decontamination of implant surfaces due to the alterations and damage they produce, regardless of the power at which they are used. Concerning the CO2 and Er: YAG lasers, they concluded that they could be used by limiting their power. The GaAlAs laser has been considered relatively harmless about the possible alterations on the implant's surface. (78)

In 2007, Deppe et al. highlighted, in an in vitro study, the efficacy of the CO2 laser in eliminating both aerobic and anaerobic bacteria. (80)

Giannini et al. in 2006 carried out a study to evaluate the effects of the Nd: YAG laser on the implant, assessing its effects on the implant surface and its capacity for decontamination. These studies show that at 20 mJ with a 50 or 70 Hz repetition rate, no alterations are produced on the implant's surface. About the decontamination capacity, its effect was tested on two species: *A. actinomycetemcomitans* and *E. coli*; the results show that this type of laser achieves a significant reduction in the bacterial load. (81)

We also have the Er: YAG laser that is the most usually utilized laser for the therapy of peri-implantitis and is characterized by a wavelength of 2940 nm; this particular wavelength allows maximum water absorption. This absorption capacity is 15 times higher than that of the CO2 laser and 2000 times higher than that of the Nd: YAG laser. (82) Studies have demonstrated the effectiveness of Er:YAG laser in the decontamination of bacterial biofilm without harming the implant surfaces. Its mechanism is based on a rise of internal pressure following calculus detection due to increased temperature and water vapor production. The effects of the rays on biological tissues are based on a so-called "thermomechanical" tissue effect. The laser's wavelength (2940 nm) allows it to be absorbed by the tissues, and the water suddenly changes from liquid to vapor. This sudden

evaporation causes an increase in pressure and a micro-explosion for a short period, making it possible to eliminate hard tissue without thermal damage. (41) (42)

This laser can cautiously eliminate, debride and degranulate calculus surrounding the implant surface. It is a good option for hard tissues. (27) The Er: YAG lasers are highly justified considering that they do not negatively impact the implant. Indeed, they do not overheat the surrounding tissues. (4)

Schwarz et al. in 2005 carried out a clinical study to evaluate the effect of the Er: YAG laser in the treatment of peri-implantitis based on the clinical studies carried out by Schwarz himself for the treatment of periodontitis with Er: YAG laser and the experimental studies also carried out by the author on the effects of the laser on the surface of the implant. The study consisted of 20 patients with moderate to advanced peri-implant lesions on 32 implants. They were divided into two groups randomly assigned to two treatment modalities: one group was treated with Er: YAG laser with a conical glass fiber tip that allows entry into the peri-implant pocket; a second group received mechanical treatment with plastic curettes and irrigation with 0.2% chlorhexidine. The results at six months show a significant reduction in BOP for both groups, being significantly higher with the laser. Regarding probing depth, the reduction was significant for both groups but with no difference between them. (83)

A pilot study, demonstrate the benefit of an Er:YAG laser in comparison to the mechanical debridement using plastic curettes and antiseptic therapy with CHX digluconate. Indeed, Er:YAG laser presented a bigger diminution of BOP than the mechanical debridement with CHX. But this laser presents some limitations, especially in case of advanced periimplantitis and its effectiveness seems to be limited to 6 months. (84)

In 2002, Kreisler et al. evaluated in an in vitro study the Er: YAG laser's bactericidal capacity on seventy-two titanium platelets three implant surfaces: sandblasted and acid-etched, titanium plasma-blasted and hydroxyapatite-coated. The discs were incubated with Str. Sanguinis suspension and subjected to laser irradiation at 60 and 120 mJ. Compared to a control group, the results show a reduction in bacterial load of between 98.3% and 99.94% for the different surfaces and treatment modalities studied. Therefore, even at low energy densities, the Er: YAG laser demonstrated a high bactericidal power in vitro without producing damage to the implant's surface. (85)

In 2011, Kim et al. carried out a study to evaluate the Er: YAG laser's effect on the surfaces of double acid-etched implants, using different levels of energy and application time. They recommend using the Er: YAG laser with less than 100 mJ/pulse parameters at 10 Hz and for less than two minutes to decontaminate this type of implant without producing surface alterations. (32) Another study also have demonstrated the limited power of this laser in comparison to the traditional mechanical treatment. (7) (86) In 2011, Schwarz failed to demonstrate the Er: YAG laser's qualities compared to manual debridement with plastic curettes and cleaning with saline solution. (34)

In 2010, Renvert et al., for six months, compared the potency of the Er: YAG laser (**Figure 19.**) with an air-abrasive device (**Figure 20.**). A significant improvement in suppuration of probing can be observed from both groups. Concerning the BOP, the results are quite similar, with only 5% of differences. None of the implants in either group had a concrete conclusion. The clinical treatment effects were restricted and alike between the two systems. (1) (86)

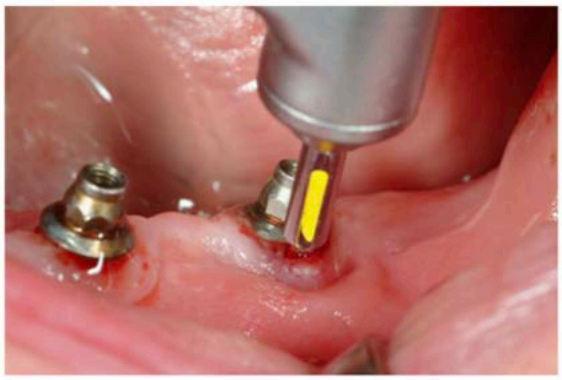

Figure 19. Use of the Er: YAG laser at an infected site with the supra-structure removed.

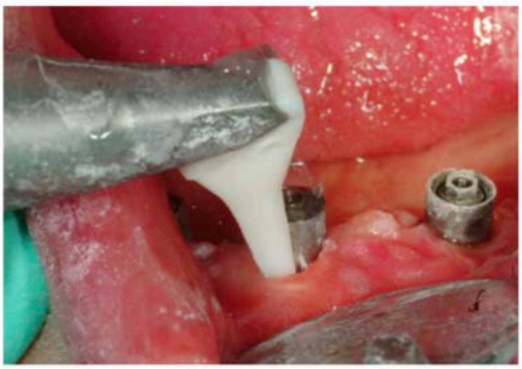

Figure 20. Use of the air-abrasive device at an infected site with the supra-structure removed.

A randomized controlled clinical trial compared the effect of the Er: YAG laser with a newly developed air-abrasive device. After six months, both systems presented a decreased in BOP and PD (0.8 mm for the Er: YAG laser and 0.9 mm for the air-abrasive device). (86)

Persson et al. in 2011 conducted a clinical study to compare two non-surgical treatment modalities for peri-implantitis: Er: YAG laser compared to glycine abrasive spray (**Figure 21.**). Forty-two patients were divided into two groups randomly assigned to each treatment modality. Follow-up is performed to evaluate clinical changes and to obtain microbiological data. The reduction in probing depth at six months was 0.9 mm for the laser group and 0.8 mm for the abrasive spray. At 3 and 6 months, neither of the two treatments options succeeded in reducing the bacterial count and in some cases, an increase was observed. According to the authors, these in vivo results contradict those in vitro studies that demonstrated both the laser and the abrasive spray's ability to be effective in decontaminating the implant. (87)

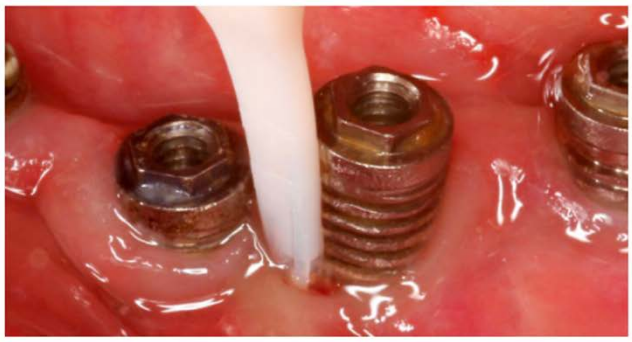

Figure 21. Debridement of peri-implant biofilm using a glycine-based air-abrasive system.

Another type of laser with a low thermal effect is the Er, Cr, YSGG (WaterlaseTM), with a symbolizes enhancement over the Er: YAG's technical attributes and which undoubtedly has a bright future in this area. (4)

Photodynamic therapy (PDT) is another option for non-surgical treatment of peri-implantitis. Also, the combination of different types of low-intensity laser with photosensitizing substances such as eosin, toluidine or methylene blue has shown excellent results in in vitro studies for the inactivation of gram-positive and gram-negative periodontopathogenic bacteria.

Haas et al. in 1997 conducted an in vitro study to evaluate the effect of PDT on different implant surfaces. Smooth-surfaced discs with different surface treatments are incubated with suspensions of *A. actinomycetemcomitans, P. gingivalis* and *Prevetolla intermedia.* The contaminated discs are treated with a toluidine blue solution and a 905 nm diode laser for one minute (**Figure 22.**). (77) The combined laser and photosensitising treatment achieved complete elimination of all bacteria, while in the control group that did not receive treatment, an increase in the number of bacteria was observed. (88)

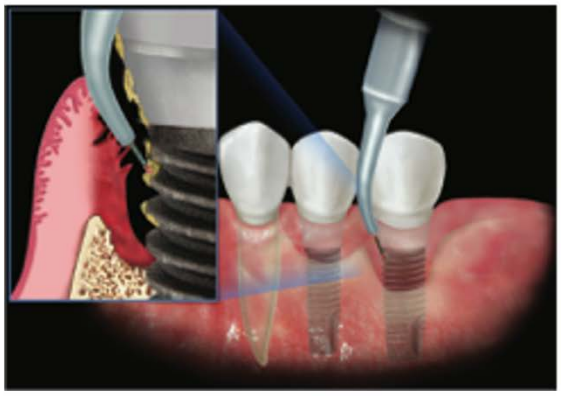

Figure 22. The diode laser has mainly a bactericidal effect. Threaded implants have a different morphology than root surfaces; therefore, debridement instruments may differ. The laser may facilitate detoxification of the implant surface.

In 2013, Deppe et al. also performed a study to evaluate the efficacy of photodynamic therapy (PDT) in the non-surgical treatment of peri-implantitis. In this case, patients are divided into two groups depending on whether the bone loss is more significant or less than 5 mm, but there is no control group. The treatment protocol was prophylaxis and irrigation with 0.2% chlorhexidine and, after two weeks, the application of PDT using a photosensitizing dye with methylene blue (**Figure 23.**). This PDT was performed using the medical hand-held battery-operator diode laser HELBO, operated in a continuous laser beam delivery mode (**Figure 24.**). A 6-month follow-up was carried out: at three months, there was a significant reduction in BOP and probing depth for both groups; however, at six months in the group with deep defects, this reduction was not maintained, and a slight increase in probing depth with a slight radiological bone loss was observed. In the group with moderate defects, at six months, the reduction in probing depth is maintained, and there are no signs of bone loss. The authors in their discussion consider that non-surgical treatment with PDT is an effective treatment to improve clinical parameters and stop bone loss in moderate defects, but not in cases of advanced peri-implantitis. They argue on the one hand that by not doing a surgical treatment, we can control the disease without creating recessions and on the other hand that if peri-implantitis is considered as a chronic disease that requires maintenance, PDT is a simple method to complement mechanical treatment in maintenance treatments. (89)

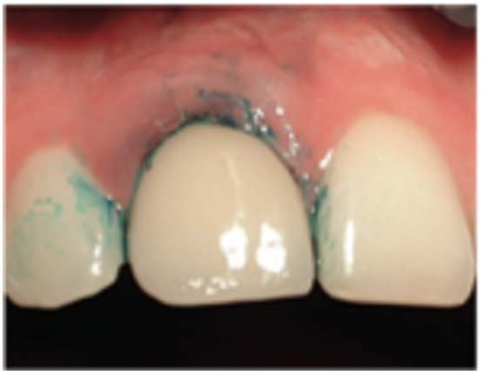

Figure 23. Clinical aspect following application of photosensitizer.

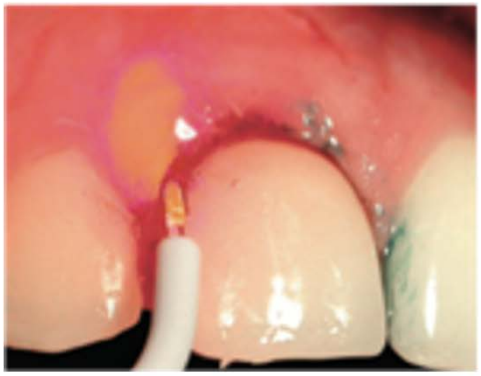

Figure 24. Nonsurgical intervention: application of diode laser light.

The laser-assisted therapy seems to be effective only in the short term, and there is insufficient confirmation on the predictability of laser therapy's potentially profitable outcomes in the nonsurgical treatment of periimplantitis, primarily if the laser treatment is performed alone.

You can find in the Annexes 11.4 one a table that compares all the different studies.

8 CONCLUSION

Concerning the treatment of peri-implantitis, there is no specific proof that demonstrates what the most effective therapy is. On the one hand, many trials have presented favorable short-term results. On the other hand, disease perseverance, progression or recurrence were also reported. (1) A treatment planning that will completely eradicate peri-implantitis has not been found yet. This situation is related to the lack of high-quality data about the potency of established therapy. Notwithstanding, there is some credit in the current method. (24) The success of the treatment is highly dependent on the detection and care of the disease, and prevention is the most reliable form of treatment. Nonsurgical treatment, combined with regular supportive care, leads to positive results and increases the implant survival rate; despite the unpredictable outcome of peri-implantitis. Routine check-ups and close monitoring of the treated implants is crucial to prevent relapse and recolonization by peri-odontopathogenic microorganism, in order for peri-implant tissues to heal. (24) (90) There is no conclusive confirmation proposing which could be the best interventions for managing peri-implantitis. (34) However, several studies have demonstrated the improvement of implant surface thanks to mechanical debridement, and this method appears to be very effective especially in mild cases of peri-implantitis (with pockets less than 3 mm). Nevertheless, it has some limitations. (36) Indeed, various authors do not recommend using metal curettes because of the alterations they can cause on the implant's surface but also due to the fact that they can promote future plaque accumulation. (57) Non-metallic instruments such as plastic curettes and abrasive sprays cause minimal or no damage to the implant surface. Some new tips, such as one made of copper metal, have a bright future because they have extreme efficient in bacterial detoxification, but at the same time produce minimal harm to the implant surface. (37)

(56) Regarding the use of antiseptics as an adjuvant to mechanical debridement, studies conclude its inutility in resolving the disease; we can especially observe this fact for the studies conducted over chlorhexidine, where we can observe that the inflammation can be resolved with mechanical treatment without the need for antiseptic treatment. (58) (60) (61) Citric acid and hydrogen peroxide seem to be the best antiseptics because they significantly reduce the bacterial load. However, their extended administration presents some toxic effect in the long term but can also alter the implant quality. (25) (60) (62) Positive results have been observed with local antimicrobials such as minocycline microspheres or by local delivery of tetracycline, compared to systemic antibiotic ingestion to remedy peri-implantitis. (1) (39) (66) (69) (74) The use of lasers are becoming more and more common in contemporary practice, but remains controversial. Lasers could be used as an alternative or as an adjunctive remedy to conventional periodontal treatment. (79) It is considered a worthy option to detoxify and decrease the number of bacteria surrounding the implant and present a better postoperative recovery. According to some authors, laser treatments improve clinical parameters over six months, especially in moderate defects. The Er: YAG laser demonstrated many advantages, such as a high bactericidal power without damaging the implant's surface. Oher types of lasers with a low thermal effect including the Er, Cr, YSGG (WaterlaseTM), which present technical attributes over the Er: YAG's undoubtedly have a bright future in this area. (4) (78) The non-surgical treatment presents some weaknesses, especially in advanced lesions, where surgical treatment might be the best option. (36) This study illustrates that peri-implantitis is a complex disease, and it requires frequent follow-ups as relapse is common. (24) More investigations are required with significant sample sizes and longer follow-ups to reinforce these outcomes and their long-term stability to optimize the results and provide more effective evidence-based approaches.

9 RESPONSIBILITY

In our society, where life expectancy is increasing, living well becomes vital: chewing, smiling are essential elements for a good quality of life. Thus, for more than 25 years, dental implants have been used to treat partially or entirely edentulous subjects. They present a high rate of success over a long time. Peri-implantitis is considered as the leading cause of morbidity of an implant. Nowadays, we are confused and lacking clinical experience about the effectiveness of non-surgical treatment of peri-implantitis.

Through this study, we evaluate several treatments, their effectiveness and limitations. Those recommendations will orientate us towards better management of this pathology. The current trajectory of human civilization is one that is concerned with environmental sustainability. This study aims to add to the significant body of research available to aid in improving human health. As Branemark, the father of implantology, says, "No one should die with their teeth sitting on a glass of water".

10 BIBLIOGRAPHY

1. Heitz-Mayfield L, Mombelli A. The Therapy of Peri-implantitis: A Systematic Review. Int J Oral Maxillofac Implants. 2014;29(Supplement):325–45.
2. Implant D, Size M, Pacific A, America L, Forecasts S, Options P, et al. Report Overview. Dent Implant Mark Size Share Rep. 56:2–7.
3. Gelb D, McAllister B, Nummikoski P, Del Fabbro M. Clinical and radiographic evaluation of brånemark implants with an anodized surface following seven-to-eight years of functional loading. Int J Dent. 2013;2013.
4. Ángeles M, Garcés S, Escoda CG, Bucal DC, Cirugía M De, Bucofacial I. Periimplantitis. Orofac Infect. 2004;(1):63–74.
5. Spring S, Tyrian PRDERS, Chool SPS, Euroscience OFN. Les Peri-implantites. Actual Sci recommandations Prat. 2014;(April):8010.
6. Froum SJ, Rosen PS. A Proposed Classi cation for. Int J Periodontics Restorative Dent. 2012;533–40.
7. Polyzois I. Treatment Planning for Periimplant Mucositis and Periimplantitis. Implant Dent. 2019;28(2):150–4.
8. Quirynen M, Vogels R, Alsaadi G, Naert I, Jacobs R, Steenberghe D Van. Predisposing conditions for retrograde peri-implantitis, and treatment suggestions. Clin Oral Implants Res. 2005;16(5):599–608.
9. Lindhe J, Meyle J. Peri-implant diseases: Consensus Report of the Sixth European Workshop on Periodontology. J Clin Periodontol. 2008;35(SUPPL. 8):282–5.
10. Berglundh T, Armitage G, Araujo MG, Avila-Ortiz G, Blanco J, Camargo PM, et al. 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. J Clin Periodontol. 2018;45(February):S286–91.

11. Andrea Monbelli, Lang NP. The diagnosis and treatment of Peri-implanitits. Periodontol 2000. 1998;17(5):63–76.

12. Mombelli A LN. The diagnosis and treatment of peri-implantitis. Periodontol 2000. 1998;17(5):63–76.

13. Heitz-Mayfield LJA. Peri-implant diseases: Diagnosis and risk indicators. J Clin Periodontol. 2008;35(SUPPL. 8):292–304.

14. Roccuzzo M, Layton DM, Roccuzzo A, Heitz-Mayfield LJ. Clinical outcomes of peri-implantitis treatment and supportive care: A systematic review. Clin Oral Implants Res. 2018;29(March):331–50.

15. Donos N, Laurell L, Mardas N. Hierarchical decisions on teeth vs. implants in the periodontitis-susceptible patient: The modern dilemma. Periodontol 2000. 2012;59(1):89–110.

16. Preshaw PM, Alba AL, Herrera D, Jepsen S, Konstantinidis A, Makrilakis K, et al. Periodontitis and diabetes: A two-way relationship. Diabetologia. 2012;55(1):21–31.

17. Koshak HH. Is a High Level of Cholesterol or Vitamin D Deficiency a Risk Factor for Dental Implants or Bone Grafting Failure? Glob J Otolaryngol. 2017;10(4):96–9.

18. Keuroghlian A, Barroso ADV, Kirikian G, Bezouglaia O, Tintut Y, Tetradis S, et al. The effects of hyperlipidemia on implant osseointegration in the mouse femur. J Oral Implantol. 2015;41(2):e7–11.

19. Kelly J, Lin A, Wang CJ, Park S, Nishimura I. Vitamin D and bone physiology: Demonstration of vitamin D deficiency in an implant osseointegration rat model.

J Prosthodont. 2009;18(6):473–8.

20. Haas R, Werner H, Georg M, Georg W. The relationship spective study of smoking tissue : A retrospective study. J Prosthet Dent. 1996;76(6):592–6.

21. Galindo-Moreno P, Fauri M, Ávila-Ortiz G, Fernández-Barbero JE, Cabrera-León A, Sánchez-Fernández E. Influence of alcohol and tobacco habits on peri-implant marginal bone loss: A prospective study. Clin Oral Implants Res. 2005;16(5):579–86.

22. Pietropaoli D, Ortu E, Severino M, Ciarrocchi I, Gatto R, Monaco A. Glycation and oxidative stress in the failure of dental implants: A case series. BMC Res Notes. 2013;6(1):1–6.

23. Albouy JP, Abrahamsson I, Persson LG, Berglundh T. Implant surface characteristics influence the outcome of treatment of peri-implantitis: An experimental study in dogs. J Clin Periodontol. 2011;38(1):58–64.

24. Alani A, Bishop K. Peri-implantitis. Part 3: Current modes of management. Br Dent J. 2014;217(7):345–9.

25. Bouazza-Juanes K, Martínez-González A, Peiró G, Ródenas JJ, López-Mollá MV. Effect of platform switching on the peri-implant bone: A finite element study. J Clin Exp Dent. 2015;7(4):e483–8.

26. Schiuma D, Plecko M, Kloub M, Rothstock S, Windolf M, Gueorguiev B. Influence of peri-implant bone quality on implant stability. Med Eng Phys [Internet]. 2013;35(1):82–7. Available from: http://dx.doi.org/10.1016/j.medengphy.2012.04.001

27. Wang CW, Renvert S, Wang HL. Nonsurgical Treatment of Periimplantitis. Implant Dent. 2019;28(2):155–60.

28. Tonetti MS, Chapple ILC, Jepsen S, Sanz M. Primary and secondary prevention

of periodontal and peri-implant diseases: Introduction to, and objectives of the 11th European Workshop on Periodontology consensus conference. J Clin Periodontol. 2015;42(S16):S1–4.

29. Ramanauskaite A, Daugela P, Faria e Almeida R, Saulacic N. Surgical Non-Regenerative Treatments for Peri-Implantitis: a Systematic Review. J Oral Maxillofac Res. 2016;7(3):1–11.

30. Sinjab K, Garaicoa-Pazmino C, Wang HL. Decision making for management of periimplant diseases. Implant Dent. 2018;27(3):276–81.

31. Renvert S, Polyzois IN. Clinical approaches to treat peri-implant mucositis and peri-implantitis. Periodontol 2000. 2015;68(1):369–404.

32. Kim JH, Herr Y, Chung JH, Shin S Il, Kwon YH. The effect of erbium-doped: Yttrium, aluminium and garnet laser irradiation on the surface microstructure and roughness of double acidetched implants. J Periodontal Implant Sci. 2011;41(5):234–41.

33. Alani A, Bishop K, Roccuzzo M, Layton DM, Roccuzzo A, Heitz-Mayfield LJ, et al. Peri-implantitis. Part 3: Current modes of management. Clin Oral Implants Res. 2014;13(7):369–404.

34. Esposito M, Grusovin MG, Kakisis I, Coulthard P, Worthington H V. Interventions for replacing missing teeth: Treatment of perimplantitis. Cochrane Database Syst Rev. 2008;(2).

35. Karring ES, Stavropoulos A, Ellegaard B, Karring T. Treatment of peri-implantitis by the Vector® system: A pilot study. Clin Oral Implants Res. 2005;16(3):288–93.

36. Sahrmann P, Ronay V, Hofer D, Attin T, Jung RE, Schmidlin PR. In vitro cleaning potential of three different implant debridement methods. Clin Oral

Implants Res. 2015;26(3):314–9.

37. Speelman JA, Collaert B, Klinge B. Evaluation of different methods to clean titanium abutments. A scanning electron microscopic study. Vol. 3, Clinical Oral Implants Research. 1992. p. 120–7.

38. Bürgers R, Witecy C, Hahnel S, Gosau M. The effect of various topical peri-implantitis antiseptics on Staphylococcus epidermidis, Candida albicans, and Streptococcus sanguinis. Arch Oral Biol. 2012;57(7):940–7.

39. Hallström H, Persson GR, Lindgren S, Olofsson M, Renvert S. Systemic antibiotics and debridement of peri-implant mucositis. A randomized clinical trial. J Clin Periodontol. 2012;39(6):574–81.

40. Mizutani K, Aoki A, Coluzzi D, Yukna R, Wang CY, Pavlic V, et al. Lasers in minimally invasive periodontal and peri-implant therapy. Periodontol 2000. 2016;71(1):185–212.

41. Quirynen M, Bollen CML, Vandekerckhove BNA, Dekeyser C, Papaioannou W, Eyssen H. Full- vs. Partial-mouth Disinfection in the Treatment of Periodontal Infections: Short-term Clinical and Microbiological Observations. J Dent Res. 1995;74(8):1459–67.

42. Rosema NAM, Timmerman MF, Versteeg PA, van Palenstein Helderman WH, Van der Velden U, Van der Weijden GA. Comparison of the Use of Different Modes of Mechanical Oral Hygiene in Prevention of Plaque and Gingivitis. J Periodontol. 2008;79(8):1386–94.

43. Augthun M, Tinschert J, Huber A. In Vitro Studies on the Effect of Cleaning Methods on Different Implant Surfaces. J Periodontol. 1998;69(8):857–64.

44. Figuero E, Graziani F, Sanz I, Herrera D, Sanz M. Management of peri-implant mucositis and peri-implantitis. Periodontol 2000. 2014;66(1):255–73.

45. Oribe D, Vicario M, Violant D, Santos A. Tratamiento de la periimplantitis. Revisión bibliográfica. Periodoncia y Osteointegración. 2009;19.

46. Matarasso S. Matarasso in Vitro.Pdf. 1996. p. 64–72.

47. Renvert S, Samuelsson E, Lindahl C, Persson GR. Mechanical non-surgical treatment of peri-implantitis: A double-blind randomized longitudinal clinical study. I: Clinical results. J Clin Periodontol. 2009;36(7):604–9.

48. Sahm N, Becker J, Santel T, Schwarz F. Non-surgical treatment of peri-implantitis using an air-abrasive device or mechanical debridement and local application of chlorhexidine: A prospective, randomized, controlled clinical study. J Clin Periodontol. 2011;38(9):872–8.

49. Sato S, Kishida M, Ito K. The Comparative Effect of Ultrasonic Scalers on Titanium Surfaces: An In Vitro Study. J Periodontol. 2004;75(9):1269–73.

50. Kawashima H, Sato S, Kishida M, Yagi H, Matsumoto K, Ito K. Treatment of Titanium Dental Implants With Three Piezoelectric Ultrasonic Scalers: An In Vivo Study. J Periodontol. 2007;78(9):1689–94.

51. Schwarz F, Rothamel D, Sculean A, Georg T, Scherbaum W, Becker J. Effects of an Er: YAG laser and the Vector® ultrasonic system on the biocompatibility of titanium implants in cultures of human osteoblast-like cells. Clin Oral Implants Res. 2003;14(6):784–92.

52. Duarte PM, Reis AF, de Freitas PM, Ota-Tsuzuki C. Bacterial Adhesion on Smooth and Rough Titanium Surfaces After Treatment With Different Instruments. J Periodontol. 2009;80(11):1824–32.

53. Máximo MB, De Mendonça AC, Renata Santos V, Figueiredo LC, Feres M, Duarte PM. Short-term clinical and microbiological evaluations of peri-implant diseases before and after mechanical anti-infective therapies. Clin Oral Implants

Res. 2009;20(1):99–108.

54. John G, Sahm N, Becker J, Schwarz F. Nonsurgical treatment of peri-implantitis using an air-abrasive device or mechanical debridement and local application of chlorhexidine. Twelve-month follow-up of a prospective, randomized, controlled clinical study. Clin Oral Investig. 2015;19(8):1807–14.

55. Schwarz F, Ferrari D, Popovski K, Hartig B, Becker J. Influence of different air-abrasive powders on cell viability at biologically contaminated titanium dental implants surfaces. J Biomed Mater Res - Part B Appl Biomater. 2009;88(1):83–91.

56. Baek SH, Shon WJ, Bae KS, Kum KY, Lee WC, Park YS. Evaluation of the safety and efficiency of novel metallic ultrasonic scaler tip on titanium surfaces. Clin Oral Implants Res. 2012;23(11):1269–74.

57. Louropoulou A, Slot DE, Van der Weijden FA. Titanium surface alterations following the use of different mechanical instruments: A systematic review. Clin Oral Implants Res. 2012;23(6):643–58.

58. Heitz-Mayfield LJA, Salvi GE, Botticelli D, Mombelli A, Faddy M, Lang NP. Anti-infective treatment of peri-implant mucositis: A randomised controlled clinical trial. Clin Oral Implants Res. 2011;22(3):237–41.

59. Ciancio SG, Lauciello F, Shibly O, Vitello M, Mather M. The Effect of an Antiseptic Mouthrinse on Implant Maintenance: Plaque and Peri-Implant Gingival Tissues. J Periodontol. 1995;66(11):962–5.

60. Ardila Medina CM GZI. Eficacia de las alternativas de tratamiento para la mucositis periimplantaria. Av en Periodoncia e Implantol Oral [Internet]. 2014;26(3):141–6. Available from: http://scielo.isciii.es/scielo.php?script=sci_arttext&pid=S1699-

6585201400030005&lng=es&nrm=iso&tlng=es

61. Thöne-Mühling M, Swierkot K, Nonnenmacher C, Mutters R, Flores-de-Jacoby L, Mengel R. Comparison of two full-mouth approaches in the treatment of peri-implant mucositis: A pilot study. Clin Oral Implants Res. 2010;21(5):504–12.

62. Gosau M, Hahnel S, Schwarz F, Gerlach T, Reichert TE, Bürgers R. Effect of six different peri-implantitis disinfection methods on in vivo human oral biofilm. Clin Oral Implants Res. 2010;21(8):866–72.

63. Ntrouka V, Hoogenkamp M, Zaura E, Van der Weijden F. The effect of chemotherapeutic agents on titanium-adherent biofilms. Clin Oral Implants Res. 2011;22(11):1227–34.

64. Ji YJ, Tang ZH, Wang R, Cao J, Cao CF, Jin LJ. Effect of glycine powder air-polishing as an adjunct in the treatment of peri-implant mucositis: A pilot clinical trial. Clin Oral Implants Res. 2014;25(6):683–9.

65. McKenna DF, Borzabadi-Farahani A, Lynch E. The Effect of Subgingival Ozone and/or Hydrogen Peroxide on the Development of Peri-implant Mucositis: A Double-Blind Randomized Controlled Trial. Int J Oral Maxillofac Implants. 2013;28(6):1483–9.

66. Javed F, Alghamdi AST, Ahmed A, Mikami T, Ahmed HB, Tenenbaum HC. Clinical efficacy of antibiotics in the treatment of peri-implantitis. Int Dent J. 2013;63(4):169–76.

67. Renvert S, Lessem J, Dahlén G, Lindahl C, Svensson M. Topical minocycline microspheres versus topical chlorhexidine gel as an adjunct to mechanical debridement of incipient peri-implant infections: A randomized clinical trial. J Clin Periodontol. 2006;33(5):362–9.

68. Renvert S, Lessem J, Dahlén G, Renvert H, Lindahl C. Mechanical and Repeated

Antimicrobial Therapy Using a Local Drug Delivery System in the Treatment of Peri-Implantitis: A Randomized Clinical Trial. J Periodontol. 2008;79(5):836–44.

69. Salvi GE, Persson GR, Heitz-Mayfield LJA, Frei M, Lang NP. Adjunctive local antibiotic therapy in the treatment of peri-implantitis II: Clinical and radiographic outcomes. Clin Oral Implants Res. 2007;18(3):281–5.

70. Schär D, Ramseier CA, Eick S, Arweiler NB, Sculean A, Salvi GE. Anti-infective therapy of peri-implantitis with adjunctive local drug delivery or photodynamic therapy: Six-month outcomes of a prospective randomized clinical trial. Clin Oral Implants Res. 2013;24(1):104–10.

71. Bassetti M, Schär D, Wicki B, Eick S, Ramseier CA, Arweiler NB, et al. Anti-infective therapy of peri-implantitis with adjunctive local drug delivery or photodynamic therapy: 12-month outcomes of a randomized controlled clinical trial. Clin Oral Implants Res. 2014;25(3):279–87.

72. Büchter A, Meyer U, Kruse-Lösler B, Joos U, Kleinheinz J. Sustained release of doxycycline for the treatment of peri-implantitis: Randomised controlled trial. Br J Oral Maxillofac Surg. 2004;42(5):439–44.

73. Mombelli A, Feloutzis A, Brägger U, Lang NP. Treatment of peri-implantitis by local delivery of tetracycline: Clinical, microbiological and radiological results. Clin Oral Implants Res. 2001;12(4):287–94.

74. Franch F, Luengo F, Bascones A. De Riesgo Coadyuvante S , Diagnóstico Y Tratamiento Según Los Protocolos Científicos. Av Periodon Implant. 2004;16(3):143–56.

75. Mombelli A LN. Antimicrobial treatment of peri-implant infections. Clin Oral Implants Res. 1992;162–8.

76. Rams TE, Degener JE, Van Winkelhoff AJ. Antibiotic resistance in human peri-

implantitis microbiota. Clin Oral Implants Res. 2014;25(1):82–90.

77. Roncati M, Lucchese A, Carinci F. Non-Surgical treatment of peri-Implantitis with the adjunctive use of an 810-nm diode laser. J Indian Soc Periodontol. 2013;17(6):812–5.

78. Kreisler M, Götz H. and GaAlAs Laser Irradiation on Surface Properties of Endosseous Dental Implants. 2002;17(2).

79. Cobb CM. Lasers in Periodontics: A Review of the Literature. J Periodontol. 2006;77(4):545–64.

80. Deppe H, Horch HH, Schrödl V, Haczek C, Miethke T. Effect of 308-nm excimer laser light on peri-implantitis-associated bacteria - An in vitro investigation. Lasers Med Sci. 2007;22(4):223–7.

81. Giannini R, Vassalli M, Chellini F, Polidori L, Dei R, Giannelli M. Neodymium:yttrium aluminum garnet laser irradiation with low pulse energy: A potential tool for the treatment of peri-implant disease. Clin Oral Implants Res. 2006;17(6):638–43.

82. Sculean A, Schwarz F, Becker J. Anti-infective therapy with an Er:YAG laser: Influence on peri-implant healing. Expert Rev Med Devices. 2005;2(3):267–76.

83. Schwarz F, Sculean A, Rothamel D, Schwenzer K, Georg T, Becker J. Clinical evaluation of an Er:YAG laser for nonsurgical treatment of peri-implantitis: a pilot study. Clin Oral Implants Res. 2004;16(1):44–52.

84. Schwarz F, Bieling K, Bonsmann M, Latz T, Becker J. Nonsurgical treatment of moderate and advanced periimplantitis lesions: A controlled clinical study. Clin Oral Investig. 2006;10(4):279–88.

85. Kreisler M, Kohnen W, Marinello C, Götz H, Duschner H, Jansen B, et al. Bactericidal Effect of the Er:YAG Laser on Dental Implant Surfaces: An In Vitro

Study. J Periodontol. 2002;73(11):1292–8.

86. Renvert S, Lindahl C, Jansåker AMR, Persson RG. Treatment of peri-implantitis using an Er:YAG laser or an air-abrasive device: A randomized clinical trial. J Clin Periodontol. 2011;38(1):65–73.

87. Persson GR, Roos-Jansåker A-M, Lindahl C, Renvert S. Microbiologic Results After Non-Surgical Erbium-Doped:Yttrium, Aluminum, and Garnet Laser or Air-Abrasive Treatment of Peri-Implantitis: A Randomized Clinical Trial. J Periodontol. 2011;82(9):1267–78.

88. Haas R, Dörtbudak O, Mensdorff-Pouilly N, Mailath G. Elimination of bacteria on different implant surfaces through photosensitization and soft laser: An in vitro study. Vol. 8, Clinical Oral Implants Research. 1997. p. 249–54.

89. Deppe H, Mücke T, Wagenpfeil S, Kesting M, Sculean A. Nonsurgical antimicrobial photodynamic therapy in moderate vs severe peri-implant defects: A clinical pilot study. Quintessence Int (Berl). 2013;44(8):609–18.

90. Meyle J. Mechanical, chemical and laser treatments of the implant surface in the presence of marginal bone loss around implants. Eur J Oral Implantol. 2012;5:71–81.

11 ANNEXES

11.1 MECHANICAL DEBRIDMENT

Authors (year)	Type of study	Number of patients and implants	Treatment	Time – Evaluated period	Results	Conclusion
Karring et al. (2005) (35)	Controlled study (randomized split mouth)	11 patients 22 implants	Oral hygiene instruction + a. Vector system b. Carbon-fiber curette	6 months	PI: a. 23,7- 9,1% b. 23,7-18,2% PD: a. 5,8-5,8 mm b. 6,2-6,3 mm BOP: a. 63,6-36,4% b. 72,7-81,8%	The use of either the Vector system or carbon-fiber curettes did not consistently allow the healing of peri-implantitis.
Renvert et al. (2009) (44)	Double-blind randomized clinical study	31 patients 31 implants	a. Titanium curette b. Ultrasonic system with specially designed tip All implants were polished with rubber cups and polishing paste + oral hygiene instructions	6 months	Plaque index (PI): (P<0,01) BOP: (P=0,026) PD: (P=0,30	No differences between both groups
Sahm et al. (2011) (51)	Prospective, randomized, controlled clinical study	25 patients with mild to moderate peri-implantitis	All the patients underwent under an oral hygiene program and were randomly treated: a. AAD (amino acid glycine powder) b. mechanical debridement using carbon curettes and antiseptic therapy with chlorhexidine digluconate (mechanical debridement (MDA)	12 months	BOP: a. 41,2-29,5 % b. 16,6-33,4% PD: a. 0,5-0,9 mm b. 0,4-0,9 mm CAL: a. 0,6-1,3 mm b. 0,5-1,1 mm	Both studies present similar improvement except with some limitation in the CAL. We can see that the AAD demonstrated better BOP decreases than MDA.
Kawashima et al. (2007) (47)	In Vivo study	14 patients	a. Piezoelectric ultrasound scalers with a carbon tip b. Ultrasound with a plastic tip c. Ultrasound with a metallic tip	3 to 9 months	No difference in the amount of plaque and calculus between the 3 systems	Piezoelectric scaler with non-metallic tips leave a smooth surface, the conventional metal-tipped ultrasound produces surface damage.

11.2 ADJUNCTIVE ANTISEPTIC THERAPY

Authors (year)	Type of study	Number of patients and implants	Treatment	Time – Evaluated period	Results	Conclusion
Gosau y cols. (2010) (59)	In vivo human study	14 specimens in every splint. Those splints were worn for 12 hours at night by four patients.	Various antimicrobial agents were placed in the tray such as Sodium hypochlorite 1%, Hydrogen peroxide 3%, Chlorhexidinglucon ate 0.2%, triclosan 0,3%, Listerine, citric acid 40% were used for 1 min on the titanium implants and used as control saline solution.	After 12 hours	Higher results with: Sodium hypochlorite, hydrogen peroxide, Listerine and CHX.	All tested antiseptics appear to be able to decrease the amount of bacterial biofilm growing on titanium surfaces.
Ciancio et al. (1995) (56)	Controlled double-blind, randomized clinical trial	20 healthy adult patients, each of whom had at least two dental implants	a. Antiseptic mouth rinse (Listerine: 20 ml, twice a day for 30 sec) b. Placebo rinse (5% hydroalcohol; twice daily for 30 sec)	3 months	a. Plaque index: 2,0 - 0,8 and BOP: 0,6 – 0,3 b. Plaque index: 1,8 – 1,6 and BOP: 0,7 – 0,5	We can see a reduced plaque levels and swelling in both groups. The rinse as an adjuvant did not produce improvements in probing depth or insertion level for either group.
Levin et al. (2015) (91)	Prospective RCT	40 patients	At home use of water jet with chlorhexidine (CHX) gel	3 months	Probing depth reduction and a great reduction of BOP	supplement the response to nonsurgical treatment for peri-implantitis lesions. Further, larger-cohort studies are warranted
Trejo et al. (2006) (57)	Experimental study	9 monkeys	a. mechanical debridement b. mechanical debridement with chlorhexidine irrigation and a 0.2% chlorhexidine gel c. control group (no treatment)	6 weeks	a – b. Improvement without any specific distinctions concerning the probing depth, gingival and plaque index + absence of inflammation. c. Inflammation	Mucositis can be resolved with mechanical treatment without the need for antiseptic treatment.

Heitz. Mayfield et al. (2011) (55)	RCT	29 patients diagnosed with mucositis	All patients received mechanical debridement and were then divided into two groups: a. 0.2% chlorhexidine gel twice a day for a month b. placebo	1 months	Both groups presented a reduction of the gingival index and probing depth but with no significant differences.	Chlorhexidine does not improve the results of mechanical treatment.
Thöne-Mühlingy cols. (2010) (58)	Pilot study	13 partially edentulous patients and 36 dental implants with mucositis	"Full-mouth" procedure: mechanical debridement with or without chlorhexidine gel and rinse.	8 months	After 24 hours, the bacterial count is reduced for both groups. After eight months, both present treatment improvement without significant differences.	After eight months, any group presented a significant bacterial reduction.
Machtei et al. (2012) (92)	Multicenter, placebo-controlled RCT	32 patients	Ultrasonic debridement with adjunctive use of an antiseptic CHX chips, placed in pockets >5mm	2, 4, 6, 6, 12 and 18 weeks. Then 6 months later reassessment	Decrease of BOP and PD with increase in the CAL	Need further studies concerning the frequency of the CHX chips application
Stein et al. (2017) (93)	Porspective clinical trial	45 patients comprising 164 screw-typed implants	Combine therapy of ultrasonic debridement, soft tissue curettage, glycine powder air polishing and a repeated submucosal application of povidone-iodine	After 12 months	Big reduction of PD (1.4 ± 0.7 mm), CAL (1.3 ± 0.8 mm) and BOP (33.4 ± 17.2%). In deep pockets (PD >6mm) changes of mean PD (2.3 ± 1.3 mm), CAL (2.0 ± 1.6 mm) and BOP (44.0 ± 41.7%) were more pronounced.	Significant clinical improvement of dental implant. The povidone iodine may be used as an antiseptic agent with combination therapy.

Ji et al. (2014) (61)	RCT	24 patients	a. All patients received oral hygiene and supragingival scaling (implant treated with ultrasonic scalers with carbon-fiber tips) b. Test group + glycine powder air polishing	3 months	a. PD: 3,5 – 3,1 and BOP: 1,5 – 1,0 b. PD: 3,6 – 3,2 and BOP: 1,4 - 1,1	Limitation of the adjunctive glycine powder air polishing compared with mechanical debridement alone
Strooker et al. (1998) (57)	Clinical trial	16 patients with lower overdentures	Two implants in each hemiarch were treated with: a. Orthophosphoric acid at 35% for one minute and rinse for 15 seconds b. Mechanical debridement with plastic curettes	5 months	A reduction in the gingival index and probing depth was observed in both groups	A better outcome in the group receiving chemical treatment: more significant reduction in the gingival index and the number of bacterial colony-forming units.
McKenna et al. (2013) (63)	Double-blind RCT	20 patients 80 implants (4 implants each)	4 treatments groups: a. air + saline b. air + peroxide, c. ozone + hydrogen peroxide d. ozone + saline.	2 weeks	Patients treated with ozone + hydrogen peroxide (c) and ozone + saline (d) achieved a significant reduction in plaque index and optimal gingival health, with similar results between the two groups, while patients treated with air + saline (a) had the worst results	Ozone therapy has a great potential for the control of mucositis.

11.3 ADJUNCTIVE ANTIBACTERIAL THERAPY

Authors (year)	Type of study	Number of patients and implants	Treatment	Time – Evaluated period	Results	Conclusion
Renvert et al. (2006) (65)	Controlled study randomized	30 patients 30 implants	Oral hygiene instruction + Supra and submucosal scaling + rubber cup polishing + submucosal administration of a. 1 mg of arestin (minocycline microspheres) b. 1 mg of 1% CHX gel	12 months	PI: a. 50-27% b. 45-21% PD: a. 3,9-3,6mm b. 3,9-3,9 mm BOP: a. 88-71% b. 86-78%	We have a better reduction of the probing depth and BOP in the minocycline group compare to the CHX group.
Renvert et al. (2008) (66)	Single-blind, randomized, two-arm clinical trial	32 patients 95 implants	a. Minocycline HCL microspheres (Arestin) b. 0,1% CHX gel	12 months	PI: slight decrease in both group PD: a. 4,8-4,2 mm b. 5,0-4,5 mm BOP: a. 100-74% b. 100-89%	We had a moderate improvement for the plaque index in both group. No significant difference in both group for the BOP and PD.
Salvi et al. (2007) (67)	Clinical study	25 patients 31 implants	Firstly, they performed mechanical debridement, then applied 0.2% chlorhexidine gel, and finally, minocycline microspheres were placed in the peri-implant pocket.	12 months	Reduction in probing depth (mean 1.6mm) and BOP. Microbiological results: a significant reduction in the bacterial count is achieved after ten days.	Minocycline are very effective for the treatment of peri-implantitis for a short period.
Schär et al. (2012) (68)	RCT	40 patients 40 implants	All patients received mechanical treatment with curettes and glycine powder spray. a. Mechanical therapy + local drug delivery (minocycline microspheres) b. Mechanical therapy + PDT	6 months	BOP: a. 1,47 to 2,20 b. 1,66 to 1,28 Absence of inflammation: a. 15% of cases b. 30% of cases	Both treatments are equally effective in the reduction of mucosal inflammation. None of the treatment modalities produced a clinical attachment gain at six months.
Bassetti et al. (2014) (69)	RCT	40 patients 40 implants	a. Mechanical therapy + local drug delivery (minocycline microspheres) b. Mechanical therapy + PDT	12 months	PI: a. 0,21 b. 0,1 PD: a. 0,56 mm b. 0,11 mm	Both treatments are equally effective in the reduction of mucosal inflammation

Mombelli & Lang (1992) (73)	Case series	9 patients 9 implants	Calculus removal + polishing with pumice and rubber cup + pocket irrigation with 0,5% CHX + systemic antibiotics (ornidazole; 1000 mg, once daily for 10 days)	12 months	BOP: 1,6-0,7 PD: 5,9-3,4mm Gram-negative-anaerobic rods: 40-16% Radiographic: "Regrowth of bone" in some patients	General improvement.
Mombelli et al. (2001) (71)	Case series	5 partially edentulous patients, 30 implants. 2 patients suspended due to persisting active peri-implantitis and pus.	Mechanical debridement with polymeric tetracycline HCl-containing fibers	1, 3, 6, and 12 months	BOP: 90-40 % PD: 6,0-4,1mm CAL: 5,2-4,9 mm	No significant reduction of the mucosal margin. We can observe a big reduction in the percentage of bleeding on probing and in the presence of bacterial biofilm.
Schenk et al. (1997) (72)	Case series	8 patients a. Group test b. Control group	Mechanical debridement with tetracycline fibers	12 weeks	a. reduction in mucosal hyperplasia and BOP b. no changes	Tetracyclines fibers lead to a reduction in mucosal hyperplasia and BOP.
Hallström et al. (2012)	RCT	48 patients (Five subjects were excluded due to antibiotic medication)	All patients received mechanical debridement and then were divided into 2 groups: a. Group test: 500mg of azithromycin (Azithromax) for four days b. Control group: nothing	6 months	Decrease in probing depth was observed with no differences between groups. a. BOP reduction from 82,6% to 27,3% b. BOP reduction from 80% to 47,5%	Systemic antibiotics does not help treat mucositis.
Rams et al. (2013) (75)	In vitro study	120 patients 160 implants with peri-implantitis	a. 4 mg/l of doxycycline b. 8 mg/l of amoxicillin c. 16 mg/l of metronidazole d. 4 mg/l of clindamycin e. Combination of amoxicillin and metronidazole	-	The best results are obtained using amoxicillin and metronidazole; only 6,7% of species are resistant to this combination.	Few cases of resistance to the combination amoxicillin and metronidazole.

11.4 LASER-ASSITED THERAPY

Authors (year)	Type of study	Number of patients and implants	Treatment	Time – Evaluated period	Results	Conclusion
Kreisler et al. (2002) (77)	In vitro study	Various implants	Nd:YAG, Ho:YAG, Er:YAG, CO2, and GaAlAs lasers at various power settings	-	Nd: YAG and Ho: YAG lasers should not be used in the decontamination of implant surfaces due to the alterations and damage they produce. CO2 and Er: YAG lasers, they concluded that they could be used by limiting their power.	The GaAlAs laser has been considered relatively harmless about the possible alterations on the implant's surface.
Schwarz et al. (2005) (82)	Pilot study	20 patients with moderate to advanced peri-implantits	The patietns were randomly divided into 2 groups: a. Er: YAG laser with a conical glass fibre tip b. mechanical treatment with plastic curettes and irrigation with 0.2% chlorhexidine	6 months	BOP: a. 83% to 31% b. 80% to 58% CAL: a. 5,8 to 5,1 b. 6,2 to 5,6	Significant reduction in BOP for both groups, being significantly higher with the laser. Regarding probing depth, the reduction was significant for both groups but with no difference between them.
Schwarz et al. (2006) (83)	Controlled study (parallel design)	20 patients 40 implants	Hygiene program 2 weeks before treatment a. Implant scaling (plastic curette) + CHX (0,2%) irrigation + CHX gel in pocket b. Er: YAG laser Maintenance: "Supragingival professional implant/tooth cleaning and reinforcement of oral hygiene" at 1, 3, 6 and 12 months	12 months	PD: a. 4,5-4,3 mm b. 5,9-5,5 mm BOP: a. 0,8-0,5 mm b. 0,8-0,6 mm	In both groups, plaque index was significantly higher at 12 months compared with baseline. Limited effectiveness of both therapies.

Kreisler et al. (2002) (84)	In vitro study	72 titanium platelets	3 implant surfaces: a. sandblasted and acid-etched (SA) b. titanium plasma-sprayed (TPS) c. hydroxyapatite-coated (HA)	-	Bacterial reduction at 60 mJ pulse energy: a. 99.51% b. 98.39% c. 99.6% Bacterial reduction at 120 mJ pulse energy: a. 99.92% b. 99.85% c. 99.94%	The Er: YAG laser demonstrated a high bactericidal power in vitro without producing damage to the implant's surface
Persson et al. (2011) (86)	RCT	42 patients	a. Er: YAG laser b. Glycine abrasive spray	6 months	PD: a. 0,9 to 0,8 mm b. 0,8 to 0,5 mm No difference in the bacterial count for both.	Neither of the two treatments options succeeded in reducing the bacterial count and in some cases, an increase was observed.
Renvert et al. (2010) (85)	RCTs	21 patients with 55 implants for Er:YAG group and 21 patients with 45 implants for the air abrasive group	2 groups: a. Er:YAG treatment b. Air-abrasive device	6 months	BOP: a. 100% to 70% b. 100% to 75% PD: a. 25% of the patients have an average PD reduction ≥ 1 mm b. 38% of the patients have an average PD reduction ≥ 1 mm.	None of the implants in either group had a positive result. The clinical treatment effects were limited and alike between the two systems.
Deppe et al. (2013) (88)	Clinical pilot study	16 patients 18 implants 2 groups: a. Deep defects b. Moderate defects	The treatment protocol was prophylaxis and irrigation with 0.2% chlorhexidine and, after two weeks, the application of PDT using a photosensitising dye with methylene blue.	6 months	BOP: a. Reduction not maintained b. Reduction maintened PD: a. Slight increase b. Maintained Bone loss: a. Mild bone loss b. No bone loss	PDT is a simple method to complement mechanical treatment in maintenance treatments.

The Therapy of Peri-implantitis: A Systematic Review

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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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Dental Implant Market Size & Share | North America, Europe, & APAC Industry Forecasts 2026: Graphical Research

Major dental implants market players include Osstem Implants, Straumann Group, Nobel Biocare, Zimmer Biomet, Dentsply Sirona, Henry Schein, A.B. Dental Devices Ltd., and Danaher Corporation.

April 19, 2021 06:00 ET | Source: Graphical Research

Pune, India, April 19, 2021 (GLOBE NEWSWIRE) --

The global dental implant market size is poised to grow substantially from during the forecast period. Dental implants are artificial and surgical components that are fixed into the teeth structure to support dental prosthetics. They are used as a replacement for natural teeth and are suited for patients suffering from tooth decay or loss due to some underlying periodontal disease that causes loss of calcium in the teeth. They help improve a person's overall appearance and boosts their self-confidence as well.

Over the course of time, however, dental implants market has seen some groundbreaking innovations to improve the global dentistry scene. These innovations have not only made these implants more accessible and affordable to the public, but they have simplified the procedures as well, thereby reducing the time spent to carry out these procedures. Computer-aided technology is being used to customize dental implants to make them tailor-made to the patient's medical requirements.

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Clinical Study

Clinical and Radiographic Evaluation of Brånemark Implants with an Anodized Surface following Seven-to-Eight Years of Functional Loading

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The aim of this study was to evaluate the clinical and radiographic long-term outcomes of dental implants with an anodized TiUnite surface, placed in routine clinical practice. Two clinical centers participated in the study. One hundred and seven implants (80 in the maxilla and 27 in the mandible) in 52 patients were followed in the long term. Both one- and two-stage techniques were used for 38 and 69 implants, respectively. Thirty-eight single tooth restorations and 22 fixed partial prostheses were delivered, according to a delayed loading protocol, within 4 to 12 months since implant placement. All implants were stable at insertion and at the long-term follow-up visit, which occurred between 7 and 8 years of functional loading. The mean followup was 7.33 ± 0.47 years. The mean marginal bone level change at the long-term followup as compared to baseline was 1.49 ± 1.03 mm. No implant failure occurred. Healthy peri-implant mucosa was found around 95% of implants, whereas 91% of implants showed no visible plaque at the implant surfaces at the long-term followup. The study showed that dental implants with the TiUnite anodized surface demonstrate excellent long-term clinical and radiographic outcomes.

1. Introduction

The long-term success of the original Brånemark machined-surfaced osseointegrated dental implants is clearly demonstrated in the scientific literature. Numerous clinical evidences prove the consistency of the guidelines suggested in the original Brånemark protocol, where osseointegration of dental implants can be achieved and maintained for a long time under functional loading [1–6]. Over the years, the original Brånemark protocol underwent many modifications that further increased the applicability and predictability of implant treatment. For example, the reduction of the healing period with the advent of early and immediate loading protocols, and the placement of implants in fresh postextraction sockets, or in regenerated bone, allow clinicians to extend implant therapy to a broader population of patients as well as improve the clinical success of such treatment. The macroscopic and microscopic features of the fixtures have also dramatically changed, due to a series of modifications aimed at optimizing the mechanical anchorage as well as the osseointegration process in different clinical situations. The role of implant surfaces has long been considered as critical for the success of the treatment, which relies upon a proper osseointegration [7, 8]. It has been demonstrated that titanium per se does not establish an intimate direct contact with the surrounding bone [9, 10]. Conversely, the surface layer of titanium oxide, which spontaneously forms when the surface is exposed to the atmosphere, is highly biocompatible and permits implant osseointegration [11]. One of the most significant breakthroughs in implant dentistry was the introduction of implants having a textured surface. The latter were developed with the aim of allowing for more predictable and

Periimplantitis

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RESUMEN

La rehabilitación bucodentaria mediante implantes proporciona un porcentaje de éxito muy elevado. En este trabajo se describen algunas de las complicaciones de esta técnica, como la enfermedad periimplantaria y, dentro de ella, la periimplantitis, una reacción inflamatoria donde coexiste, junto con la inflamación, una pérdida del soporte óseo del implante.

La etiología de la enfermedad está condicionada por el estado del tejido periimplantario, el diseño del implante, el desajuste de sus componentes, la morfología externa del mismo y la sobrecarga mecánica.

Los microorganismos más relacionados con el fallo de integración de un implante son las espiroquetas y las formas móviles Gramnegativo anaerobias, salvo que el origen sea debido a una sobrecarga mecánica pura.

El diagnóstico se basa en los cambios de coloración de la encía, sangrado y profundidad del sondaje de las bolsas periimplantarias, supuración, radiología y pérdida progresiva de la altura ósea que rodea al diente.

El tratamiento será diferente según se trate de una mucositis o una periimplantitis. Se basará en corregir los defectos técnicos, aplicar un tratamiento quirúrgico y utilizar técnicas de descontaminación (arenado con partículas de carbono, ácido cítrico, tetraciclinas de aplicación tópica y láser quirúrgico).

En este trabajo también se expone un estudio microbiológico de la periimplantitis efectuado en la Facultad de Odontología de la Unniversidad de Barcelona que determina que el antibiótico que demostró una mayor eficacia, en el antibiograma, fue la asociación de amoxicilina con ácido clavulánico.

Palabras clave: *Enfermedad periimplantaria, mucositis, periimplantitis, etiología, diagnóstico, tratamiento.*

INTRODUCCION

La rehabilitación bucodentaria mediante implantes es hoy en día una técnica de resultados altamente predecibles. Por este motivo forma parte del abanico de alternativas en el tratamiento de los pacientes total o parcialmente edentulos (1). El porcentaje de éxito a corto y largo plazo es muy elevado, pero se describen también algunas complicaciones relacionadas con esta terapia (2), entre ellas habría que reseñar" la pérdida progresiva del hueso alveolar que rodea al implante".

Se denomina enfermedad periimplantaria a los cambios patológicos de tipo inflamatorio de los tejidos que rodean un implante sometido a carga (3). Para algunos autores es la complicación más frecuente en la implantología bucofacial (4).

Dentro del concepto de enfermedad periimplantaria se describen dos entidades:

- Mucositis: cuadro clínico que se caracteriza por la aparición de cambios inflamatorios limitados a la mucosa periimplantaria que, con el tratamiento adecuado, es un proceso reversible (5) (Figuras 1 y 2).
- Periimplantitis: cuadro clínico en el que, junto a la reacción inflamatoria de la mucosa periimplantaria, coexiste una pérdida del soporte óseo del implante, evidenciada clínica y radiológicamente (6). Los signos y síntomas que pueden presentarse en este caso son:
- Enrojecimiento de la mucosa periimplantaria.
- Supuración purulenta (en ocasiones).
- Sangrado al sondaje.
- Aumento de la profundidad de la bolsa periimplantaria.
- Dolor a la percusión o al apretar los dientes.
- Pérdida radiológica de la altura ósea periimplantaria.
- Movilidad progresiva del implante (en casos avanzados).

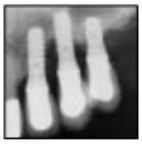
La oseointegración se define como la conexión directa entre el hueso vivo y un implante endoóseo en función (6-8). En esta definición, es importante destacar el término "en función", que implica que el contacto entre el hueso vivo y la superficie del implante debe mantenerse a lo largo de su periodo activo o de carga.

Cuando se habla de periimplantitis también debe insistirse en esta puntualización. El implante debe estar "en función", ya que así quedan excluidos todos los demás cuadros clínicos de origen

Actualités scientifiques & recommandations pratiques

LES PERI-IMPLANTITES

A Proposed Classification for Peri-Implantitis



*Stuart J. Froum, DDS**
*Paul S. Rosen, DMD, MS***

The lack of a standardized classification to differentiate the various degrees of peri-implantitis has resulted in confusion when interpreting the results of studies evaluating the prevalence, treatment, and outcomes of therapy. The purpose of this paper is to propose a classification for peri-implantitis based on the severity of the disease. A combination of bleeding on probing and/or suppuration, probing depth, and extent of radiographic bone loss around the implant is used to classify the severity of peri-implantitis into early, moderate, and advanced categories. The rationale and method of measurement for the classification are presented and discussed. This classification should help in communication between researchers and clinicians and thus provide a better understanding of peri-implantitis. (Int J Periodontics Restorative Dent 2012;32:533–540.)

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Peri-implantitis was first introduced as a term in the 1980s and then modified in the 1990s to describe an inflammatory disease that results in loss of supporting bone around an implant.[1,2] This entity has clearly been differentiated from mucositis, in which the inflammation in the mucosa around an implant is not accompanied by bone loss and is reversible.[2] The general term *peri-implantitis* has been often applied to any implant with varying degrees of bone loss if accompanied by probing depths (PDs) ≥ 4 mm and bleeding and/or purulent exudate on probing.[3,4] However, as noted in a literature review by Zitzmann and Berglundh,[5] the clinical definition of peri-implantitis has differed in many studies. For example, Berglundh et al[6] defined peri-implantitis as having a PD > 6 mm or attachment loss or bone loss of ≥ 2.5 mm.[6] Although the pathogenesis of peri-implantitis has been described as the early lesion, established lesion, and advanced lesion, this peri-implantitis staging pertained to a histologic, not clinical, differentiation.[7] To date, there have been no standardized

Treatment Planning for Periimplant Mucositis and Periimplantitis

Ioannis Polyzois, PhD, DMD

Treatment of periimplant diseases can be challenging, and as a result, careful consideration should be given to a number of factors and parameters before the treatment commences. The aim of this review was to propose a simple and evidence-based step-by-step process for treatment planning after a diagnosis of periimplant mucositis and/or periimplantitis. Treatment guidelines for periimplant diseases are evolving, and much of the proposed treatment modalities are based on empirical evidence. Existing evidence, however, shows that periimplant mucositis is reversible. Therefore, and since periimplant mucositis may develop into periimplantitis, early detection and treatment of periimplant mucositis is of paramount importance.[1] Successful treatment of periimplant mucositis will prevent its progression to periimplantitis, which can be challenging to manage even for experienced clinicians.[2]

Purpose: *A literature search was performed in a number of health care databases for articles published until January 2018.*

Discussion: *A number of anatomical factors, risk indicators, possible aesthetic complications, and financial implications have to be taken into consideration before treatment commences. When diagnosed early, periimplant mucositis is a problem that can be easily managed as long as the patient is motivated and maintains good levels of oral hygiene. Periimplantitis is more difficult to treat and results can be unpredictable. Nonsurgical therapy has limited effectiveness on the treatment of periimplantitis, but it should always precede a surgical intervention. Clinically predictable surgical outcomes seem to rely mainly on the configuration of the bone defect, the position of the affected implant, and the patient's ability to perform good oral hygiene.*

Conclusions: *Thorough treatment planning of periimplant diseases is paramount for the success of the treatment that follows. Local and general factors as well as patients' expectations have to be considered before proceeding, but treatment planning should also allow for a degree of flexibility, which will accommodate the unknown parameters. (Implant Dent 2019;28:150–154)*

Key Words: periimplant pocket, infection, treatment plan

MATERIALS AND METHODS

A literature search was performed in MEDLINE through PubMed database of the US National Library of Medicine, the Web of Science, and the Cochrane library databases for articles published until January 2018 using Medical Subject Heading search terms + free text terms and in different combinations. To be included in the article, studies had to be written in English language and published in an international peer-reviewed journal.

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REVIEW

Treatment Planning of Periimplant Mucositis

Based on the consensus report of workgroup 4 of the 2017 world workshop on the classification of periodontal and periimplant diseases and conditions, "the diagnosis of periimplant mucositis requires presence of bleeding and/or suppuration on gentle probing with or without increased probing depth compared to previous examinations." In addition, it requires "absence of bone loss beyond crestal bone level changes resulting from initial bone remodeling."[3] When periimplant mucositis is diagnosed, a treatment plan has to be constructed to effectively resolve the inflammation. A number of risk indicators for the development of periimplant mucositis have been identified over the past few years including inadequate oral hygiene, not participating in maintenance visits, remnants of cement, and smoking. Other issues such as systemic diseases, lack of keratinized tissue, and abutment characteristics could contribute to the presenting inflammation and should be taken into consideration.[4]

It is now well documented that plaque accumulation at implants will result in the development of periimplant

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Predisposing conditions for retrograde peri-implantitis, and treatment suggestions

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Key words: endodontics, dental implant, implant failure, marginal bone loss, peri-apical lesion, peri-implantitis, periodontology, retrograde peri-implantitis

Abstract

Background: Recent case reports introduced the term retrograde peri-implantitis as a lesion (radiolucency) around the most apical part of an osseointegrated implant. It develops within the first months after insertion. This retrospective study aimed to find predisposing conditions for such peri-apical lesions and to evaluate treatment strategies.

Methods: All single implants (426 in the upper, 113 in the lower jaw, all Brånemark system® type) placed at the department of Periodontology of the University Hospital (Catholic University Leuven) were included in this retrospective evaluation to check the incidence of retrograde peri-implantitis. Eventual predisposing factors such as patient characteristics (age, medical history), recipient site (local bone quality and quantity, cause of tooth loss), periodontal and endodontic conditions of neighboring teeth, implant characteristics (length, surface characteristics), and surgical aspects (guided bone regeneration, osseous fenestration, or dehiscency) were considered. Moreover, implants with retrograde peri-implantitis were followed longitudinally to verify their treatment outcome by means of different parameters (Periotest® values (PTV), marginal bone level, radiological size of peri-apical defect).

Results: Seven implants in the upper (1.6%) and 3 in the lower jaw (2.7%) showed retrograde peri-implantitis, before or at abutment connection. In comparison with successful implants, such peri-apical lesions occurred preferably at sites with a history of an obvious endodontic pathology of the extracted tooth to be replaced. The incidence of retrograde peri-implantitis was significantly higher ($P < 0.0001$) for TiUnite® implants when compared with the machined implants (8/80 vs. 2/459). The machined implant surface, however, showed a higher failure rate (6.8%) than the TiUnite® implants (2.5%). Failures with machined surfaces preferably occurred at extraction sites of teeth with a history of endodontic pathology or sites adjacent to teeth with an obvious endodontic pathology. No other predisposing factors could be identified. A curettage of the peri-apical lesions and the use of a bone substitute material prevented further progression of such lesions in the upper jaw (implants maintained their marginal bone and low PTV scores). A treatment in the lower jaw was less successful.

Conclusions: Within the limitations of a retrospective study, these results seem to indicate that retrograde peri-implantitis is provoked by remaining scar or granulomatous tissue at the recipient site: endodontic pathology of extracted tooth (scar tissue-impacted tooth) or possible endodontic pathology from a neighboring tooth.

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Journal of Clinical Periodontology

Peri-implant diseases: Consensus Report of the Sixth European Workshop on Periodontology

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Lindhe J, Meyle J. Peri-implant diseases: Consensus Report of the Sixth European Workshop on Periodontology. J Clin Periodontol 2008; 35 (Suppl. 8): 282–285. doi: 10.1111/j.1600-051X.2008.01283.x

Abstract

Issues related to peri-implant disease were discussed. It was observed that the most common lesions that occur, i.e. peri-implant mucositis and peri-implantitis are caused by bacteria. While the lesion of peri-implant mucositis resides in the soft tissues, peri-implantitis also affects the supporting bone. Peri-implant mucositis occurs in about 80% of subjects (50% of sites) restored with implants, and peri-implantitis in between 28% and 56% of subjects (12–40% of sites). A number of risk indicators were identified including (i) poor oral hygiene, (ii) a history of periodontitis, (iii) diabetes and (iv) smoking. It was concluded that the treatment of peri-implant disease must include anti-infective measures. With respect to peri-implant mucositis, it appeared that non-surgical mechanical therapy caused the reduction in inflammation (bleeding on probing) but also that the adjunctive use of antimicrobial mouthrinses had a positive effect. It was agreed that the outcome of non-surgical treatment of peri-implantitis was unpredictable. The primary objective of surgical treatment in peri-implantitis is to get access to the implant surface for debridement and decontamination in order to achieve resolution of the inflammatory lesion. There was limited evidence that such treatment with the adjunctive use of systemic antibiotics could resolve a number of peri-implantitis lesions. There was no evidence that so-called regenerative procedures had additional beneficial effects on treatment outcome.

Key words: Consensus report; diagnostics; infectious diseases; non-surgical treatment; peri-implant diseases; peri-implantitis; peri-implant mucositis; prevalence; risk indicators; surgical treatment

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Conflict of interest and source of funding statement

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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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The diagnosis and treatment of peri-implantitis

ANDREA MOMBELLI & NIKLAUS P. LANG

Peri-implantitis is defined as an inflammatory process affecting the tissues around an osseointegrated implant in function, resulting in loss of supporting bone (1st European Workshop on Periodontology (4)). The term peri-implant mucositis has been proposed for reversible inflammations of the soft tissues surrounding implants in function. The purpose of this chapter is to discuss the requirements for diagnostic procedures to prevent and intercept these diseases and to outline the options for therapy at different stages. This will be based on the hypothesis that microbial colonization of dental implants and infection of the peri-implant tissues can cause peri-implant bone destruction and may lead to implant failure. (Disease conditions associated with implants not designed for osseointegration, and primary failures to achieve tissue integration are not discussed in this chapter.)

Evidence for a microbial cause of peri-implant infections

Although it is clear that multiple factors can contribute to implant failure, an increasing number of studies point to the detrimental effect of anaerobic plaque bacteria on peri-implant tissue health. There are essentially five lines of evidence supporting the view that microorganisms play a major role in causing peri-implantitis: (i) an experiment in humans, showing that deposition of plaque on implants can induce peri-implant mucositis, (ii) the demonstration of distinct quantitative and qualitative differences in the microflora associated with successful and failing implants, (iii) placement of plaque-retentive ligatures in animals leading to shifts in the composition of the microflora and peri-implantitis, (iv) antimicrobial therapy improving the clinical status of peri-implantitis patients, and (v) evidence that the level of oral hygiene has an impact on the long-term success of implant therapy (Table 1).

Experimentally induced peri-implant mucositis

The experimental gingivitis model, originally described by Löe et al. (55) and representing the ultimate proof for a cause-and-effect relationship between bacterial plaque accumulation and gingivitis, was duplicated with regard to the peri-implant situation (74). Following a period of 6 months with

Table 1. Sources of evidence for a bacterial cause of peri-implantitis

Source	References
Experimentally induced peri-implant mucositis: plaque accumulation on implants leads to peri-implant mucositis	12, 74
Demonstration of distinct quantitative and qualitative differences in the microflora associated with successful and failing implants	6, 9, 11, 26, 69, 80, 82, 86, 87
Peri-implant microflora is established shortly after implant placement. Successful implants experience no shifts in microbial composition over time	1, 7, 13, 47, 60, 65
Periodontal pathogens may be transmitted from residual teeth to implants	7, 37, 38, 49, 64, 75
Induction of peri-implantitis by placement of plaque retentive ligatures in animals	41, 50
Therapy aimed at a reduction of the peri-implant microflora improves clinical conditions	24, 25, 62
Edentulous patients with poor oral hygiene have more bone resorption around fixtures than do subjects with good hygiene	52

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Peri-implantitis is defined as an inflammatory process affecting the tissues around an osseointegrated implant in function, resulting in loss of supporting bone (1st European Workshop on Periodontology (4)). The term peri-implant mucositis has been proposed for reversible inflammations of the soft tissues surrounding implants in function. The purpose of this chapter is to discuss the requirements for diagnostic procedures to prevent and intercept these diseases and to outline the options for therapy at different stages. This will be based on the hypothesis that microbial colonization of dental implants and infection of the peri-implant tissues can cause peri-implant bone destruction and may lead to implant failure. (Disease conditions associated with implants not designed for osseointegration, and primary failures to achieve tissue integration are not discussed in this chapter.)

Evidence for a microbial cause of peri-implant infections

Although it is clear that multiple factors can contribute to implant failure, an increasing number of studies point to the detrimental effect of anaerobic plaque bacteria on peri-implant tissue health. There are essentially five lines of evidence supporting the view that microorganisms play a major role in causing peri-implantitis: (i) an experiment in humans, showing that deposition of plaque on implants can induce peri-implant mucositis, (ii) the demonstration of distinct quantitative and qualitative differences in the microflora associated with successful and failing implants, (iii) placement of plaque-retentive ligatures in animals leading to shifts in the composition of the microflora and peri-implantitis, (iv) antimicrobial therapy improving the clinical status of peri-implantitis patients, and (v) evidence that the level of oral hygiene has an impact on the long-term success of implant therapy (Table 1).

Experimentally induced peri-implant mucositis

The experimental gingivitis model, originally described by Löe et al. (55) and representing the ultimate proof for a cause-and-effect relationship between bacterial plaque accumulation and gingivitis, was duplicated with regard to the peri-implant situation (74). Following a period of 6 months with

Table 1. Sources of evidence for a bacterial cause of peri-implantitis

Source	References
Experimentally induced peri-implant mucositis: plaque accumulation on implants leads to peri-implant mucositis	12, 74
Demonstration of distinct quantitative and qualitative differences in the microflora associated with successful and failing implants	6, 9, 11, 26, 69, 80, 82, 86, 87
Peri-implant microflora is established shortly after implant placement. Successful implants experience no shifts in microbial composition over time	1, 7, 13, 47, 60, 65
Periodontal pathogens may be transmitted from residual teeth to implants	7, 37, 38, 49, 64, 75
Induction of peri-implantitis by placement of plaque retentive ligatures in animals	41, 50
Therapy aimed at a reduction of the peri-implant microflora improves clinical conditions	24, 25, 62
Edentulous patients with poor oral hygiene have more bone resorption around fixtures than do subjects with good hygiene	52

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Journal of Clinical Periodontology

Peri-implant diseases: diagnosis and risk indicators

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Abstract

Background: Peri-implant diseases include peri-implant mucositis, describing an inflammatory lesion of the peri-implant mucosa, and peri-implantitis, which also includes loss of supporting bone.

Methods: A literature search of the Medline database (Ovid), up to 21 January 2008 was carried out using a systematic approach, in order to review the evidence for diagnosis and the risk indicators for peri-implant diseases.

Results: Experimental and clinical studies have identified various diagnostic criteria including probing parameters, radiographic assessment and peri-implant crevicular fluid and saliva analyses. Cross-sectional analyses have investigated potential risk indicators for peri-implant disease including poor oral hygiene, smoking, history of periodontitis, diabetes, genetic traits, alcohol consumption and implant surface. There is evidence that probing using a light force (0.25 N) does not damage the peri-implant tissues and that bleeding on probing (BOP) indicates presence of inflammation in the peri-implant mucosa. The probing depth, the presence of BOP, and suppuration should be assessed regularly for the diagnosis of peri-implant diseases. Radiographs are required to evaluate supporting bone levels around implants. The review identified strong evidence that poor oral hygiene, a history of periodontitis and cigarette smoking, are risk indicators for peri-implant disease. Future prospective studies are required to confirm these factors as true risk factors.

Key words: diagnosis; peri-implantitis; peri-implant mucositis; review; risk factor

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Peri-implant disease following successful integration of an endosseous implant is the result of an imbalance between bacterial load and host defence. Peri-implant diseases may affect the peri-implant mucosa only (peri-implant mucositis) or also involve the supporting bone (peri-implantitis), (Zitzmann & Berglundh 2008). Correct diagnosis of peri-implant disease is critical for appropriate management of peri-implant disease. Bleeding on probing (BOP) is always present with peri-implant disease (Zitzmann & Berglundh 2008). Other clinical signs of disease may include suppuration, increased probing depths relative to baseline, mucosal recession, a draining sinus (fistula) and peri-implant mucosal swelling/hyperplasia. If undiagnosed, peri-implant disease may lead to complete loss of osseointegration and implant loss.

This review excludes post-operative complications and early implant loss. In this paper, diagnostic parameters relevant to peri-implant diseases are reviewed with the aim of providing guidelines for clinical practice and future research. The review also aims to identify potential risk factors associated with peri-implant diseases.

Conflict of interest and source of funding statement

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Material and Methods

Search strategy

A literature search was performed of the Medline database (Ovid) from 1 January 1950 to 21 January 2008. The search strategy used included the terms ''peri-implantitis or peri-implant mucositis or peri-implant disease$ or peri-implant infection$ or peri-implant complication$ or peri-implant bone loss'' OR ''dental implant$ and diagnosis'' OR ''endosseous implant$ and diagnosis'' OR ''dental implant$ and risk'' OR ''endosseous implant$ and risk''. The search was limited to the English language and resulted in 1113 articles. Titles and abstracts were screened and the full text of publications reporting on peri-implant diseases (peri-implantitis or peri-implant mucositis) were obtained (138). All levels of evidence were included. Case reports were included if 10 or more patients were reported with a follow-up of at least 6 months. In addition, the reference lists of review papers were hand searched.

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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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Hierarchical decisions on teeth vs. implants in the periodontitis-susceptible patient: the modern dilemma

Nikolaos Donos, Lars Laurell & Nikolaos Mardas

Osseointegrated implants were originally introduced for the treatment of fully edentulous jaws (25). Now, dental implants are frequently used to restore partially edentulous jaws. Dental implants are also increasingly being used as a means of tooth replacement in the management of patients with periodontal disease to replace teeth lost as a result of periodontitis.

The extraction of a periodontally compromised tooth and its subsequent replacement with a dental implant, as opposed to its retention by means of comprehensive periodontal therapy, is one of the most complex and debatable decisions that a dentist must make during everyday clinical practice. Usually, the decision to extract a tooth is based on multiple patient and site risk factors, determined according to periodontal, endodontic and restorative criteria, which are also associated with the strategic role of the tooth in the dentition. The choice of treatment may not be influenced solely by the scientific evidence on the efficacy of these two treatment principles (i.e. to maintain and treat the tooth or to extract the tooth and replace it with an implant). The dentist's personal clinical experience, access to technology and postgraduate education, as well as patient preferences and economic parameters, will also affect the decision-making process (77, 156, 157).

Current clinical evidence has positioned implants as one of the first choices of treatment for partially or fully edentulous patients and has influenced the decision to extract periodontitis-affected teeth, which in a number of cases may be treatable (27, 52, 108). It has been suggested that 'pro-active' or 'strategic extractions' will prevent further bone destruction in a potential implant site (78). However, such an approach is not always supported by the current evidence (50), especially if we consider that any tooth extraction will result in resorption of alveolar bone that cannot be completely controlled by either alveolar ridge-preservation techniques (110) or immediate implant placement (9, 20).

The concept of early extraction of periodontally involved teeth and their replacement with dental implants is based on a perceived advantage of implants over teeth in terms of: (i) unpredictability of tooth survival following treatment of periodontal disease, (ii) better long-term prognosis of implant-supported restorations in comparison to teeth or tooth-supported restorations, (iii) lack of complications in comparison with teeth, (iv) better function than teeth, (v) better long-term cost–benefit, (vi) better esthetics, and (vii) better patient satisfaction. However, it is questionable to which extent these postulations are supported by the current evidence.

It is also important to emphasize that the extraction of periodontitis-affected teeth does not resolve or eliminate the underlying host response-related problems that may have contributed to the development of periodontal disease and which may be predisposing factors for the development of peri-implantitis. Therefore, it could be argued that periodontally compromised teeth should be treated for as long as possible, being extracted and replaced by some means only when successful periodontal treatment is no longer possible. Admittedly, the 'good' or 'poor' prognosis of periodontally involved teeth is not always easy to predict.

Unfortunately, it seems that traditional well-documented and evidence-based means to treat

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REVIEW

Periodontitis and diabetes: a two-way relationship

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Abstract Periodontitis is a common chronic inflammatory disease characterised by destruction of the supporting structures of the teeth (the periodontal ligament and alveolar bone). It is highly prevalent (severe periodontitis affects 10–15% of adults) and has multiple negative impacts on quality of life. Epidemiological data confirm that diabetes is a major risk factor for periodontitis; susceptibility to periodontitis is increased by approximately threefold in people with diabetes. There is a clear relationship between degree of hyperglycaemia and severity of periodontitis. The mechanisms that underpin the links between these two conditions are not completely understood, but involve aspects of immune functioning, neutrophil activity, and cytokine biology. There is emerging evidence to support the existence of a two-way relationship between diabetes and periodontitis, with diabetes increasing the risk for periodontitis, and periodontal inflammation negatively affecting glycaemic control. Incidences of macroalbuminuria and end-stage renal disease are increased twofold and threefold, respectively, in diabetic individuals who also have severe periodontitis compared to diabetic individuals without severe periodontitis. Furthermore, the risk of cardiorenal mortality (ischaemic heart disease and diabetic nephropathy combined) is three times higher in diabetic people with severe periodontitis than in diabetic people without severe periodontitis. Treatment of periodontitis is associated with HbA_{1c} reductions of approximately 0.4%. Oral and periodontal health should be promoted as integral components of diabetes management.

Keywords Diabetes · Diabetes complications · Periodontal diseases · Periodontitis · Type 1 diabetes mellitus · Type 2 diabetes mellitus

Abbreviations

CRP	C-reactive protein
ESRD	End-stage renal disease
GCF	Gingival crevicular fluid
INVEST	Oral Infections and Vascular Disease Epidemiology Study
MMP	Matrix metalloproteinase
NHANES	National Health and Nutrition Examination Survey

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Is a High Level of Cholesterol or Vitamin D Deficiency a Risk Factor for Dental Implants or Bone Grafting Failure?

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Introduction

The search for a biological anomaly labeled as a risk factor before dental implants is limited to disease states such as diabetes, periodontitis and smoking. However, it seems in recent years cholesterol and vitamin D levels should be more systematically investigated [1]. There is also clearly a close relationship between cholesterol, and vitamin D. It is interesting to note that cholesterol and vitamin D have the same precursor, namely, 7- Dehydrocholesterol [2]. There is good cholesterol (high-density lipoprotein [HDL]) and bad cholesterol (low-density lipoprotein [LDL]) [3]. Vitamin D is one of the most important vitamins related to bone growth hormones. In addition, vitamin D also plays a role in reducing the effects of inflammation and helps improve the body's natural immune reactions [4].

Cholesterol and Bone Metabolism

A. What is the role of LDL?: According to Luegmayr et al, 2004 elevated levels of cholesterol may lead to an imbalance in the bone-remodeling process, a reduction of bone mass by increasing the activity, and a differentiation of osteoclasts [5]. Krieger 1998 [6] demonstrated an increase in the number of osteoclasts, the inhibition of osteoblastic activity, and a decreased bone remodeling in hyperlipidemic rats. An increase of circulating levels of oxidized LDL induces alveolar bone loss and is associated with the severity of the local inflammatory response to bacteria as well as the susceptibility to periodontal disease in diabetic patients [7].

The bone releases enzymes that are involved in the oxidation of LDL. It is possible that the oxidized LDL accumulated in the bone could induce subsequent deleterious cellular effects on bone density [8]. Hyperlipidemia causes a reduction of bone density in vivo due to the inhibition of osteoblast differentiation by bioactive lipids [9]. Oxidized LDL caused an inhibition of the alkaline phosphatase activity and also mineralization, which are markers of osteoblast differentiation. In addition, it has recently been shown that oxidized LDL also induces cell death by apoptosis of osteoblastic cells [10]. Hirasawa et al. [11] 2007 confirmed that atherogenic conditions (high LDL levels) caused the death of osteoblasts. Oxidized low-density lipoprotein particles have been shown both to stimulate the proliferation and promote apoptosis of bone-forming osteoblasts [12].

Oxidized low density lipoproteins (OxLDL) are known to promote atherosclerosis, but it is only recently that OxLDL have been associated with alterations of the functions of bone-forming osteoblasts and osteoporosis. HDL3 prevent the cell death induced by OxLDL in human osteoblastic cells. Simultaneous exposure of the cells to HDL3 and OxLDL abolished the reduction of cell viability monitored by MTT activity measurement and the induction of apoptosis determined by annexin V staining indicating that HDL3 prevent the apoptosis of osteoblasts induced by OxLDL. This protection correlated with the displacement by HDL3 of OxLDL association to osteoblasts, signifying that OxLDL binding and/or internalization are/is necessary for their cytotoxic effects [13].

B. What is the role of HDL?: Various antioxidants carried by HDL may interrupt the cascade of events leading to the oxidation of LDL [14]. Another important property of HDL is its ability to inhibit cell death induced by oxidized LDL In particular, it has been reported that HDL inhibits the apoptosis of monocytic cells by inducing cholesterol efflux and thus preventing the accumulation of cholesterol caused by the presence of oxidized LDL. HDL should be considered as a bone cell protector [15]. Brodeur et al. 2008 found that osteoblastic cells to HDL3 prior to incubation with OxLDL reduced cell death and preserved the lysosomal integrity.

The Effects of Hyperlipidemia on Implant Osseointegration in the Mouse Femur

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A high-fat (HF) diet inducing hyperlipidemia has been associated with the pathophysiology of major diseases, such as atherosclerosis and osteoporosis. A HF diet has significant adverse effects on bone, including lower bone density, volume, and strength. Statins, drugs that lower serum cholesterol levels have beneficial effects on bone metabolism. Since the host's bone quantity, quality, and healing potential play a crucial role in osseointegration of dental implants, we hypothesized that hyperlipidemia may negatively affect implant osseointegration. In the present study, we evaluated the effects of hyperlipidemia on implant osseointegration in mice. Atherosclerosis susceptible C57BL/6J male mice were randomly placed on a control chow or a HF diet. After 12 weeks on the diet, each mouse received a titanium implant in the proximal metaphysis of the femur. The animals were humanely killed at 4 or 8 weeks after the implant surgery. Results showed that the mice fed a HF diet had significantly increased implant loss as well as decreased formation and strength of bone-to-implant interface. These results support the hypothesis that a HF diet can significantly compromise osseointegration, causing poor outcome in dental implant therapy.

Key Words: high-fat diet, hyperlipidemia, dental implant, osseointegration

INTRODUCTION

The atherogenic or high-fat (HF) diet induces hyperlipidemia, characterized by an elevation of lipids in the bloodstream. Hyperlipidemia is widespread in our society, with total cholesterol levels above 200 mg/mL for over 45.0% of people 20 years of age or older.[1] HF diet is associated with the pathophysiology of major diseases, including atherosclerosis and osteoporosis.[2–4] Interestingly, both hyperlipidemia and atherosclerosis have been linked to periodontal disease.[5–7]

A HF diet has significant adverse effects on bone health, leading to lower bone mineral density and to higher risk of osteoporosis and bone fracture.[8,9] Statins, HMG-CoA reductase inhibitors that lower cholesterol levels, have beneficial effects on bone metabolism by inducing bone formation and mineral density as well as decreasing the risk of hip fractures.[10–13] At the cellular level, osteoblasts are capable of oxidizing low-density lipoproteins, possibly increasing the local concentration of oxidized reactive products in bone milieu.[14] Oxidative stress generated in hyperlipidemic conditions inhibits the differentiation of bone cells.[15,16] Statins enhance osteoblastic differentiation and mineralization[17] and suppress osteoclastogenesis.[18] Furthermore, around implants, statins increase osteogenesis, suppress osteoclast formation, and increase bone volume.[19]

The effects of hyperlipidemia on bone health may also interfere with dental implant therapy since the host's bone quantity, quality, and healing potential play an important role in osseointegration.[20–22] Currently, the role of hyperlipidemia in implant osseointegration is unknown. Because of the deleterious effects of hyperlipidemia in bone, we hypothesized that hyperlipidemia negatively affects implant osseointegration. The present study evaluates implant osseointegration in hyperlipidemic mice at 4 and 8 weeks after implant placement.

MATERIALS AND METHODS

Mice and diets

Four-week-old C57BL/6J male mice (atherosclerosis susceptible strain, The Jackson Laboratories, Bar Harbor, Maine) were

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Vitamin D and Bone Physiology: Demonstration of Vitamin D Deficiency in an Implant Osseointegration Rat Model

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Keywords
Push-in test; bone-to-implant contact; nutrition; rats; vitamin D insufficiency; osseointegration failure.

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Abstract

Purpose: The patient population varies in nutritional deficiencies, which may confound the host response to biomaterials. The objective of this study was to evaluate the effect of a common deficiency of vitamin D on implant osseointegration in the rat model.
Materials and Methods: Male Sprague-Dawley rats were maintained under the cessation of vitamin D intake and UV exposure. The serum levels of $1,25(OH)_2D_3$, 25 OHD_3, Ca, and P were determined. Miniature cylindrical Ti6Al4V implants (2-mm long, 1-mm diameter) were fabricated with double acid-etched (DAE) surface or modified DAE with discrete crystalline deposition (DCD) of hydroxyapatite nanoparticles. DAE and DCD implants were placed in the femurs of vitamin D-insufficient and control rats. After 14 days of healing, the femur-implant samples were subjected to implant push-in test and nondecalcified histology. The surfaces of recovered implant specimens after the push-in test were further evaluated by scanning electron microscopy (SEM).
Results: The decreased serum level of 25 OHD_3 demonstrated the establishment of vitamin D insufficiency in this model. The implant push-in test revealed that DAE and DCD implants in the vitamin D-insufficient group (15.94 ± 8.20 N, $n = 7$; 15.63 ± 3.96 N, $n = 7$, respectively) were significantly lower than those of the control group (24.99 ± 7.92 N, $n = 7$, $p < 0.05$; 37.48 ± 17.58 N, $n = 7$, $p < 0.01$, respectively). The transcortical bone-to-implant contact ratio (BIC) was also significantly decreased in the vitamin D-insufficient group. SEM analyses further suggested that the calcified tissues remaining next to the implant surface after push-in test appeared unusually fragmented.
Conclusions: The effect of vitamin D insufficiency significantly impairing the establishment of Ti6Al4V implant osseointegration in vivo was unexpectedly profound. The outcome of Ti-based endosseous implants may be confounded by the increasing prevalence of vitamin D insufficiency in our patient population.

Once placed in the host environment, biomaterials are subjected to a complex process of cellular and extracellular reactions involving intrinsic and extrinsic factors. Thus, behaviors of a given biomaterial may vary in different hosts, who carry predisposing pathophysiological conditions. For example, when titanium-based endosseous implants are placed in chemically induced diabetic rodents, the degree of bone-to-implant integration or osseointegration was significantly decreased for the long term;[1,2] however, other studies found that bone remodeling around the implant during early healing periods was not affected by the diabetic condition.[3,4] Besides diagnosed or undiagnosed chronic disorders, our patient populations may be suffering from various degrees of nutritional deficiencies. A report by the Institute of Medicine of the National Academy of Sciences has indicated that approximately 50% of women in the United States are potentially vitamin D deficient.[5]

Vitamin D is a fat-soluble hormone transformed into an active form through the liver and kidney; it plays an essential role in maintaining normal blood levels of calcium and phosphorus, and thus affects sound bone remodeling.[6,7] While severe vitamin D deficiency causes rickets in children and osteomalacia in adults, there is evidence that lesser degrees of vitamin D insufficiency can cause deleterious effects on bone tissues. Increased unmineralized osteoid has been reported in biopsy specimens collected in winter months,[8] and hip fracture patients have been associated with vitamin D insufficiency.[9,10]

The relationship of smoking on peri-implant tissue: A retrospective study

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The term "peri-implantitis" is used to describe the formation of deep mucosal pockets around dental implants, inflammation of the peri-implant mucosa, and increased resorption of peri-implant bone. It has been speculated that when left untreated, peri-implantitis can result in implant failure. This retrospective study examines a possible correlation between smoking and the appearance of peri-implantitis. The clinical and radiographic observations of 366 implants in 107 patients who smoke were compared with those of a group of 1000 implants in 314 nonsmoking patients. Despite the retrospective nature of this study, a comparison between the two groups was possible. The mean follow-up period, mean patient age, implant locations, and percentages of fixed partial dentures and overdentures were consistent in both groups. There was no significant difference in the mean maxillary and mandibular hygienic indices between the group of smokers and that of nonsmokers. However, the group of smokers showed a higher score in the bleeding index, the mean peri-implant pocket depth, the degree of peri-implant mucosal inflammation, and radiographically discernible bone resorption mesial and distal to the implant. In the maxilla of the smoking group, these observations were significantly higher than both the mandibular observations for smokers and the maxillary observations of the group of nonsmokers ($p < 0.01$). No differences between the two groups were observed in the mandible. Aside from the systemic effects of tobacco smoking on the human organism, local cofactors seem to be responsible for the higher incidence of peri-implantitis in smokers and have a particularly negative effect on the maxilla. These findings confirm that smokers treated with dental implants have a greater risk of development of peri-implantitis. (J Prosthet Dent 1996;76:592-6.)

There is no doubt about the negative effects of active cigarette smoking on the human organism. The oral cavity, too, is affected adversely by cigarette smoke; an increase in plaque accumulation,[1-3] a higher incidence of gingivitis and periodontitis,[4-10] increased resorption of the alveolar ridge,[8,11-14] and a higher rate of tooth loss[15] have been found. However, only a few studies deal with the consequences of smoking for the prognosis of dental implants.

Bain and Moy[16] reported a significant decrease in the survival of 390 implants in smokers when compared with nonsmokers. In a study examining 208 screw-shaped implants, De Bruyn and Collaert[17] found that smokers demonstrated a significantly higher failure rate before functional loading of implants than the nonsmokers. Small et al.[18] found disturbed wound healing in smokers who underwent combined sinus floor elevation and placement of dental implants. After a period of nonsmoking and administration of antibiotics, the wounds healed properly.

Implant failure is the result of a multifactorial process. Significant factors influencing the prognosis of implants include the length of the implant,[19] bone quality,[20] patient's sex,[21] time of implant placement,[22] location of the implant,[19,21,22] and indication for implant treatment.[21] From a statistical point of view, a one-dimensional evaluation of the influence of smoking on implant prognosis can often result in considerable problems. Particularly for a retrospective study, it is difficult to assess the adverse effects of smoking on the prognosis of implants on the basis of implant failure alone because of the multifactorial genesis of implant failure. In contrast, a possible effect of smoking on the condition of the peri-implant mucosa and bone, on the development of peri-implantitis, can be assessed.

The purpose of this retrospective study was to examine the possible influence of smoking on the peri-implant tissue.

MATERIAL AND METHODS

This study was based on the data of patients treated with implants who underwent regular recall examinations and whose smoking habits were known. Another criterion for inclusion was masticatory-functional loading of the implant for at least 1 year. Patients with a fixed suprastructure and patients with removable partial dentures (RPDs) (overdentures) were included (Table

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Influence of alcohol and tobacco habits on peri-implant marginal bone loss: a prospective study

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Key words: alcohol, dental implants, implant failure, peri-implant marginal bone loss, peri-implantitis, tobacco

Abstract: A prospective clinical study was conducted to explore the possible link between peri-implant bone loss and the widespread habits of tobacco smoking and alcohol consumption. One hundred and eighty-five patients who received 514 implants were followed up for 3 years. Peri-implant marginal bone loss was evaluated by digital panoramic radiography and image analysis techniques. Multivariate analysis showed that peri-implant marginal bone loss was significantly related to a daily consumption of >10 g of alcohol, tobacco use and increased plaque levels and gingival inflammation. The present results indicate that daily alcohol consumption and tobacco use may have a negative influence on predictable long-term implant treatment outcomes, producing peri-implant bone loss and compromising restorative treatment with implant-supported prostheses.

Alcohol consumption has been associated with a moderately increased severity of periodontitis [Larato 1972; Tezal et al. 2001]. Individuals who use alcohol may have inadequate nutrition or a vitamin deficit, which can lead to a poor response of oral tissues to implant techniques [Schuckit 1979]. Alcohol has a toxic action on the liver and can disrupt the production of prothrombin and vitamin K, affecting coagulation mechanisms [Walker & Shand 1972]. It can produce a delay in the healing of surgical wounds, even when only moderate amounts are consumed and there is no vitamin deficit [Williamson & Davis 1973]. Alcohol consumption is associated with deficiencies in the complement system and an alteration in the function of neutrophils, reducing their adherence, mobility, and phagocytic activity [Christen 1983; Drake 1995] and it also modulates T lymphocyte activity [Waltenbaugh et al. 1998; Taieb et al. 2002].

Moreover, some substances contained in alcoholic drinks, such as fusel oil, nitrosamines and ethanol, can produce bone resorption and block the stimulation of bone neoformation [Farley et al. 1985].

Tobacco use is considered a major etiologic factor in the early onset or aggravation of periodontitis and peri-implantitis [Haber et al. 1993]. Smoking is associated with higher failure rates for machined titanium implants, probably because of its negative effects on bone blood flow during early healing [Bain 2003]. In fact, numerous factors may be involved in the greater bone loss observed among tobacco users. Nociti et al. [2000] demonstrated that nicotine increases alveolar bone loss rates, and tobacco itself can directly produce periodontal bone loss [González et al. 1996], regardless of bacterial plaque levels [Bergström & Eliasson 1987]. Tobacco also has a harmful effect on the soft tissues of the oral cavity, because nicotine is a potent

Pietropaoli et al. BMC Research Notes 2013, 6:296
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BMC Research Notes

SHORT REPORT Open Access

Glycation and oxidative stress in the failure of dental implants: a case series

Davide Pietropaoli*, Eleonora Ortu, Marco Severino, Irma Ciarrocchi, Roberto Gatto and Annalisa Monaco

Abstract

Background: The aim of this case series/control study is to investigate the presence of the Advanced Glycation End products (AGEs) and oxidative stress in periimplantitis.
The study group was composed of five dental implants, failed within 6 months after implantation, taken from 5 subjects (3 M/2 F) aged between 43–57 years and stored in isotonic liquid before freezing at −80°C, according to literature. All the implants had been placed using traditional submerged technique. The whole saliva was also collected using Salimetrics device and stored at −80°C, to assess molecular analysis. Two age-matched control groups were examined: they consisted of 5 subjects encountering dental extraction for chronic periodontal disease (2 M/3 F) and 5 healthy subjects (3 M/2 F) who needed extraction for dental trauma. Their whole saliva was collected with the same method. The implants and the tooth of control groups were processed to assess Western Blotting for identification of AGEs. The case/control whole saliva was used to perform ThioBarbituric Acid Reactive Substances (TBARS) for oxidative stress evaluation.

Findings: The Western Blotting analysis on periimplantitis and periodontal disease tissues showed marked increase of AGEs when compared to healthy control tissues. Also TBARS assay of whole saliva confirmed the expectations, showing higher oxidative stress levels in periimplantitis and periodontitis groups than in healthy group.

Conclusions: With the limitation of the sample size, these results showed that oxidative stress could be involved in the aetiology of periimplantitis. This hypothesis could lead to new therapeutic strategies in periimplantitis, using antioxidant approach in addition to conventional treatments.

Keywords: Dental implants, Periimplantitis, Oxidative stress, Glycation, Advanced glycation end products, AGEs, ROS

Findings

To date it is commonly accepted that the failure of dental implants can be defined as the inability of tissue to establish or maintain osteointegration, caused by host response and opportunistic infection. In fact, the Sixth European Workshop on Periodontology in 2008 has confirmed that "*peri-implant diseases are infectious in nature. Peri-implant mucositis describes an inflammatory lesion that resides in the mucosa, while periimplantitis also affects the supporting bone*" [1].

To date many studies suppose that oxidative stress plays and important role in the aetiology and severity of periodontal diseases, but there are no researches in this field for periimplantitis. We suppose that the same mechanisms are involved in the failure of dental implants.

Substantially, the periodontal bacteria promote the flogistic events that lead to an increase in intracellular production of physiological Reactive Oxygen Species (ROS). The latter are highly reactive compounds due to the presence of shell electrons with unpaired valence. The most relevant radicals are OH and H_2O_2. ROS are formed as natural products of normal oxygen metabolism and play important roles in cells signaling and homeostasis. However, during inflammation, ROS levels can dramatically increase. This may result in the increase of oxidizing conditions, thus leading to cell structures damage. Cumulatively, this is known as *oxidative stress* [2]. Normally, cells defend themselves against ROS damage with enzymatic and non-enzymatic systems. Alpha-1-microglobulin, superoxide dismutases, catalases, lactoperoxidases, glutathione peroxidases and peroxiredoxins are considered an

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Journal of Clinical Periodontology

Implant surface characteristics influence the outcome of treatment of peri-implantitis: an experimental study in dogs

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***Abstract*:**

Aim: To analyse the effect of surgical treatment of peri-implantitis without systemic antibiotics at different types of implants.

Material and methods: Four implants representing four different implant systems – turned (Biomet 3i), TiOblast (Astra Tech AB), SLA (Straumann AG) and TiUnite (Nobel Biocare AB) were placed in the left side of the mandible in six dogs, 3 months after tooth extraction. Experimental peri-implantitis was initiated by placement of ligatures and plaque formation. The ligatures were removed when about 40–50% of the supporting bone was lost. Four weeks later, surgical therapy including mechanical cleaning of implant surfaces was performed. No systemic antibiotics or local chemical antimicrobial therapy were used. After 5 months, block biopsies were obtained and prepared for histological analysis.

Results: Two of the TiUnite implants were lost after surgical therapy. Radiographic bone gain occurred at implants with turned, TiOblast and SLA surfaces, while at TiUnite implants additional bone loss was found after treatment. Resolution of peri-implantitis was achieved in tissues surrounding implants with turned and TiOblast surfaces.

Conclusion: Resolution of peri-implantitis following treatment without systemic or local antimicrobial therapy is possible but the outcome of treatment is influenced by implant surface characteristics.

Key words: bone level; dental implants; infection; inflammatory lesion; peri-implantitis; titanium; treatment

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Peri-implantitis is a common biological complication in implant therapy and is characterized by inflammatory lesions in peri-implant tissues and an associated loss of supporting bone (Zitzmann & Berglundh 2008). It is by definition an infectious disease and the inflammatory lesion in peri-implant tissues develops as a result of accumulation of bacteria on implant surfaces. In a consensus report from the Sixth European Workshop on Periodontology, it was stated that because the disease is caused by bacteria, treatment should include anti-infective measures (Lindhe & Meyle 2008).

Different protocols have been suggested in the treatment of peri-implantitis. Non-surgical procedures alone appear to be insufficient to resolve peri-implantitis lesions (Renvert et al. (2008), while surgical procedures may promote access for removal of the biofilm formed on the implant surface and thereby attain resolution. There is limited information on the long-term outcome of treatment of peri-implantitis. Claffey et al. (2008) in a review article reported that data obtained from case series and animal experiments indicate that no single cleaning method including chemical agents used during surgical treatment of peri-implantitis was proven

Conflict of interest and sources of funding statement

The authors declare that they have no conflict of interests.

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Peri-implantitis. Part 3: Current modes of management

A. Alani*[1] and K. Bishop[2]

PRACTICE

IN BRIEF

- Explores current management strategies for peri-implantitis.
- Informs there is currently no optimal management strategy.
- Suggests current understanding purports that peri-implantitis might be best managed non-surgically in the aesthetic zone but a surgical approach supported by decontamination of the implant surface may provide the best outcome.

Peri-implantitis is an inflammatory condition fuelled by the presence of bacteria on the implant surface. As such, in a similar manner to periodontal disease management, the removal of biofilm from the implant surface should result in regression of the disease process. The optimal manner with which this is achieved has yet to be realised. This may be unsurprising due to the relative surface complexity of the implant surface when compared to natural tooth root. Other management strategies include surface decontamination, the removal of implant threads known as implantoplasty, and in severe cases the need to explant. Favourable defects can be reconstructed utilising guided bone regeneration techniques. The current review appraises some of the techniques for the management of peri-implantitis.

INTRODUCTION

Peri-implantitis presents a significant challenge to both the clinician and to the patient.[1] The implant surface has a high surface energy and surface area, which aids osseointegration. This is best exemplified by comparing the surface area of natural teeth and implants; the root surface area of a mandibular central incisor has been shown to be approximately 250 mm^2 while implants can have surface area of 650 mm^2 or greater (Fig. 1).[2,3] However, the methods used to increase surface area and surface energy may also make the implant more vulnerable to peri-implantitis since the surface itself, once exposed, is populated rapidly by microorganisms and provides an ideal environment for the formation of extensive and robust biofilms.[4]

Currently the management of peri-implantitis is based on methods used to treat periodontal disease.[5] Unfortunately, despite a number of studies into a variety of techniques, there is neither a strong consensus or a recognised treatment modality that will predictably eradicate peri-implantitis.[6-9] This is largely due to an absence of high quality evidence into the efficacy of current treatment modalities.[6-8] Despite these shortcomings there is some merit in appraising currently available methods.

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NON-SURGICAL MANAGEMENT

Periodontal instruments have continually developed over the course of the last 100 years or so. These have largely been designed to instrument a relatively flat surface. It seems slightly strange that instruments used to treat teeth are now engaged to debride a surface that is markedly different to that for which they were originally designed. Indeed instrumentation utilising a sickle scaler shape generally begins at the bottom of the pocket moving upwards to remove biofilm on a root surface with each stroke. This cannot be achieved with implants due to the presence of threads that bring an abrupt stop to any such motion. These mechanical aspects of implants provide significant challenges in achieving effective non-surgical debridement. Standard metallic scalers utilised for root surfaces result in damage to the titanium oxide surface, which can result in the corrosion of the implant and subsequent breakdown.[5,9,10] Moreover utilisation of standard metal scalers may result in a surface that is even more plaque retentive due to microscopic groove development.[9,11] Local factors may also further compromise debridement such as the presence of bulky restorations. These may require removal before instrumentation (Fig. 2).

Due to the above issues modifications and innovations have been made to periodontal instruments used for peri-implantitis.

For example scalers made from plastic have been produced to prevent damage to the surface of the implant. These, in the author's experience, make debridement of the implant surface difficult. The purchase produced is poor as is the rake angle to dislodge retentive

Fig. 1 An implant and a root surface. The relative differences in the surface characteristics are clear in that the implant surface is rougher with an increased surface area. The thread arrangement provides a perfect sheltered niche for bacteria to populate when compared to the relatively smooth surface of a natural tooth. The implant presents a difficult surface to decontaminate and disinfect

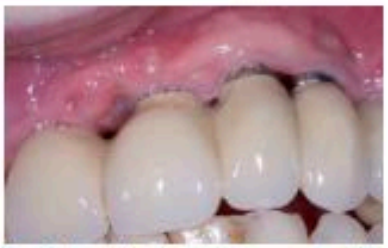

Fig. 2a Implant retained bridge spanning with implants in the 11, 21, 22 and 23 sites. The patient found interproximal cleaning difficult to achieve

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Effect of platform switching on the peri-implant bone: A finite element study

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Abstract

Background: There exists a relation between the presence and location of the micro-gap and the loss of peri-implant bone. Several authors have shown that the treatments based on the use of platform switching result in less peri-implant bone loss and an increased tissue stability. The purpose of this study was to analyse the effect of the platform switching on the distribution of stresses on the peri-implant bone using the finite element method.

Material and Methods: A realistic 3D full-mandible finite element model representing cortical bone and trabecular bone was used to study the distribution of the stress on the bone induced by an implant of diameter 4.1 mm. Two abutments were modelled. The first one, of diameter 4.1 mm, was used in the reference model to represent a conventional implant. The second one, of diameter 3.2 mm, was used to represent the implant with platform switching. Both models were subjected to axial and oblique masticatory loads.

Results: The analyses showed that, although no relevant differences can be found for the trabecular bone, the use of platform switching reduces the maximum stress level in the cortical bone by almost 36% with axial loads and by 40% with oblique loads.

Conclusions: The full 3D Finite Element model, that can be used to investigate the influence of other parameters (implant diameter, connection, …) on the biomechanical behaviour of the implant, showed that this stress reduction can be a biomechanical reasons to explain why the platform switching seems to reduce or eliminate crestal bone resorption after the prosthetic restoration.

Key words: *Dental implant, platform switching, finite element method.*

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Influence of peri-implant bone quality on implant stability

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ABSTRACT

Introduction: Insufficient primary stability is still reported for proximal humerus fractures in elderly patients. Fixation stability could be improved by aiming locking screws at bone volumes with better properties. The aims of this study were to investigate the bone regions engaged by the locking screws of a Proximal Humeral Nail (MultiLoc PHN), and to evaluate the influence of peri-screw bone quality on bone–nail construct stability.

Materials and methods: Twelve cadaveric humeri were divided into two groups. The distal locking part of the PHN was fixed to the specimens. The nails were removed and the bones scanned using HR-pQCT. Bone properties were evaluated at the locations where the proximal locking screws would have been positioned after complete instrumentation. A three-part fracture model was used for mechanical testing of the instrumented bones, considering axial displacement and varus deformation as parameters of interest.

Results: The secondary locking screws targeted bone volumes in the posteromedial part of the humerus with statistically significant higher quality, thus reducing varus deformation. Significant correlation was found between axial displacement and bone properties at the primary proximal screws. Significant correlation was found between the varus deformation and apparent BMD at the secondary locking screws.

Conclusion: The findings of this study confirmed that directing the proximal locking screws at bone regions with better properties can improve fixation stability.

1. Introduction

Proximal humeri fractures are the third most common fractures in people over the age of 65 years. Fixation with plates or intramedullary nails are very common among different operative treatment options, because the primary angular stability is improved by inserting interlocking screws in the humeral head [1]. Although the use of new locking techniques is beneficial for the treatment of these fractures, recent studies still report secondary fragment dislocations in a high percentage of patients [2,3]. A possible reason could be that the implant design is not optimized for bone characteristics of osteopenic and osteoporotic patients [4]. Fixation stability could be improved by aiming locking screws at regions with better bone quality, as several in vitro investigations have confirmed a direct relationship between mechanical and densitometric properties for different anatomical regions [5,6]. The quality of cancellous bone in the proximal humerus has already been investigated. Higher bone mineral density (BMD) was found in its proximal aspect as well as in the medial and posterior regions [4,7,8], while the peak values of bone strength were found to increase from anterior to posterior [8]. The superior anterior part was found to have a significantly lower BMD and pull out strength than all other regions [4]. The influence of local peri-implant bone properties on implant stability has also been recently investigated with micro-finite element modeling [9], supporting the need for a tool to quantify peri-screw bone quality in order to help surgical interventions in reaching better clinical outcomes.

We recently developed a method, based on a high-resolution peripheral quantitative computed tomography (HR-pQCT) to investigate local BMD distribution and bone micro-architecture (BMA) around the expected paths of the locking screws [10]. This method can be applied to any locking implant and can be used to improve the design of locking implants by finding the optimal paths for the anchoring elements. This novel method needs to be validated in order to demonstrate that implant stability and fixation outcomes can be improved by finding those regions with higher bone quality for the proximal locking screws. The same method has already been used to evaluate BMD around the proximal screw

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Nonsurgical Treatment of Periimplantitis

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Purpose: *Periimplantitis has become an emerging challenge faced by practicing dentists worldwide. When treating periimplantitis, we should attempt to manage this problem via nonsurgical therapies that include addressing all modifiable systemic risk factors and local contributing factors. Hence, the aim of this narrative review was to examine published studies on nonsurgical treatment of periimplantitis and evaluate their effectiveness and limitations.*

Materials and Methods: *A literature search was performed in MEDLINE via PubMed database up to December 31, 2017. Current published clinical approaches focused on mechanical debridement, adjunctive antiseptic therapy, adjunctive antibiotic therapy, laser-assisted therapy, and combination approaches were included in this analysis.*

Results: *Nonsurgical therapy of periimplantitis may result in complete healing of the disease and the patient is then placed on a supportive maintenance program. If the disease is not resolved and surgical intervention is not an option, active nonsurgical retreatment may be considered. In many cases where disease is not resolved, surgical therapy or implant removal could be considered.*

Conclusions: *Nonsurgical treatment of periimplantitis usually provides clinical improvements in reducing bleeding tendency and in some cases pocket reduction. Early diagnosis, detection, and intervention remain the key for managing periimplantitis. (Implant Dent 2019;28:155–160)*

Key Words: dental implant, periimplant disease, debridement, antiseptic, antibiotics, laser

Although the main etiology of periimplantitis is the establishment of a bacterial plaque at an implant in susceptible hosts, it is important to recognize that various risk factors and contributing conditions may coexist. Currently, most studies of nonsurgical treatment primarily have focused on different methods of debridement with antibacterial adjunctive measures. Limited information is, however, available about the importance of other variables and contributing factors, such as presence of residual cement, implant position, prosthesis, occlusion, and host systemic conditions. For nonsurgical treatment of periimplantitis, it is essential to identify and address all potential problems in conjunction with the antiinfective therapy, before we can assess the overall outcome of the nonsurgical treatment. In some cases with multiple unmodifiable factors, implant removal may be advised (Fig. 1). The aim of this narrative review was to examine published original studies on nonsurgical treatment of periimplantitis and evaluate their effectiveness and limitations.

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MATERIALS AND METHODS

A literature search was performed in MEDLINE via PubMed database of the US National Library of Medicine, for articles published until December 31, 2017 using Medical Subject Heading search terms and free text terms and in different combinations.

To be included in the data screening and further analyses, studies have to:be written in the English language;to be published in an international peer-reviewed journal;be human clinical trials or studies.

Review of the Literature

Current published studies on nonsurgical therapy for periimplantitis include mechanical debridement and/or adjunctive antiseptic therapy, adjunctive antibiotic therapy, and laser-assisted therapy. There are limited studies available with significant heterogeneity comparing test approaches with the control group, which not only includes the mechanical debridement but also with different combination of adjunctive measures.

Additionally, depending on the definition, sometimes the line between periimplant mucositis and periimplantitis can vary among the published studies. A few clinical trials[1–4] published under the title of periimplant mucositis accept bone loss up to 3 mm, whereas others may already consider these lesions as periimplantitis. For the

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Primary and Secondary Prevention of Periodontal and Peri-Implant Diseases

Introduction to, and Objectives of the Consensus from the 11th European Workshop on Periodontology

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Conflict of interest and source of funding
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Surgical Non-Regenerative Treatments for Peri-Implantitis: a Systematic Review

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ABSTRACT

Objectives: The purposes of the present study were 1) to systematically review the literature on the surgical non-regenerative treatments of peri-implantitis and 2) to determine a predictable therapeutic option for the clinical management of peri-implantitis lesions.
Material and Methods: The study search was performed on primary database MEDLINE and EMBASE from 2005 until 2016. Sequential screenings at the title, abstract, and full-text levels were performed. Clinical human studies in the English language that had reported changes in probing depth (PD) and/or bleeding on probing (BOP) and/or radiologic marginal bone level changes after peri-implantitis surgical non-regenerative treatment at 6-month follow-up or longer were included accordingly PRISMA guidelines.
Results: The first electronic and hand search resulted in 765 citations. From 16 full-text articles reviewed, 6 were included in this systematic review. Surgical non-regenerative methods were found to be efficient in reducing clinical parameters. BOP and PD values were significantly decreased following implantoplasty and systematic administration of antibacterials, but not after local application of chemical compounds or diode laser. Similarly, significant improvement in clinical and radiographic parameters was found only after implantoplasty compared with resective surgery alone. We found significant heterogeneity in study designs and treatments provided among the pooled studies. All of the studies revealed an unclear or high risk of bias.
Conclusions: Surgical non-regenerative treatment of peri-implantitis was found to be effective to reduce the soft tissue inflammation and decrease probing depth. More randomized controlled clinical trials are needed to assess the efficacy of surgical non-regenerative therapy of peri-implantitis.

Keywords: alveolar bone loss; oral surgery; nonsurgical periodontal debridement; peri-implantitis; review.

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Decision Making for Management of Periimplant Diseases

Khaled Sinjab, DDS,* Carlos Garaicoa-Pazmino, DDS, MS,† and Hom-Lay Wang, DDS, MSD, PhD‡

Introduction: *Nonsurgical and surgical management of periimplant mucositis and periimplantitis have shown promising results in arresting periimplant marginal bone loss (MBL) and preventing implant loss. However, management of periimplant diseases still remains unpredictable for full reconstruction of lost tissues and completely arrests disease progression. The present study proposes a decision tree that compiles both clinical and radiographic presentation of failing implants to aid in the decision making for their management.*

Materials and Methods: *An extensive literature review was performed using 3 electronic databases (PubMed, Ovid MEDLINE, and Cochrane Central) on the most recent treatment modalities for the management of periimplant diseases.*

Discussion: *Evidence-based treatment suggestions were primarily derived from periimplant defect morphology, presence, and severity of periimplant MBL. More evidence is required supporting soft-tissue augmentation for the treatment of periimplant diseases.*

Conclusion: *Management of periimplant diseases can include lasers, mechanical instrumentation, chemical detoxification, and antimicrobial agents for nonsurgical approaches. On the other hand, removal of failing implants, resective surgery, guided bone regeneration, and soft-tissue grafting are presented as valid options for the surgical treatment of periimplantitis. (Implant Dent 2018;27:276–281)*

Key Words: dental implants, periimplantitis, periodontal plastic surgery, soft tissue

Dental implants are considered the treatment of choice to replace missing teeth for edentulous patients and proven effective based on high survival rates and long-term predictable outcomes. Widespread use of implants has led to an increasing trend of technical and biological complications commonly grouped as periimplant diseases.

In recent years, Derks and Tomasi[1] reported an alarming prevalence of 43% for periimplant mucositis and 22% for periimplantitis. Both entities are commonly related with an inflammatory origin due to dysbiosis surrounding the periimplant tissues and distinguished on clinical and radiographic parameters. According to the American Academy of Periodontology (AAP), the pathogenesis of periimplant mucositis is confined to soft tissues, with no apparent bone loss beyond physiological bone remodeling, whereas periimplantitis has been described as an inflammatory process including both soft and hard tissues, with evident signs of progressive bone loss beyond biological bone remodeling.[2] Despite the current understanding of periimplant diseases, the management of these conditions remains unpredictable, with no general acceptable consensus.

Seemingly, nonsurgical approaches are sufficient for the management of periimplant mucositis because its pathogenesis possesses a reversible nature and often resembles gingivitis lesions. Schincaglia et al[3] explored the impact of biofilm and changes in the microbiome around implants in a human experimental periimplant mucositis model. Findings from their work confirmed that reinstitution of oral hygiene was efficacious for resolution of inflammation combined with a heterogeneous response on the periimplant microbiome.

Conversely, it is of paramount importance to treat periimplantitis without delay to avoid implant loss.[4] Surgical therapies combined with regenerative or resective modalities have been reported for the management of periimplant diseases and attempted to fill or remove periimplant bone defects, reduction in probing depths (PD), and signs of inflammation.[5] In addition, emerging technologies (eg, lasers) and antimicrobial/chemical agents (eg, chlorhexidine, citric acid, minocycline, and ethylenediaminetetraacetic acid) had been proposed for

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PERIODONTOLOGY 2000

Clinical approaches to treat peri-implant mucositis and peri-implantitis

Stefan Renvert & Ioannis N. Polyzois

In 1994, Albrektsson & Isidor (1) defined peri-implant mucositis as 'a reversible inflammatory change of the peri-implant soft tissue without bone loss (Fig. 1a,b). They further described peri-implantitis as 'an inflammatory process resulting in loss of supporting bone' (Fig. 2) (1). A few years later, at the 6th European Workshop on Periodontology (in 2008), the new term 'peri-implant disease' was introduced as a 'collective term for inflammatory reactions in the tissues surrounding the implants' (78). The description of inflammation around implants is congruent with inflammation around natural teeth and this may explain why all therapies proposed for the management of peri-implant disease are primarily based on the treatments available for targeting periodontitis.

Just as the subgingival microflora associated with periodontitis becomes established around the exposed surface of natural teeth, dental implants become contaminated soon after installation into the oral cavity. The development of this adherent biofilm on the implant surface seems to play a significant role in the initiation and progression of peri-implant diseases. This process mimics the establishment of subgingival microflora around the exposed surface of natural teeth, a process that has been associated with periodontitis (36, 74). Furthermore, the peri-implant diseases have been associated with predominantly gram-negative anaerobic bacteria, similar to those found around natural teeth in patients with advanced periodontitis (27, 31, 34). As a result, elimination of the established biofilm from the implant surface is the main objective in the treatment of peri-implant mucositis and peri-implantitis.

Implant surface debridement is still a common way of treating peri-implant diseases. However, implant design, implant surface characteristics and the design of the superstructure may hamper mechanical nonsurgical therapy, resulting in an ineffective treatment (Fig. 3). Adjunctive therapies for additional surface decontamination include the use of antibiotics, antiseptics, lasers and air-abrasive devices (40). In some cases, following successful decontamination, the bone that was lost as a result of infection may be regenerated using surgical approaches. The ultimate goal is re-osseointegration of the exposed implant surface. For this purpose a number of resective and regenerative surgical techniques have been introduced. In a recent review of the literature it was concluded, based on animal studies, that re-osseointegration is possible at a previously infected implant surface (41).

Clinical approach to treatment of peri-implant mucositis

It is generally believed that peri-implant mucositis is the precursor of peri-implantitis, in the same way that gingivitis is the precursor of periodontitis. In the consensus report of the 7th European Workshop on Periodontology it was concluded that the 'epithelial sealing' around implants is similar to that of teeth and that evidence leading us to believe that the existing structural differences can significantly affect the host response to the bacterial challenge were lacking (26, 34, 76, 77). Furthermore, we currently have enough evidence to suggest that peri-implant mucositis, like gingivitis, is reversible when effectively treated with the indicated therapeutic regimens (26, 34).

When signs of inflammation are identified around the implant head, mechanical therapy (with or without adjunctive use of antiseptic rinses) is usually the initial treatment of choice. However, in two studies, professional irrigation of the sulci with chlorhexidine,

Research Article

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The effect of erbium-doped: yttrium, aluminium and garnet laser irradiation on the surface microstructure and roughness of double acid-etched implants

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Purpose: One of the most frequent complications related to dental implants is peri-implantitis, and the characteristics of implant surfaces are closely related to the progression and resolution of inflammation. Therefore, a technical modality that can effectively detoxify the implant surface without modification to the surface is needed. The purpose of this study was to evaluate the effect of erbium-doped: yttrium, aluminium and garnet (Er:YAG) laser irradiation on the microstructural changes in double acid-etched implant surfaces according to the laser energy and the application duration.

Methods: The implant surface was irradiated using an Er:YAG laser with different application energy levels (100 mJ/pulse, 140 mJ/pulse, and 180 mJ/pulse) and time periods (1 minute, 1.5 minutes, and 2 minutes). We then examined the change in surface roughness value and microstructure.

Results: In a scanning electron microscopy evaluation, the double acid-etched implant surface was not altered by Er:YAG laser irradiation under the condition of 100 mJ/pulse at 10 Hz for any of the irradiation times. However, we investigated the reduced sharpness of the specific ridge microstructure that resulted under the 140 mJ/pulse and 180 mJ/pulse conditions. The reduction in sharpness became more severe as laser energy and application duration increased. In the roughness measurement, the double acid-etched implants showed a low roughness value on the valley area before the laser irradiation. Under all experimental conditions, Er:YAG laser irradiation led to a minor decrease in surface roughness, which was not statistically significant.

Conclusions: The recommended application settings for Er:YAG laser irradiation on double acid-etched implant surface is less than a 100 mJ/pulse at 10 Hz, and for less than two minutes in order to detoxify the implant surface without causing surface modification.

Keywords: Dental implants, Peri-implantitis, Lasers.

INTRODUCTION

As dental implant therapy has become more common, many original products have been flowing onto the dental implant market. Their common aim is to develop an implant design that can achieve faster and more stable osseointegration during a short period of time, and a higher success rate over time. However, as better results and higher success rates are reported annually, implant-related complications have also been increasing. One of the most frequent complications is

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Peri-implantitis. Part 3: Current modes of management

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PRACTICE

IN BRIEF

- Explores current management strategies for peri-implantitis.
- Informs there is currently no optimal management strategy.
- Suggests current understanding purports that peri-implantitis might be best managed non-surgically in the aesthetic zone but a surgical approach supported by decontamination of the implant surface may provide the best outcome.

Peri-implantitis is an inflammatory condition fuelled by the presence of bacteria on the implant surface. As such, in a similar manner to periodontal disease management, the removal of biofilm from the implant surface should result in regression of the disease process. The optimal manner with which this is achieved has yet to be realised. This may be unsurprising due to the relative surface complexity of the implant surface when compared to natural tooth root. Other management strategies include surface decontamination, the removal of implant threads known as implantoplasty, and in severe cases the need to explant. Favourable defects can be reconstructed utilising guided bone regeneration techniques. The current review appraises some of the techniques for the management of peri-implantitis.

INTRODUCTION

Peri-implantitis presents a significant challenge to both the clinician and to the patient.[1] The implant surface has a high surface energy and surface area, which aids osseointegration. This is best exemplified by comparing the surface area of natural teeth and implants; the root surface area of a mandibular central incisor has been shown to be approximately 250 mm^2 while implants can have surface area of 650 mm^2 or greater (Fig. 1).[2,3] However, the methods used to increase surface area and surface energy may also make the implant more vulnerable to peri-implantitis since the surface itself, once exposed, is populated rapidly by microorganisms and provides an ideal environment for the formation of extensive and robust biofilms.[4]

Currently the management of peri-implantitis is based on methods used to treat periodontal disease.[5] Unfortunately, despite a number of studies into a variety of techniques, there is neither a strong consensus or a recognised treatment modality that will predictably eradicate peri-implantitis.[6-8] This is largely due to an absence of high quality evidence into the efficacy of current treatment modalities.[8-9] Despite these shortcomings there is some merit in appraising currently available methods.

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NON-SURGICAL MANAGEMENT

Periodontal instruments have continually developed over the course of the last 100 years or so. These have largely been designed to instrument a relatively flat surface. It seems slightly strange that instruments used to treat teeth are now engaged to debride a surface that is markedly different to that for which they were originally designed. Indeed instrumentation utilising a sickle scaler shape generally begins at the bottom of the pocket moving upwards to remove biofilm on a root surface with each stroke. This cannot be achieved with implants due to the presence of threads that bring an abrupt stop to any such motion. These mechanical aspects of implants provide significant challenges in achieving effective non-surgical debridement. Standard metallic scalers utilised for root surfaces result in damage to the titanium oxide surface, which can result in the corrosion of the implant and subsequent breakdown.[5,9,10] Moreover utilisation of standard metal scalers may result in a surface that is even more plaque retentive due to microscopic groove development.[9,11] Local factors may also further compromise debridement such as the presence of bulky restorations. These may require removal before instrumentation (Fig. 2).

Due to the above issues modifications and innovations have been made to periodontal instruments used for peri-implantitis.

For example scalers made from plastic have been produced to prevent damage to the surface of the implant. These, in the author's experience, make debridement of the implant surface difficult. The purchase produced is poor as is the rake angle to dislodge retentive

Fig. 1 An implant and a root surface. The relative differences in the surface characteristics are clear in that the implant surface is rougher with an increased surface area. The thread arrangement provides a perfect sheltered niche for bacteria to populate when compared to the relatively smooth surface of a natural tooth. The implant presents a difficult surface to decontaminate and disinfect

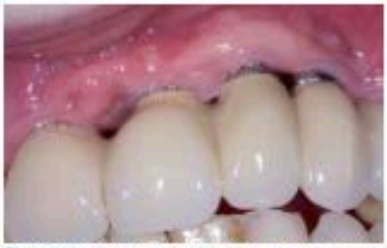

Fig. 2a Implant retained bridge spanning with implants in the 11, 21, 22 and 23 sites. The patient found interproximal cleaning difficult to achieve

Interventions for replacing missing teeth: treatment of perimplantitis (Review)

Esposito M, Grusovin MG, Kakisis I, Coulthard P, Worthington HV

This is a reprint of a Cochrane review, prepared and maintained by The Cochrane Collaboration and published in *The Cochrane Library* 2008, Issue 2

http://www.thecochranelibrary.com

WILEY

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Treatment of peri-implantitis by the Vector® system

A pilot study

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Key words: curettes, peri-implantitis, randomized controlled clinical trial, ultrasonic instrument, Vector® system

Abstract

Aim: To compare the effectiveness of treatment of peri-implantitis with a novel ultrasonic device, the Vector® system, with that of subgingival debridement with carbon fiber curettes.

Material and methods: The study, comprising 11 patients with at least two screw type implants with bleeding on probing (BOP), probing pocket depth (PPD) ≥ 5 mm, and at least 1.5 mm radiographic bone loss and exposed implant threads, was carried out as a single blind randomized clinical trial. At baseline one randomly chosen implant in each patient was treated by the Vector® system (test) while the other implant (control) was treated by submucosal debridement with a carbon fiber curette. After 3 months, the same treatments were repeated. Plaque, BOP, and PPD were recorded on all implant surfaces at baseline, and after 3 and 6 months. Bone levels were recorded on radiographs taken prior to the start of the study, and after 6 months.

Results: Oral hygiene around both test and control implants was improved at 3 and 6 months compared with baseline. At 6 months, four of the Vector®-treated sites, and only one site treated with curettes, had stopped to bleed. In neither the test nor the control group, were there any differences between baseline and 6 months regarding PPD and bone levels.

Conclusion: Although there was a greater reduction in the number of sites with BOP following treatment with the Vector® system than following instrumentation with carbon fiber curettes, there was no significant difference between the two methods.

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Peri-implantitis is an inflammatory process affecting the tissues around osseointegrated implants resulting in loss of supporting bone. When the inflammatory process is confined to the soft tissue compartment around the implant, the condition is termed peri-implant mucositis (Albrektsson & Isidor 1994).

Peri-implant mucositis and peri-implantitis have become an increasing problem in recent years because of the more and more frequent use of endosseous dental implants as part of prosthetic rehabilitation. It is well documented that microbial colonization of the implant surface is the main causative factor in the pathogenesis of these diseases (for a review, see Mombelli 1999). Although some structural differences exist between the tissues surrounding teeth and implants (Berglundh et al. 1991), the composition of the microbiota causing inflammation and/or breakdown of their supporting tissues is similar (Mombelli et al. 1987; Sanz et al. 1990; Augthun &

CLINICAL ORAL IMPLANTS RESEARCH

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In vitro cleaning potential of three different implant debridement methods

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Key words: air flow, debridement, nonsurgical, peri-implantitis

Abstract

Objectives: To assess the cleaning potential of three different instrumentation methods commonly used for implant surface decontamination *in vitro*, using a bone defect-simulating model.

Materials and methods: Dental implants were stained with indelible ink and mounted in resin models, which represented standardized peri-implantitis defects with different bone defect angulations (30, 60 and 90°). Cleaning procedures were performed by either an experienced dental hygienist or a 2nd-year postgraduate student. The treatment was repeated 20 times for each instrumentation, that is, with a Gracey curette, an ultrasonic device and an air powder abrasive device (PAD) with glycine powder. After each run, implants were removed and images were taken to detect color remnants in order to measure planimetrically the cumulative uncleaned surface area. SEM images were taken to assess micromorphologic surface changes (magnification 10,000×). Results were tested for statistical differences using two-way ANOVA and Bonferroni correction.

Results: The areas of uncleaned surfaces (%, mean ± standard deviations) for curettes, ultrasonic tips, and airflow accounted for 24.1 ± 4.8%, 18.5 ± 3.8%, and 11.3 ± 5.4%, respectively. These results were statistically significantly different ($P < 0.0001$). The cleaning potential of the airflow device increased with wider defects. SEM evaluation displayed distinct surface alterations after instrumentation with steel tips, whereas glycine powder instrumentation had only a minute effect on the surface topography.

Conclusion: Within the limitations of the present *in vitro* model, airflow devices using glycine powders seem to constitute an efficient therapeutic option for the debridement of implants in peri-implantitis defects. Still, some uncleaned areas remained. In wide defects, differences between instruments are more accentuated.

Implant therapy has become a successful standard treatment in dentistry (Jung et al. 2008; Romanos et al. 2012), and thus, an increasing number of implants is being placed (http://www.aaid.com; Brennan et al. 2010). However, biological and technical complications are a clinical reality as well, and peri-implantitis has been shown to occur in 28-56% of patients with dental implants (Zitzmann & Berglundh 2008), thereby consituting the main biologic reason for long-term implant failure (Aglietta et al. 2009; Jung et al. 2008). As a consequence, peri-implantitis cases emerge as well in the general dental practice, and peri-implantitis treatment itself is becoming more and more an integral part of standard treatment protocols (Schmidlin et al. 2012).

The primary etiologic factor for these inflammatory conditions is the establishment of bacterial biofilms on the implant surfaces (Heitz-Mayfield & Lang 2010). Within this biofilm, bacteria show an extreme resistance to topical disinfectants and systemic antibiotics (Stewart & Costerton 2001). Accordingly, the aim of any cause-related therapy still remains the effective mechanical removal of the intact biofilm (Mombelli & Lang 1994). For this purpose, manual curettes, ultrasonic and air-polishing devices are commonly used (Romanos & Weitz 2012; Mombelli et al. 2012). However, due to the special implant and defect-specific characteristics, access to all affected areas is limited. As a consequence, nonsurgical techniques still do not provide predictable and successful outcomes,

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Evaluation of different methods to clean titanium abutments

A scanning electron microscopic study

Speelman JA, Collaert B, Klinge B. Evaluation of different methods to clean titanium abutments. A scanning electron microscopic study. Clin Oral Impl Res 1992: 3: 120–127.

The cleaning effectiveness of different treatment methods for titanium abutments was evaluated using scanning electron microscopy (SEM). In the mandible of 4 beagle dogs, 25 titanium abutments were installed (modum Brånemark). After 16 weeks of plaque accumulation, mineralized deposits had formed on 23 abutments. Each of these abutments was subjected to one of the following treatment methods: scaling with (1) metal, (2) plastic, or (3) ultrasonic instruments; (4) air-polishing, (5) weekly rubber cup polishing or (6) daily brushing with a conventional toothbrush. Fourteen abutments were removed immediately after treatment. On 9 abutments, the scaling procedures and air-polishing were repeated after another 16 weeks of plaque accumulation. The abutments were prepared for SEM, and each of them was viewed and photographed at 3 different magnifications. The photomicrographs were evaluated by 3 examiners who, guided by reference pictures, gave each abutment a "cleanliness" score, ranking from 0 to 5. Regular rubber cup polishing and regular brushing resulted in the highest surface cleanliness, while the air-polishing procedure showed the lowest cleanliness score. None of the 3 scaling methods created a cleanliness score better than 3. The 3 scaling methods were considered equal in their cleaning effectiveness. No differences could be observed between surfaces treated 1 × or 2 ×. Taken the present findings and those of other studies concerning the effects of scaling on the surface roughness and biocompatibility into consideration, it was concluded that plastic scalers may be the instruments of choice for debridement of titanium implant surfaces.

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Key words: scanning electron microscopy – titanium abutment – calculus – scaling – polishing – brushing

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The use of osseointegrated implants is becoming a common treatment procedure in the replacement of missing teeth. A large number of implant systems are available, and many are manufactured of commercially pure titanium. For natural teeth, a cause-effect relationship between dental plaque and periodontal disease has been established. The peri-implant tissues seem to be affected by bacteria in a similar way (Adell et al. 1986, Lekholm et al. 1986a, b, Mombelli et al. 1987, Mombelli et al. 1988, Apse et al. 1989). Poor oral hygiene after implant placement leads to a weaker tissue attachment apparatus surrounding the implants (Koth et al. 1988). Moreover, oral hygiene appeared to be the most important factor associated with marginal bone loss around implant fixtures over a period of 6 years (Lindqvist et al. 1988).

In general, the same oral hygiene methods are advocated for implants and natural teeth (Halpert 1979, Adell et al. 1981, Fallschussel 1984, Tetsch & Dohm 1984, Balshi 1986). However, the implant surface creates a specific problem. Although titanium is a strong metal, it is easily scratched and marred, especially by metal instruments (Balshi 1986). Scratches or cuts change the surface roughness, increasing plaque retention. *In vitro* studies have applied several treatment procedures on various implant materials and have found them to create surface changes of different extents (Thomson-Neal et al. 1989, Parham et al. 1989, Fox et al. 1990, Dmytryk et al. 1990, Rapley et al. 1990).

The 1st aim of this scanning electron microscopic (SEM) study was to compare the cleaning potential of (1) metal, (2) plastic, and (3) ultrasonic scalers, and (4) air-polishing, (5) rubber cup polishing and (6) brushing on titanium implants. The 2nd aim was to evaluate if the one-time application of the different instruments would make a 2nd treatment

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The effect of various topical peri-implantitis antiseptics on *Staphylococcus epidermidis*, *Candida albicans*, and *Streptococcus sanguinis*

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ABSTRACT

Objective: Although peri-implantitis has presented an ever increasing problem in modern dentistry, satisfying therapeutic strategies or scientifically based treatment recommendations are still not available. The main object of the present study was to evaluate the antibacterial efficacy of six different topical antiseptics on three test microorganisms attached to titanium implant specimens.

Material and methods: For biofilm formation, plane titan specimens were incubated either in *Candida albicans*, *Streptococcus sanguinis*, or *Staphylococcus epidermidis* for 2 h. The specimens were then treated with different topical antiseptics for 60 s (sodium hypochlorite 1.0%, hydrogen peroxide 3.0%, chlorhexidine gluconate 0.2%, citric acid 40.0%, Plax, or Listerine) and with sterile saline as control. Remaining vital fungi were quantified by means of a bioluminometric assay and the bacterial load and the viability of adhering *S. epidermidis* and *S. sanguinis* by live or dead cell labelling in combination with fluorescence microscopy.

Results: Sodium hypochlorite was effective against all three species, whereas hydrogen peroxide was solely effective against *C. albicans*. CHX and Listerine showed antimicrobial activity against *S. sanguinis* and *C. albicans* and citric acid and Plax against both tested bacteria.

Conclusions: None of the tested antimicrobial agents, except for sodium hypochlorite, showed a significant *in vitro* effect on all three test microbes. Considering the possible toxicity of sodium hypochlorite, none of the tested – and so far widely used – antiseptics showed any broad-spectrum antimicrobial effect and could therefore not be recommended for the topical disinfection and detoxification of infected implant surfaces.

1. Introduction

In modern dentistry (titanium) implants are one of the most frequently used treatment options for tooth replacement. The oral microflora – consisting of over 600 different microbial species – and its dynamic interactions with implant surfaces are the defining factors for both short-term and long-term success or failure of an osseointegrated implant.[1,2] Peri-implantitis, i.e. infection of the oral tissues surrounding an implant, is an inflammatory disease due to bacteria and biofilm formation on an implant, which can lead to bone

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Journal of Clinical Periodontology

Systemic antibiotics and debridement of peri-implant mucositis. A randomized clinical trial

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Hallström H, Persson GR, Lindgren S, Olofsson M, Renvert S. Systemic antibiotics and debridement of peri-implant mucositis. A randomized clinical trial. J Clin Periodontol 2012; 39: 574–581. doi: 10.1111/j.1600-051X.2012.01884.x.

Abstract

Background: This RCT compared non-surgical treatment of peri-implant mucositis with or without systemic antibiotics.

Materials and Methods: Forty-eight subjects received non-surgical debridement with or without systemic Azithromax ® (4 days), and were followed during 6 months. The checkerboard DNA-DNA hybridization method was used to analyse the microbiological material.

Results: Five subjects were excluded due to antibiotic medication during follow-up. At baseline,1 and 3 months no group differences were found. Statistical analysis failed to demonstrate differences in probing pocket depths (PPD) values at 6 months (Mean diff PPD: 0.5 mm, SE: ±0.4 mm, 95% CI: −0.2, 1.3, $p = 0.16$). Mean% implant bleeding decreased between baseline and month 6 from 82.6% to 27.3% in the test, and from 80.0% to 47.5% in the control group ($p < 0.02$). Throughout the study, no study group differences in bacterial counts were found.

Conclusion: No short-term differences were found between study groups. The clinical improvements observed at 6 months may be attributed to improvements in oral hygiene. The present study does not provide evidence for the use of systemic antibiotics in treatment of peri-implant mucositis.

Key words: antibiotics; microbiology; peri-implant disease; peri-implant mucositis; therapy

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Oral peri-implant mucositis is a reversible prevalent inflammatory process of the peri-implant soft tissues not including alveolar bone loss (Ferreira et al. 2006, Roos-Jansåker et al. 2006, Lindhe et al. 2008, Zitzmann & Berglundh 2008). The infectious aetiology of peri-implant mucositis is well documented (i.e. Renvert et al. 2007, Ata-Ali et al. 2011, Lang et al. 2011). Assuming that peri-implant mucositis may transfer to irreversible peri-implantitis, it is important to establish healthy conditions through effective interceptive treatments of peri-implant mucositis.

Few studies have documented efficacious treatment methods of peri-implant mucositis. Mechanical debridement of implants with peri-implant mucositis can result in clinical improvements and bacterial reductions over 3 months (Máximo et al. 2009). Although non-surgical full-mouth debridement may have no impact on the microbiota, a decrease in bleeding, and probing pocket depth at implants with peri-implant mucositis is possible (Thöne-Mühling et al. 2010). Nevertheless, following non-surgical debridement, bleeding on probing at implants with a diagnosis of peri-implant mucositis may

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Periodontology 2000

Lasers in minimally invasive periodontal and peri-implant therapy

Koji Mizutani, Akira Aoki, Donald Coluzzi, Raymond Yukna, Chen-Ying Wang, Verica Pavlic & Yuichi Izumi

'Pain free' and 'simple procedure' are two of the most attractive phrases to patients who are otherwise reluctant to accept any dental treatment (138). Minimally invasive dental therapy (81) could satisfy the demands of such patients. The procedures can be comfortable, although not necessarily without any pain; and be effective for disease control whilst preserving more healthy dental tissue.

Scaling and root planing is an example of a minimally invasive procedure because it is a conservative, cause-related therapy that attempts to eliminate etiologic factors from the root surface (26). Scaling and root planing can result in improved clinical outcomes such as reduced bleeding on probing and decreased periodontal pocket depth. However, some calculus occasionally remains on the 'scaled' and 'planed' root surface. Moreover, treatment outcomes may not always be successful for moderate and deep periodontal pockets (95). In those cases, and after further evaluation, surgical procedures may be performed in an attempt to eliminate the remaining etiological factors, as well as to achieve regeneration of lost periodontal tissue. Although periodontal surgery is not minimally invasive, it will produce better results if preceded by scaling and root planing (47).

Clearly, if predictable treatment could be established for moderate periodontitis without surgery or with minimally invasive flapless surgery, it would provide a significant benefit to many patients with chronic periodontal disease, as well as to dentists providing their care. Thus far, conventional mechanical therapy has not resulted in such an ideal treatment outcome, even when using power-driven devices. Moreover, antimicrobial therapy using systemic or locally delivered antibiotics has only occasionally demonstrated some effectiveness. Recent evidence demonstrates that laser treatment has the potential to improve therapeutic outcomes and therefore be a valuable addition to conventional treatments (55). Currently, high-power-output lasers are used adjunctively with scaling and root planing or as minimally invasive surgery. Also, very-low-power-output lasers are employed for cellular stimulation and/or activation of antimicrobial agents following scaling and root planing. Both of these laser applications can be considered as minimally invasive approaches to periodontal disease treatment.

The aim of the present review was to survey the relevant literature of the clinical application of lasers as minimally invasive treatment in periodontal and implant therapy for periodontists, general practitioners and dental hygienists who are the primary providers of initial treatment of these periodontal diseases and conditions. This paper will focus on the potential therapeutic benefits of photonic energy produced by laser instruments and exclude discussions of other nonlaser optical devices, such as light-emitting diodes.

Lasers in periodontics and peri-implant therapy

Laser applications for periodontal and implant therapy have gradually expanded as a result of the increase in published basic and clinical investigations using diode, carbon dioxide (CO_2), neodymium-doped yttrium aluminium garnet (Nd:YAG), erbium-doped yttrium aluminium garnet (Er:YAG) and erbium, chromium-doped: yttrium, scandium, gallium, garnet (Er,Cr:YSGG) lasers. All of these wavelengths with moderate

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Full- *vs.* Partial-mouth Disinfection in the Treatment of Periodontal Infections: Short-term Clinical and Microbiological Observations

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Abstract. In a standard periodontal treatment strategy with consecutive root planings (*per* quadrant at a one- to two-week interval), re-infection of a disinfected area might occur before completion of the treatment. This study examines, both clinically and microbiologically, whether a full-mouth disinfection within 24 hours significantly improves the outcome of periodontal treatment. Ten patients with advanced chronic periodontitis were randomly allocated to a test and a control group. The patients from the control group received scalings and root planings as well as oral hygiene instructions *per* quadrant at two-week intervals. Full-mouth disinfection in the test group was sought by the removal of all plaque and calculus (in two visits within 24 hours). In addition, at each of these visits, the tongue was brushed with a 1% chlorhexidine gel for one min and the mouth rinsed with a 0.2% chlorhexidine solution for two min. Furthermore, subgingival chlorhexidine (1%) irrigation was performed in all pockets. The recolonization of the pockets was retarded by oral hygiene and 0.2% chlorhexidine rinses during two weeks. The clinical parameters were recorded, and plaque samples were taken from the right upper quadrant at baseline and after one and two months. The test group patients showed a significantly higher reduction in probing depth for deep pockets at both follow-up visits ($p < 0.05$). At the one-month visit, differential phase-contrast microscopy revealed significantly lower proportions of spirochetes and motile rods in the test group ($p = 0.01$). Culturing showed that the test group harbored significantly fewer pathogenic organisms at one month ($p = 0.005$). At two months, the same sites harbored singificantly more "beneficial" bacteria ($p = 0.02$). Moreover, all sites of the test group initially harboring *P. gingivalis* (6/10) became negative after treatment. These findings suggest that it is possible to achieve a significant improvement of the treatment outcome (both microbiologically and clinically) with a one-stage full-mouth disinfection.

Key words: bacterial infection, chlorhexidine, dental plaque, dental calculus, periodontal disease, periodontal therapy, root planing.

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Introduction

The concept of bacterial specificity in periodontal infections has become largely accepted (Slots and Rams, 1991; Socransky and Haffajee, 1992). Three factors are currently considered for the establishment of an active periodontal infection: (1) a susceptible host, (2) the presence of periodontopathogens, and (3) the absence of beneficial species (Socransky and Haffajee, 1992; Wolff *et al.*, 1994). Whereas *Actinobacillus actinomycetemcomitans, Bacteroides forsythus, Eikenella corrodens, Fusobacterium nucleatum, Peptostreptococcus micros, Porphyromonas gingivalis, Prevotella intermedia, Campylobacter rectus*, and spirochetes are frequently associated with periodontal destruction, *Actinomyces* species, *Streptococcus mitis* and *sanguis*, *Veillonella parvula*, and *Capnocytophaga ochracea* are considered beneficial, although their role is not always well-understood (Socransky and Haffajee, 1992; Wolff *et al.*, 1994). Some of these periodontopathogens should be considered as exogenous (*P. gingivalis, A. actinomycetemcomitans*), whereas others are endogenous (Slots, 1986; Van Winkelhoff, 1994). This has been confirmed by the observed transmission of identical bacteria between spouses or family members (Alaluusua *et al.*, 1991; Petit *et al.*, 1994). The degree of elimination of the exogenous periodontopathogens, *e.g.*, by antibiotic therapy, was found to have a major impact on the treatment outcome (Slots and Rams, 1990; Pavicic *et al.*, 1994). Therefore, the target organisms during periodontal therapy are the exogenous species.

Several pathogenic micro-organisms have been found to spread subgingivally, including at sites without clinical loss of periodontal attachment (Van Winkelhoff *et al.*, 1994). Moreover, they can also colonize other intra-oral niches such as the tonsils, the tongue, and other mucous membranes (Van Winkelhoff *et al.*, 1986, 1988a; Asikainen *et al.*, 1991; Danser *et al.*, 1994). Studies on artificial transgingival abutments have also illustrated the possibility of an intra-oral transmission of periodontopathogens (Papaioannou, 1994; Quirynen *et al.*, 1995).

Comparison of the Use of Different Modes of Mechanical Oral Hygiene in Prevention of Plaque and Gingivitis

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Wim H. van Palenstein Helderman,† Ubele Van der Velden,* and G.A. Van der Weijden*

Background: The objective of this study was to evaluate the effect of an oscillating/rotating/pulsating powered toothbrush on plaque and gingivitis prevention over a 9-month period.

Methods: The study had an examiner-masked, randomized, three-group parallel design. A total of 122 subjects ≥18 years of age in good general health and with at least five teeth per quadrant and no pockets ≥5 mm were included. A 3-week preexperimental period of extensive oral home care, including rinses, was started to improve gingival health. Professional oral hygiene instruction with a manual brush was provided. At baseline, subjects were assigned to one of three regimens: twice daily brushing with a manual toothbrush, a manual toothbrush and the use of floss, or a powered toothbrush. Subjects were professionally instructed in their regimen and given a prophylaxis. Two weeks later, oral hygiene reinforcement was provided. Gingival bleeding, plaque, staining, and gingival abrasion were assessed during the preexperimental period and at baseline, 10 weeks, and 6 and 9 months.

Results: There was a significant reduction in plaque and gingivitis from the preexperimental period to baseline. At 10 weeks and 6 and 9 months, the level of plaque was statistically significantly lower with the powered toothbrush versus the other two regimens ($P \leq 0.002$). At 10 weeks and 6 months, the level of bleeding in the powered toothbrush group was statistically significantly lower versus manual brushing alone ($P \leq 0.024$).

Conclusions: The powered toothbrush maintained lower plaque levels for 9 months following the 3-week treatment phase better than the manual toothbrush with or without floss. The powered toothbrush showed significant benefits in preventing gingival bleeding versus manual brushing alone. All regimens were safe for oral tissues. *J Periodontol 2008;79:1386-1394.*

KEY WORDS

Dental floss; dental plaque; gingivitis; toothbrushing.

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The presence of high levels of plaque found in most people is largely responsible for the widespread prevalence of gingivitis, which is socially and clinically undesirable. Löe et al.[1] established the importance of plaque in the etiology of gingival inflammation. They also demonstrated that the reinstatement of thorough tooth cleaning after a period of no cleaning resulted in the reestablishment of healthy gingivae. Powered toothbrushes are now generally regarded to be more efficacious than manual toothbrushes in removing plaque and maintaining or improving the gingival condition.[2-4] Experience has shown that they are efficient and surprisingly appealing to patients.[5] Because of these reasons, they have a definite place in the oral hygiene program.

Studies[6-13] over the past decade showed that certain powered toothbrushes (e.g., oscillating-rotating) are effective at plaque removal and reducing the signs of gingival inflammation. They are capable of effectively reestablishing gingival health after a period of experimentally induced inflammation.[14-16]

Although it is generally recognized that mechanical cleaning is potentially useful in controlling supragingival plaque, the expectation that each individual will maintain a good standard seems to be beyond most people's capabilities. Few people can sustain the dedication required to

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In Vitro Studies on the Effect of Cleaning Methods on Different Implant Surfaces*

Michael Augthun, Joachim Tinschert, and Anja Huber

THE EFFECT OF SPECIFIC CLEANING PROCEDURES was examined on the surfaces of 3 implant types with different coatings and shapes (plasma sprayed [PS]; hydroxyapatite coated [HA] implants; and smooth titanium surface screws) using a scanning electron microscope. Each implant was treated for 60 seconds per instrument with one of 6 different hygiene measures: plastic curet, metal curet, diamond polishing device, ultrasonic scaler, air-powder-water spray with sodium hydrocarbonate solution, and chlorhexidine 0.1% solution rinse. The air-powder-abrasive system, chlorhexidine rinse, and curettage with a plastic instrument caused little or no surface damage in all but the hydroxyapatite-coated fixtures. Therefore, these 3 methods were tested to determine their cleaning efficacy in a second clinical study, which did not include the HA-coated fixture. Two implants were placed on the facial aspects of both upper molar regions using individual acrylic plates. Thus, 2 fixtures on each side were examined in each patient. The examination revealed that only the sodium hydrocarbonate spray yielded a clean fixture without damage to the implant surface. In a third stage, which imitated the clinical procedure of the second approach, the cell growth of mouse-fibroblasts on implant surfaces was examined after cleaning the surface with plastic scaler and the air-abrasive system, which represents the least damaging and most effective methods. In contrast to the implant surfaces treated with plastic scalers, mostly vital cells were found on implants sprayed with the air-abrasive system. *J Periodontol 1998;69:857–864.*

Key Words: Curettage; scaling; chlorhexidine; air abrasion; cleansing agents; dental implants; oral hygiene/instrumentation; oral hygiene/methods.

Although there has been great progress in treating patients with implants as an alternative to traditional, tooth supported prostheses, maintaining healthy peri-implant tissues remains a challenge. This is in contrast with the abundance of literature on maintaining periodontal tissues.[1–3] There is general agreement that plaque control is essential in preventing peri-implant infections.[4–6] Due to the nature of implants, hygiene procedures must be modified from those used for teeth. So far, studies have mainly concentrated on the impact of cleaning procedures where the implant enters the oral cavity or the abutment area, both of which are smooth and highly polished.[7,8]

However, experience with deep peri-implant bone defects is still limited.[9–11] This area concerns the treatment of the peri-implant bone defect itself, as well an appropriate cleaning method for contaminated implant surfaces in order to support implant re-osseointegration.

The first aim of this study was to examine common hygiene measures used in periodontal therapy with respect to their damaging and cleaning effects on different implant surfaces. The second aim was to determine if growth of vital cells on contaminated implant surfaces could be observed after treatment with different hygiene methods.

MATERIALS AND METHODS

Preparation of Specimens and Instrumentation

At first the influence of cleaning procedures on the surfaces of different implant types was examined. Six plasma-sprayed,† 6 hydroxyapatite-coated cylinder implants,† and 6 implants with smooth titanium surfaces‡ were used.

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PERIODONTOLOGY 2000

Management of peri-implant mucositis and peri-implantitis

Elena Figuero, Filippo Graziani, Ignacio Sanz, David Herrera & Mariano Sanz

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

REVISIÓN

Tratamiento de la periimplantitis. Revisión bibliográfica

Daniel Oribe, Mónica Vicario, Deborah Violant, Antonio Santos

Palabras clave: *periimplantitis, tratamiento, protocolo, periodontitis, actualización*

Resumen: La sustitución de los dientes perdidos por implantes dentales es cada día más habitual en las consultas dentales. Aunque el índice de supervivencia de los implantes es elevado, el odontólogo se encuentra con fracasos debidos fundamentalmente a la sobrecarga o a la infección de los tejidos de soporte del implante. En la literatura médica encontramos distintos enfoques en el tratamiento de la periimplantitis; el objetivo de este trabajo es analizar estas diferentes modalidades. En primer lugar se expondrá la importancia de la prevención de la periimplantitis y de los factores asociados a su aparición. A continuación se revisará la investigación realizada en animales, y por último los realizados en seres humanos, incluyendo estudios sobre el uso de antibióticos locales y sistémicos, la eficacia del tratamiento no quirúrgico, el uso del láser y las distintas técnicas y materiales que se pueden utilizar en el tratamiento quirúrgico.

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Introducción

Los implantes dentales osteointegrados, utilizados cada vez más en odontología, proporcionan al paciente unas prótesis confortables, funcionales y estéticas que sustituyen a los dientes naturales perdidos.

El porcentaje de supervivencia de los implantes supera el 90% en la mayoría de estudios longitudinales, como el de Roos-Jansåker y cols. (2006a), en el que tras 9-14 años de seguimiento el éxito fue del 95,7%. Las causas del fracaso del implante pueden ser la sobrecarga, la infección de los tejidos periimplantarios o determinadas condiciones locales o sistémicas (Esposito y cols. 1998). El término periimplantitis se refiere a las reacciones inflamatorias que causan pérdida de soporte óseo alrededor del implante (Roos-Jansåker y cols. 2006b). Muchas de las bacterias que se pueden aislar en estos procesos son las clásicas que se asocian a la periodontitis, como *Porphyromonas gingivalis*, *Prevotella intermedia*, *Prevotella nigrescens* y *Aggregatybacter actinomycetemcomitans*, pero sorprende la presencia de algunas otras que en principio no están asociadas a la enfermedad periodontal como *Staphylococcus spp.*, Enterococos y *Cándida spp* (Leonhardt y cols. 1999).

Al igual que en la periodontitis, existen determinadas condiciones sistémicas que afectan al desarrollo de la periimplantitis. Como ejemplos más significativos tenemos la diabetes mellitus y el tabaquismo. La revisión de Mellado-Valero y cols. (2007) sobre el efecto de la diabetes en la osteointegración de los implantes constata un mayor índice de fracasos entre los pacientes diabéticos que entre los no diabéticos, fracasos que sobre todo se dan en el primer año de carga, lo que apunta a los problemas de microcirculación asociados a la diabetes como posible causa del problema. En la revisión de la literatura llevada a cabo por Klokkevold y Han (2007) se propone una relación entre la periimplantitis y la diabetes mellitus, aunque según los autores el número limitado de estudios no nos permite llegar a una conclusión definitiva. En cuanto al tabaco, los distintos autores (Esposito y cols. 1998, Klokkevold y Han 2007, Roos-Jansåker y cols. 2006c; y Leonhardt y cols. 2003) parecen estar de acuerdo en el

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Maintenance of implants: an *in vitro* study of titanium implant surface modifications subsequent to the application of different prophylaxis procedures

Matarasso S, Quaremba G, Coraggio F, Vaia E, Cafiero C, Lang NP. Maintenance of implants: an in vitro study of titanium implant surface modifications subsequent to the application of different prophylaxis procedures.
Clin Oral Impl Res 1996: 7: 64–72. © Munksgaard, 1996

The aim of the present study was to evaluate surface alterations on titanium implant necks subsequent to different prophylaxis procedures. Fifty ITI implants were utilized. Forty implants were treated with 10 different prophylaxis procedures (ultrasonic scaler, plastic tip ultrasonic scaler, stainless steel curette, titanium curette, teflon curette, air powered system, abrasive rubber cups, polishing rubber cup and brush), and 10 implants were left as untreated controls.
Surface alterations were studied on an area of 1mm×0.9mm and quantified using optical microscopic, SEM and laser prophylometer analysis. The use of the laser prophylometer provided an objective criterion for evaluation, expressing implant neck surface alterations in numeric values in terms of two roughness indexes, Ra and Rz.
The results showed that, in comparison with the controls (Ra=0.50; Rz=3.98) the procedures investigated could be divided into 3 main groups:
1) Methods which altered the implant neck surface producing increased roughness (Ra=0.68–2.08 ; Rz=4.68–11.92);
2) Methods which left the implant neck surface unaltered (Ra=0.44–0.57; Rz=0.42–3.46);
3) Methods resulting in a smoothening of the implant neck surface (Ra=0.36; Rz=2.15).
Group 1 included procedures that should be avoided. However, it appeared safe to apply the procedures of groups 2 and 3.
To confirm these results, it will be necessary to evaluate the plaque- and calculus-removing efficacy from titanium neck implant surfaces *in vivo*.

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Key words: Dental implants – surface roughness – prophylaxis – laser profilometry – cleaning devices – *in vitro* study

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The role of bacteria in the etiology of gengivitis and periodon titis has been conclusively demonstrated, and periodontal health can only exist as a consequence of a perfect plaque control. The main aim of maintenance therapy is therefore to ensure perfect supragingival and subgingival plaque control. Conclusions derived from studies of periodontal patients may also be applied in patients with dental implants.

Failing implants may frequently be linked to the presence of infection of the surrounding tissues. In fact the surrounding soft tissues may develop plaque-related inflammation, resulting in mucositis and peri-implantitis (Berglundh et al. 1992; Lindhe et al. 1992; Lang et al. 1993; Schou et al. 1993). From a microbiological point of view, successful implant sites are colonized by few microbic species, mostly Gram-positive, while unsuccessful implant

Mechanical non-surgical treatment of peri-implantitis: a double-blind randomized longitudinal clinical study. I: clinical results

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Renvert S, Samuelsson E, Lindahl C, Persson GR. Mechanical non-surgical treatment of peri-implantitis: a double-blind randomized longitudinal clinical study. I: Clinical results. J Clin Periodontol 2009; 36: 604–609. doi: 10.1111/j.1600-051X.2009.01421.x.

Abstract

Background: Peri-implantitis is a frequent finding in patients with dental implants. The present study compared two non-surgical mechanical debridement methods of peri-implantitis.

Material and Methods: Thirty-seven subjects (mean age 61.5; S.D ± 12.4), with one implant each, demonstrating peri-implantitis were randomized, and those treated either with titanium hand-instruments or with an ultrasonic device were enrolled. Data were obtained before treatment, and at 1, 3, and 6 months. Parametric and non-parametric statistics were used.

Results: Thirty-one subjects completed the study. The mean bone loss at implants in both groups was 1.5 mm (SD ± 1.2 mm). No group differences for plaque or gingival indices were found at any time point. Baseline and 6-month mean probing pocket depths (PPD) at implants were 5.1 and 4.9 mm ($p = 0.30$) in both groups. Plaque scores at treated implants decreased from 73% to 53% ($p < 0.01$). Bleeding scores also decreased ($p < 0.01$), with no group differences. No differences in the total bacterial counts were found over time. Higher total bacterial counts were found immediately after treatment ($p < 0.01$) and at 1 week for ultrasonic-treated implants ($p < 0.05$).

Conclusions: No group differences were found in the treatment outcomes. While plaque and bleeding scores improved, no effects on PPD were identified.

Key words: mechanical; non-surgical therapy; peri-implantitis; ultrasonic; ultrasonic

Accepted for publication 15 April 2009

During the most recent decades, implant dentistry has become an effective method to re-establish aesthetics and chewing function following tooth loss. Although in most cases dental implants, as a tooth replacement device, have a good prognosis, complications do occur. Biological complications are referred to as peri-implant mucositis or peri-implantitis (Albrektsson & Isidor 1994). Peri-implant infections have been associated with biofilm development (Costerton et al. 1999, Lamont & Jenkinson 2000). As a consequence, the elimination of the biofilm seems to be essential in the management and control of peri-implant infections. Therapies proposed for the management of peri-implant infections, however, appear to be largely based on the evidence available from the treatment of periodontitis. The screw-shaped designs of dental implants, combined with various degrees of surface modifications allowing for an enhanced osseointegration, may also enhance biofilm formation, and thereby increase the risk for inflammation. Most publications on treatment of peri-implant lesions in humans report individual cases treated by combined procedures, aimed at reducing the bacterial load within the peri-implant pocket

Conflict of interest and source of funding statement

None of the authors have a conflict of interests.
All authors met the authorship requirements listed by the ICJME guidelines.
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Journal of Clinical Periodontology

Non-surgical treatment of peri-implantitis using an air-abrasive device or mechanical debridement and local application of chlorhexidine: a prospective, randomized, controlled clinical study

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Sahm N, Becker J, Santel T, Schwarz F. Non-surgical treatment of peri-implantitis using an air-abrasive device or mechanical debridement and local application of chlorhexidine: a prospective, randomized, controlled clinical study. J Clin Periodontol 2011; 38: 872–878. doi: 10.1111/j.1600-051X.2011.01762.x.

Abstract

Objectives: The aim of this prospective, parallel group designed, randomized controlled clinical study was to evaluate the effectiveness of an air-abrasive device (AAD) for non-surgical treatment of peri-implantitis.

Material and Methods: Thirty patients, each of whom displayed at least one implant with initial to moderate peri-implantitis, were enrolled in an oral hygiene program (OHI) and randomly instrumented using either (1) AAD (amino acid glycine powder) or (2) mechanical debridement using carbon curets and antiseptic therapy with chlorhexidine digluconate (MDA). Clinical parameters were measured at baseline, 3 and 6 months after treatment [e.g. bleeding on probing (BOP), probing depth (PD), clinical attachment level (CAL)].

Results: At 6 months, AAD group revealed significantly higher ($p < 0.05$; unpaired t-test) changes in mean BOP scores when compared with MDA-treated sites ($43.5 \pm 27.7\%$ *versus* $11.0 \pm 15.7\%$). Both groups exhibited comparable PD reductions (AAD: 0.6 ± 0.6 mm *versus* MDA: 0.5 ± 0.6 mm) and CAL gains (AAD: 0.4 ± 0.7 mm *versus* MDA: 0.5 ± 0.8 mm) ($p > 0.05$; unpaired t-test, respectively).

Conclusions: Within its limitations, the present study has indicated that (i) both treatment procedures resulted in comparable but limited CAL gains at 6 months, and (ii) OHI+AAD was associated with significantly higher BOP reductions than OHI+MDA.

Key words: air powder flow; air-abrasive device; amino acid glycine powder; non-surgical; peri-implantitis; plastic curettes

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The consensus report of the 6th European Workshop on Periodontology has confirmed that peri-implant diseases are infectious in nature (Lindhe & Meyle 2008). Peri-implant mucositis describes an inflammatory lesion that resides in the mucosa, while peri-implantitis also affects the supporting bone (Heitz-Mayfield 2008). The key parameter for the diagnosis of peri-implant mucositis is bleeding on gentle probing (BOP). In contrast, peri-implantitis is characterized by crestal bone level changes in conjunction with BOP and pus forma-

The Comparative Effect of Ultrasonic Scalers on Titanium Surfaces: An In Vitro Study

Shuichi Sato,*† Mamoru Kishida,‡ and Koichi Ito*†

Background: Professional maintenance is as important for patients with dental implants as it is for patients with natural teeth. However, no proper maintenance instruments have been available for implant patients. The purpose of this in vitro study was to compare the effects of a new ultrasonic scaler (VR), a conventional ultrasonic scaler (SP), and a plastic scaler (PS) on titanium surfaces.

Methods: To simulate subgingival conditions, the implant healing abutments were connected to acrylic resin blocks with artificial gingiva using silicon impression material. The abutments were painted with ink as an artificial form of debris. The ink was removed with the VR, SP, or PS scaler for 60 seconds under standardized conditions, and the removal rate was calculated. The roughness of the abutment surface was measured with a profilometer and observed by scanning electron microscopy (SEM).

Results: The removal rate using the VR and SP scalers was higher than that using the PS scaler. No significant differences in the surface roughness or SEM observations were found among the VR, SP, or PS scalers.

Conclusions: In this preliminary study, the new ultrasonic scaler and conventional ultrasonic scaler were shown to be useful for removing artificial debris and produced no significant damage to titanium surfaces compared to plastic scalers. We concluded that new and conventional ultrasonic scalers with a non-metal tip would be suitable for implant maintenance. *J Periodontol 2004;75:1269-1273.*

KEY WORDS

Comparison studies; scaling/instrumentation; titanium; ultrasonics/instrumentation.

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Plaque accumulation and formation of pockets have been reported to occur following placement of titanium implants.[1,2] Therefore, to achieve a successful outcome for titanium implants, it is necessary to perform professional maintenance and to ensure that home oral hygiene is adequate. Furthermore, the peri-implant area seems to be more susceptible than the periodontium to bacteria,[3] indicating that early plaque removal is essential in patients with dental implants.[4]

The main problem in removing plaque from implants relates to possibly damaging the implant surface. In particular, conventional sonic and ultrasonic scalers cause considerable changes to implant surfaces.[5-7] Thus, plastic curets, graphite or nylon-type instruments, rubber polishing cups, brushes with abrasive paste, or air-powder abrasive systems have been recommended.[5-20] On the other hand,conventional sonic and ultrasonic scalers are considered to be rapid and efficient cleaning tools with potential to reach areas not readily accessible by other instruments.

A recently developed ultrasonic scaler generates ultrasonic vibration at a frequency of 25 kHz that is converted to horizontal vibration by a resonating ring. As a result, the instrument tip moves only parallel to the surface and thus causes only minimal damage to the implant surface. However, the value of ultrasonic scalers in implant maintenance has not been clarified. Some studies have shown that non-metallic ultrasonic tips or modified ultrasonic tips may be useful for implant maintenance,[21-24] but there is little consensus as to which instruments are

Treatment of Titanium Dental Implants With Three Piezoelectric Ultrasonic Scalers: An In Vivo Study

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Background: Dental implants require regular maintenance. It is crucial that the instrument used for maintenance be able to remove plaque and calculus from the implant surface effectively and efficiently, while causing minimal damage to its circumference. Some ultrasonic scalers may be useful for implant maintenance; however, no clinical study has examined this. This study evaluated the treatment of titanium implants with three piezoelectric scalers in vivo.

Methods: Fourteen patients underwent implant treatment in which plaque and calculus were removed from the abutment surfaces with ultrasonic scalers. The abutments were treated with scalers with carbon (VS; N = 7), plastic (PS; N = 7), or metallic (ES; N = 7) tips. The abutment surface characteristics were examined after instrumentation using scanning electron microscopy. The amount of plaque remaining and roughness were estimated using a modification of the remaining plaque and calculus score and the modified roughness score, respectively. In addition, the abutment surfaces were imaged with a laser profilometer and a laser scanning electron microscope (SEM).

Results: The remaining plaque and calculus scores did not differ significantly among the VS, PS, and ES groups. VS and PS produced a significantly smoother abutment surface than ES. The laser SEM three-dimensional images also demonstrated that VS and PS produced smooth abutment surfaces, whereas ES resulted in damaged surfaces.

Conclusions: VS and PS produced clean, smooth abutment surfaces. Piezoelectric scalers with non-metal tips are suitable for use in dental implant maintenance. *J Periodontol 2007;78:1689-1694.*

KEY WORDS

Dental plaque; observation; titanium.

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Plaque and calculus that accumulate on the surface of a dental implant may damage the implant and lead to pocket formation around the implant.[1,2] Therefore, regular professional maintenance and preventative oral hygiene at home are crucial. Because implant circumference may be affected by the accumulation of periodontal pathogenic bacteria,[3] early plaque removal is essential for patients who have undergone dental implant surgery.[4] Unfortunately, plaque removal may damage the implant surface. Conventional sonic and ultrasonic scalers cause considerable changes to implant surfaces.[5-7] Therefore, the use of plastic curets, graphite or nylon-type instruments, rubber polishing cups, brushes with abrasive paste, and air-powder abrasive systems have been recommended.[5-20] A new ultrasonic scaler features a changed vibration direction and a tip with a novel composition and shape that seems to reduce the damage caused to implant and root surfaces.[21,22] Although ultrasonic scalers are effective in rapid plaque removal, they can damage implant surfaces.

The value of ultrasonic scalers in implant maintenance remains unclear. Previous reports suggested that nonmetallic ultrasonic tips or modified ultrasonic tips are effective in implant maintenance;[23,24] however, there is no consensus as to which instrument is the

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Effects of an Er : YAG laser and the Vector® ultrasonic system on the biocompatibility of titanium implants in cultures of human osteoblast-like cells

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Key words: cell adhesion, human osteoblast-like cells, lasers/therapeutic use, ultrasonic devices/therapeutic use, titanium surfaces

Abstract: The aim of the present study was to investigate the effects of an Er : YAG laser (ERL) and the Vector® ultrasonic system (VS) on the biocompatibility of titanium implants in cultures of human osteoblast-like cells (SAOS-2). One hundred and sixty-eight titanium discs with four different surfaces (sand-blasted and acid-etched, titanium plasma-sprayed, machine-polished, and hydroxyapatite-coated) were used to evaluate cell attachment. The samples were equally and randomly assigned to the following groups: (1) an ERL at an energy level of 100 mJ/pulse and 10 Hz using a special application tip, (2) the VS using carbon fibre tips, or (3) untreated control (C). The discs were placed in culture plates, covered with a solution of SAOS-2 cells, and incubated for 7 days. The specimens were then washed with phosphate buffer to remove cells not attached to the surface, and the adherent cells were stained with hematoxilin–eosin. Cells were counted using a reflected light microscope and the cell density per mm^2 was calculated. Additionally, cell morphology and surface alterations of the titanium discs after treatment were investigated using scanning electron microscopy (SEM). All titanium discs treated with ERL demonstrated nearly the same cell density per mm^2 as the untreated C surfaces. There was a significant decrease in the number of cells that attached to the implant surfaces treated with VS. The SEM examination showed no visible differences between lased and C titanium surfaces. All surfaces treated with VS showed conspicuous surface damage and debris of the used carbon fibres. The results of the present study indicate that (i) ERL does not damage titanium surfaces and subsequently does not influence the attachment rate of SAOS-2 cells, and (ii) VS, used with this type of carbon fibre tip, does not seem to be suitable for the instrumentation of titanium surfaces.

Today, oral rehabilitation by means of endosseus dental implants has gained importance in clinical practice. Various surface characteristics ranging from relatively smooth machined surfaces to more roughened surfaces (created by coatings, blasting by various substances, acid treatments, or by combinations of the treatments) are available [Cochran 1999]. Results from animal and *in vitro* experiments provide clear evidence that rough implant surfaces have increased bone-to-implant contact and require greater forces to break the bone–implant interface compared to smooth surfaces [Carlsson et al. 1988; Deporter et al. 1990].

Although the clinical results during the first decade are promising, about 10% of the osseointegrated implants are lost after loading [Adell et al. 1990]. Several factors have been implicated in the pathogenesis of implant failures. One of them is related to the presence of pathogens around the collar of the dental implants [Mombelli et al. 1988; Becker et al. 1990; Alcoforado et al.

Bacterial Adhesion on Smooth and Rough Titanium Surfaces After Treatment With Different Instruments

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Background: Newly formed biofilm after implant debridement may challenge the long-term stability of peri-implant therapy. This in vitro study aimed to assess the roughness and adherence of *Streptococcus sanguinis* after treatment of smooth and rough titanium surfaces with an erbium-doped: yttrium, aluminum, and garnet (Er:YAG) laser, metal and plastic curets, and an air-powder abrasive system.

Methods: Forty titanium disks with smooth-machined surfaces and 40 with sand-blasted and acid-etched surfaces were divided into the following treatment groups: Er:YAG laser; plastic curet; metal curet, and air-powder abrasive system. The surface roughness (roughness average [Ra]) before and after treatments was determined using a profilometer. *S. sanguinis* (American Type Culture Collection 10556) was grown on treated and untreated specimens, and the amounts of retained bacteria on the surfaces were measured by the culture method. Rough and smooth surfaces with and without a suspension of *S. sanguinis* were also analyzed using scanning electron microscopy (SEM).

Results: For smooth surfaces, the roughest surfaces were produced by metal curets (repeated-measures analysis of variance [ANOVA] and Tukey test; $P < 0.05$). The rough-surface profile was not altered by any of the treatments (repeated-measures ANOVA; $P > 0.05$). Rough surfaces treated with metal curets and air-powder abrasion showed the lowest level of bacterial adhesion (two-way ANOVA and Tukey test; $P < 0.05$). SEM analysis revealed distinct surface profiles produced by all devices.

Conclusions: Metal curets are not recommended for smooth titanium surface debridement due to severe texture alteration. Rough surfaces treated with a metal curet and the air-powder abrasive system were less susceptible to bacterial adhesion, probably due to texture modification and the presence of abrasive deposits. *J Periodontol 2009;80:1824-1832.*

KEY WORDS

Air-powder abrasive system; Er:YAG laser; metal curets; mucositis; peri-implantitis; plastic curets; SEM; scaling.

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Titanium dental implants have been considered excellent alternatives to conventional prostheses in the oral rehabilitation of partially and totally edentulous subjects. Therefore, various types of implant surfaces, ranging from smooth machined to rough surfaces, are currently present in human oral cavities.[1] Despite the efforts to improve osseointegration by the modification of implant surfaces, evidence has shown that bacterial infection inducing mucositis or peri-implantitis can jeopardize the long-term success of some implant rehabilitations.[2,3] Both peri-implant diseases are infectious disorders associated with pathogenic bacterial species commonly observed in periodontal diseases.[2,3] Therefore, similar to periodontal treatment, the removal of bacterial biofilm and calculus deposits around implants seems to be crucial in the prevention and treatment of peri-implant infections.[4-6]

Various procedures and instruments have been proposed to reduce the number of pathogenic species and, consequently, to improve or preserve periodontal health around titanium implants.[4,5] Besides the mechanical removal of biofilm by plastic curets, air-powder abrasive systems, and the application of chemical agents and local antimicrobials, lasers have been introduced as a potential alternative in reducing pathogens on implant surfaces.[4,6-9] Among lasers used in dentistry,

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Short-term clinical and microbiological evaluations of peri-implant diseases before and after mechanical anti-infective therapies

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doi: 10.1111/j.1600-0501.2008.01618.x

Key words: biofilm, DNA hybridization probes, mucositis, peri-implantitis, therapy

Abstract

Objectives: The aim of this study was to evaluate the clinical and microbiological effects of mechanical anti-infective therapies for mucositis and peri-implantitis.

Material and methods: Subjects with at least one dental implant were assigned to healthy ($n = 10$), mucositis ($n = 12$) or peri-implantitis ($n = 13$) groups. Implants with mucositis or peri-implantitis were decontaminated by means of teflon curettes and abrasive sodium carbonate air-powder, performed by an open flap for peri-implantitis and without surgery for mucositis. Visible plaque (PI), marginal bleeding (MB), bleeding on probing (BOP), suppuration (SUP), probing depth (PD) and relative clinical attachment level (rCAL) were assessed at baseline and at 3 months after therapies. At the same time points, submucosal plaque samples were collected from each implant and analyzed by Checkerboard DNA–DNA hybridization for 40 bacterial species.

Results: All clinical parameters improved at 3 months post-therapy in mucositis and peri-implantitis groups ($P < 0.05$). The mean reduction in rCAL ($\pm$ SD) was 1.4 $\pm$ 1.2 mm and 2.3 $\pm$ 1.6 mm, and it was 1.3 $\pm$ 1.2 mm and 3.1 $\pm$ 1.7 mm in PD ($\pm$ SD) for mucositis and peri-implantitis, respectively. Levels of *Treponema denticola*, *Tanerella forsythia* and *Parvimonas micra*, and of *Fusobacterium nucleatum ss nucleatum*, were significantly reduced after peri-implantitis therapy and after mucositis therapy, respectively ($P < 0.05$). In addition, counts of *Porphyromons gingivalis*, *Treponema socranskii* and the proportions of red complex were reduced in both groups at 3 months after treatments ($P < 0.05$).

Conclusion: Mechanical therapies alone were effective in treating mucositis and peri-implantitis over a period of 3 months. The open debridement procedure showed clinical and microbiological benefits on the treatment of peri-implantitis and could be safely used as a standard control group for future studies.

For well over two decades, osseointegrated titanium implants have become an important alternative to conventional prostheses in totally and partially edentulous patients (Albrektsson et al. 1986; Zarb & Schmitt 1990). However, with the increasing demand for dental implants, early and late complications have also increased. Late failures have been associated with microbiological and/or biomechanical challenges that can represent serious threats to the longevity of the implant (Esposito et al. 1998; Tonetti 1998; Berglundh et al. 2002). Extensive evidence has shown that bacterial infection plays the most important role in the late failures of dental implants (Esposito et al. 1998; Tonetti 1998; Berglundh et al. 2002). While mucositis is a reversible inflammatory reaction confined to the soft tissues around osseointegrated implants, peri-implantitis is a site-specific infection that results in soft tissue

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ORIGINAL ARTICLE

Nonsurgical treatment of peri-implantitis using an air-abrasive device or mechanical debridement and local application of chlorhexidine. Twelve-month follow-up of a prospective, randomized, controlled clinical study

Gordon John · Narja Sahm · Jürgen Becker · Frank Schwarz

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Abstract
Objectives The purpose of this prospective, parallel group-designed, randomized controlled clinical study was the evaluation of the effectiveness of an air-abrasive device (AAD) for nonsurgical treatment of peri-implantitis.
Material and methods Twenty five patients, showing at least one implant with initial to moderate peri-implantitis, underwent an oral hygiene programme and were randomly treated using either (1) AAD (amino acid glycine powder) or (2) mechanical debridement using carbon curettes and antiseptic therapy with chlorhexidine digluconate (mechanical debridement (MDA)). Clinical parameters were measured at baseline and 12 months after treatment (e.g. bleeding on probing (BOP), probing depth (PD), clinical attachment level (CAL)).
Results At 12 months, the AAD group revealed significantly higher ($p<0.05$; unpaired t test) decrease in mean BOP scores when compared with MDA-treated sites (41.2±29.5 vs. 16.6 ±33.4 %). Both groups exhibited comparable PD reductions (AAD=0.5±0.9 mm vs. MDA=0.4±0.9 mm) and CAL gains (AAD=0.6±1.3 mm vs. MDA=0.5±1.1 mm) ($p>0.05$; Mann-Whitney test, respectively).
Conclusions Within its limitations, the present study has indicated that both treatment procedures resulted in comparable but limited CAL gains at 12 months. Furthermore, it could be detected that AAD was associated with significantly higher BOP decrease than MDA.
Clinical relevance The present results have indicated that nonsurgical therapy of peri-implantitis using both AAD and MDA resulted in comparable PD reductions and CAL gains after 12 months of healing. The BOP reductions were significantly higher in the AAD in comparison to the MDA group. So, AAD may be more effective for nonsurgical therapy of peri-implantitis than MDA.

Keywords Peri-implantitis · Nonsurgical · Air-powder flow · Air-abrasive device · Amino acid glycine powder · Plastic curettes

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Introduction

Peri-implant infections depict an increasing focus in dental implantology [1]. The demographic change additionally enhances this issue [2]. A distinction is made between peri-implant mucositis and peri-implantitis. Whereas peri-implant mucositis is the term for reversible inflammation of the soft tissue surrounding the implants [3], peri-implantitis characterizes the nonreversible inflammation of the implant surrounding tissues and leads to a decrease of the bony basement of the implants [4]. The prevalence of peri-implant mucositis is about 80 % in the implant sites and in about 50 % in patients [1], while peri-implantitis occurs in up to 56 % in the implant sites and 43 % in patients [5]. Without any successful treatment, peri-implantitis can lead to implant loss [6–8]. The main factor for establishment of peri-implant infections is the formation and maturation of bacterial biofilm [7]. Directly after being inserted to the oral cavity, the implant surface is covered

Influence of Different Air-Abrasive Powders on Cell Viability at Biologically Contaminated Titanium Dental Implants Surfaces

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Abstract: Studies have indicated that oral biofilm formation at structured titanium surfaces interferes with cell adhesion and proliferation, and its removal by means of conventional treatment procedures may not be sufficient to render these surfaces biologically acceptable. Therefore, the aim of the study was to evaluate the influence of different air-abrasive powders on cell viability at biologically contaminated titanium dental implant surfaces. Intraoral splints were used to collect an *in vivo* biofilm on sandblasted and acid-etched titanium discs for 48 h. A single (1x) and repeated (2x) use of four different powders (amino acid glycine or sodium bicarbonate particles; range of mean particle size ($d_{v,50}$):20—75 μm) was applied at two distances (1 and 2 mm) and angles (30° and 90°) to the surfaces. Specimens (2x) were incubated with SaOs-2 cells for 7 days. Residual biofilm (RB) areas (%), and surface alterations (SEM) (1x and 2x), as well as SaOs-2 cell viability, expressed as mitochondrial cell activity (MA) (counts/second) (2x specimens), were assessed. Comparable mean RB areas were observed within and between groups after both 1x (RB: 0.0% ± 0.0% to 5.7% ± 5.7%) and 2x (RB: 0.0% ± 0.0%) treatments. All surface treatments did not lead to MA (2x) values comparable to the sterile control group. However, sodium bicarbonate particles resulted in significantly higher MA (2x) values than amino acid glycine powders of different sizes. This was associated with pronounced alterations of the surface morphology (2x). Within the limits of the present study, it was concluded that SaOs-2 cell viability at biologically contaminated titanium surfaces was mainly influenced by the particle type of the powder. © 2008 Wiley Periodicals, Inc. J Biomed Mater Res Part B: Appl Biomater 88B: 83–91, 2009

Keywords: cell–material interactions; dental/endosteal implant; surface modification

INTRODUCTION

Previous studies have pointed to a cause- and effect-relationship between microbial plaque colonization and the pathogenesis of peri-implant infections.[1,2] While peri-implant mucositis describes reversible inflammatory reactions in the mucosa adjacent to an dental implant, peri-implantitis is defined as a series of inflammatory reactions affecting the tissues around an osseointegrated dental implant in function, resulting in a loss of the supporting alveolar bone.[3] Indeed, a multicenter study, including 159 patients and 558 dental implants, revealed that during the second and third year as many as 2% of the remaining implants failed, and failure occurred more frequently in subjects with a high degree of plaque accumulation.[4] Since peri-implantitis was also classified as a disease process associated with micro-organisms known from chronic periodontitis,[5,6] it was assumed that the removal of bacterial plaque biofilms is also a prerequisite for treatment of peri-implant infections. According to a cause-related concept, several treatment procedures have been recommended for the management of inflammatory processes affecting the tissues around an osseointegrated dental implant in function. In particular, mechanical and ultrasonic debridement, the adjunctive use of chemical agents (i.e., irrigation with local disinfectants, local or systemic antibiotic therapy), or laser application have been reported to be clinically effective in controlling disease progression.[7–9] However, the amount of documented bone regeneration and re-osseointegration varied considerably. Most commonly, the re-establishment of osseointegration has even been questioned.[10] Several factors have been discussed to explain the lack of re-osseointegration at failing dental implants. First of all, removal of biological contamination from structured implant surfaces is difficult to achieve, since conventional treatment approaches, such as plastic curettes and sonic/ultrasonic scalers, have been proven to be insufficient for obtaining a complete removal and elimination of both plaque biofilms and bacteria on roughened implant surfaces.[11,12] Moreover, mechanical instrumenta-

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CLINICAL ORAL IMPLANTS RESEARCH

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Evaluation of the safety and efficiency of novel metallic ultrasonic scaler tip on titanium surfaces

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Key words: maintenance therapy, novel ultrasonic scaler tip, surface roughness implant failures

Abstract

Aim: To evaluate the safety and efficiency of novel ultrasonic scaler tips, conventional stainless-steel tips, and plastic tips on titanium surfaces.

Material and methods: Mechanical instrumentation was carried out using conventional ultrasonic scalers (EMS, Nyon, Switzerland) with novel metallic implant tip (BS), a plastic-headed tip (ES), a plastic tip (PS) and a conventional stainless-steel tip (CS) on 10 polished commercially pure titanium disks (Grade II) per group. Arithmetic mean roughness (R_a) and maximum height roughness (R_y) of titanium samples were measured and dissipated power of the scaler tip in the tip-surface junction was estimated to investigate the scaling efficiency. The instrumented surface morphology of samples was viewed with a scanning electron microscope (SEM) and surface profile of the each sample was investigated using contact mode with a commercial atomic force microscope (AFM).

Results: There were no significant differences in surface roughness (R_a and R_y) among BS, ES, and PS group. However, CS group showed significant higher surface roughness (R_a and R_y). The efficiency of CS tip is twice as much higher than that of BS tip, the efficiency of BS tip is 20 times higher than that of PS tip, and the efficiency of BS tip is 90 times higher than that of ES tip.

Conclusion: Novel metallic copper alloy ultrasonic scaler tips may minimally influence the titanium surface, similar to plastic tip. Therefore, they can be a suitable instrument for implant maintenance therapy.

Long-term clinical studies have revealed that dental implants are a successful and predictable treatment option for both fully and partially edentulous patients [Lindquist et al. 1996]. Recently, it seems that clinical concern has turned to the causes of implant failures due to biomechanical or bacterial factors [Mombelli 1997]. The pathogenic bacteria around implant-supported prostheses may lead to peri-implantitis, an inflammatory lesion involving both soft and hard tissues around the bone-implant interface. This area seems to be even more susceptible than the periodontium to bacteria [Ericsson et al. 1992], indicating that the maintenance therapy is indispensable after the installation of implant-supported prostheses.

Instruments for cleaning dental implants should be efficient, bring minimal damage to titanium surface, and have durability. Conventional sonic and ultrasonic scalers with metal tips have an advantage in that they can remove plaque and calculus effectively and efficiently, but induce considerable modifications to implant surfaces. A positive correlation between surface roughness and the rate of supragingival and subgingival plaque deposition has been reported [Gildenhuys & Stallard 1975; Shafagh 1986; Quirynen et al. 1990]. Therefore, the use of plastic curettes, graphite or nylon-type instruments, rubber polishing cups, brushes with abrasive paste, and air-powder abrasive systems have been recommended [Sato et al. 2004]. Although such various instruments have been tested, there is still little consensus as to which instrument is most appropriate for use on implant surfaces. Some authors showed scalers with teflon-coated, plastic, fiber, or carbon tips caused minimal damage to implant surfaces [Ruhling et al. 1994; Kawashima et al. 2007]. However, they did not consider mechanical properties of scaler tips, such as fracture resistance or wear resistance,

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CLINICAL ORAL IMPLANTS RESEARCH

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Titanium surface alterations following the use of different mechanical instruments: a systematic review

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Key words: implant surface, mechanical means, profilometry, SEM, surface alterations, systematic review

Abstract

Objective: To systematically collect and evaluate existing evidence on the effects of different mechanical instruments on the surface characteristics of smooth and rough titanium surfaces.

Materials and methods: PubMed-MEDLINE, Cochrane-CENTRAL and EMBASE databases were searched up to December 2010 to identify appropriate studies. The eligible studies were controlled studies investigating titanium surface alterations following treatment with different mechanical instruments.

Results: In total, 3275 unique papers were identified. A screening of the titles and abstracts resulted in 34 publications that met all of the eligibility criteria. Surface roughness was evaluated using scanning electron microscopy in most studies and using a profilometer in only 10 studies. The rough surfaces evaluated were titanium plasma sprayed and sandblasted and acid-etched surfaces only. Non-metal instruments were found to cause minimal or no damage to both smooth and rough titanium surfaces. Metal instruments were found to cause major damage to smooth surfaces. Burs seemed to be the instruments of choice, if smoothening of a rough surface was required.

Conclusion: Non-metal instruments and rubber cups seem to be the instruments of choice for the treatment of smooth surfaces. Similarly, for rough implant surfaces, non-metal instruments and air abrasives are the instruments of choice, if surface integrity needs to be maintained. Metal instruments and burs are recommended only in cases requiring the smoothening of the surface roughness. The clinical impact of these findings requires clarification.

The inflammatory lesions that develop in the tissues around implants are collectively recognized as peri-implant diseases. Peri-implant diseases include two entities: peri-implant mucositis and peri-implantitis (Zitzmann & Berglundh 2008). According to the consensus report of the 6th European Workshop on Periodontology, peri-implant mucositis is defined as an inflammatory reaction in the mucosa surrounding a functioning implant while peri-implantitis describes an inflammatory process that affects the soft tissues around an osseointegrated implant in function and results in the loss of supporting bone (Lindhe & Meyle 2008).

Peri-implant disease is the result of an imbalance between the bacterial load and host defense (Tonetti & Schmid 1994). Peri-implant diseases have been associated with predominantly Gram-negative anaerobic flora (Mombelli & Lang 1998). Bacterial colonization on oral implant surfaces starts immediately after contact with the oral environment and occurs rapidly (Fürst et al. 2007). Within weeks after the placement of implants in the oral cavity, a sub-gingival flora associated with periodontitis is established (van Winkelhoff et al. 2000; Quirynen et al. 2006). This colonization seems to be influenced by the surface roughness, surface-free energy and chemical composition (Quirynen et al. 1993; Rimondini et al. 1997). A surface roughness value (R_a) of ≈ 0.2 μm has been suggested as a threshold roughness value below which no further significant changes in the total amount of adhering bacteria can be observed due to the larger size of most bacteria (Quirynen et al. 1993; Bollen et al. 1996). Because of their physical characteristics (i.e., screw-shaped design together with the various degrees of surface modifications), implants and implant components seem to accumulate more plaque than natural teeth (Quirynen et al. 1993; Quirynen & Bollen 1995). Currently, various types of implant surfaces, ranging from smooth machined to rough surfaces, are used in different implant components (Esposito et al. 2007). It has been reported that even on relatively smooth implant surfaces (e.g., abutments), plaque accumulates faster when compared with natural teeth, with up to 25 times more bacteria

CLINICAL ORAL IMPLANTS RESEARCH

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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

The Effect of an Antiseptic Mouthrinse on Implant Maintenance: Plaque and Peri-Implant Gingival Tissues*

S.G. Ciancio, F. Lauciello, O. Shibly, M. Vitello, and M. Mather

THE PURPOSE OF THIS CONTROLLED DOUBLE-BLIND, parallel, randomized clinical study was to determine the effect of antiseptic mouthrinse on parameters important to dental implant maintenance. Plaque, peri-implant gingivitis, gingival bleeding, probing depth, and attachment level were assessed over a 3-month test period. Twenty healthy adult patients each of whom had at least two dental implants, a modified gingival index > 1.5, and a modified Quigley-Hein plaque index score > 1.7 were enrolled into the study. After a thorough oral prophylaxis, patients were randomly assigned to either the antiseptic mouthrinse or a 5% hydroalcohol placebo mouthrinse group and instructed to rinse twice daily for 30 seconds with 20 ml of their assigned mouthrinse as an adjunct to their usual oral hygiene procedures. The baseline examination included plaque index, gingival index, bleeding index, probing depth measurement, and attachment level measurements. The plaque and gingival indices were rescored at 1, 2, and 3 months. Probing depths, attachment levels, and bleeding index were determined again at 3 months only. At the end of 3 months, the antiseptic mouthrinse group had statistically significant reductions in plaque index, gingival index, and bleeding index compared to the placebo group. There were no significant differences between groups in probing depth or attachment level. The results of this clinical study indicate that twice daily use of an antiseptic mouthrinse may provide benefits in the maintenance of dental implants. *J Periodontol 1995;66:962–965.*

Key Words: Dental implants; gingival diseases/prevention and control; mouthrinses/therapeutic use; dental plaque index; bleeding index; gingival index; controlled clinical study.

The use of dental implants to replace missing teeth has become an important part of dental practice. It has been estimated that approximately 642,000 implants are placed in the United States annually.[1] Although techniques and materials have been developed which are capable of a high degree of clinical success, the ultimate long-term success of implants is dependent upon the efforts of both the patient and dentist in maintaining the health of the peri-implant tissues.

Listerine† is an oral antiseptic mouthrinse which in long-term clinical studies has produced plaque reductions between 14% and 34% and gingivitis reductions between 22% and 36%.[2–5] The product has been accepted by the Council on Scientific Affairs of the American Dental Association as an effective anti-plaque and anti-gingivitis chemotherapeutic agent when used adjunctively in oral hygiene regimens.[6]

The purpose of this controlled clinical study was to determine the effect of this antiseptic mouthrinse on plaque at the gingival/implant interface and on the health of the peri-implant tissues, when used as an adjunct to usual mechanical oral hygiene procedures.

MATERIALS AND METHODS

Subject Inclusion/Exclusion Criteria

Twenty adult male and female subjects between the ages of 35 to 65 who met the following inclusion/exclusion criteria and who had signed informed consent forms participated in this 3-month clinical study: good general health; at least two contralateral permucosal endosteal root form dental implants (osseointegrated titanium implants) and appropriate prosthodontic restorations successfully placed; availability for the 3-month study peri-

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Eficacia de las alternativas de tratamiento para la mucositis periimplantaria

Efficacy of treatment options for periimplant mucositis

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Ardila Medina CM, Guzmán Zuluaga IC. *Eficacia de las alternativas de tratamiento para la mucositis periimplantaria.* Av Periodon Implantol. 2014; 26, 3: 141-146.

RESUMEN

Numerosos estudios han demostrado que la infección bacteriana juega un papel muy importante en el fracaso de los implantes dentales. Un desequilibrio huésped parásito en la interfase implante tejidos blandos inducen una prolongada reacción inflamatoria que ocasiona daño en los tejidos periimplantarios afectando la estabilidad del implante. Durante los primeros estados de inflamación ocurre un considerable daño tisular que exige la intervención del clínico con el fin de evitar lesiones irreversibles. Como en las enfermedades periodontales, se han propuesto varios tipos de terapias para reducir el número de especies patogénicas y mejorar así los parámetros clínicos de la mucositis periimplantar (MPI). De esta manera, la terapia básica para el tratamiento de la MPI comprende raspado mecánico, enjuagues con antisépticos, aplicación de sustancias quimioterapéuticas, aplicación local de antibióticos, o la combinación de estas alternativas. Con la poca evidencia disponible, parece que la terapia mecánica es efectiva en el tratamiento de la MPI.

PALABRAS CLAVE: Inflamación, mucositis periimplantaria, implantes, terapia.

SUMMARY

Numerous studies have shown that bacterial infection plays the most important role in the late failures of dental implants. A host parasite imbalance, at the soft tissue-implant interface, inducing a prolonged inflammatory reaction, will result in periimplant tissue breakdown and possible implant failure. During the early stages of inflammation, tissue damage occurs that requires considerable intervention by the clinician to avoid irreversible damage. As in periodontal diseases, various therapies have been proposed to reduce the number of pathogenic species and improve the clinical parameters of peri-implant mucositis. In this way, the basic therapy for the treatment of MPI includes mechanical treatment, rinsing with antiseptics, application of chemotherapeutic substances, local application of antibiotics, or the combination of the above. With little evidence available, it appears that mechanical therapy alone is effective in the treatment of MPI.

KEY WORDS: Inflammation, periimplant mucositis, implants, therapy.

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CLINICAL ORAL IMPLANTS RESEARCH

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Comparison of two full-mouth approaches in the treatment of peri-implant mucositis: a pilot study

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Key words: bacterial infection, chlorhexidine, dental implants, disinfection, full mouth, mechanical debridement, peri-implantitis, peri-implant mucositis, real-time PCR

Abstract

Objectives: The aim of the present study was to test the hypothesis that an additional full-mouth disinfection results in a greater clinical and microbiological improvement compared with sole mechanical debridement within one session in patients with peri-implant mucositis and treated chronic periodontitis.

Material and methods: The study included 13 partially edentulous patients (mean age 51.5 years) with treated chronic periodontitis and 36 dental implants with mucositis (bleeding on probing and/or a gingival index ≥1 at least at one site at baseline, absence of peri-implant bone loss during the last 2 years before baseline). After randomized assignment to a test and a control group, patients received a one-stage full-mouth scaling with or without chlorhexidine. Clinical and microbiological examination was performed at baseline, after 1, 2, 4 and 8 months. Additional microbial samples were taken 24 h after treatment. Microbiological analysis was performed by real-time polymerase chain reaction.

Results: Both treatment modalities resulted in significant reductions of probing depth at implant sites after 8 months, with no significant group differences. The bacteria at implants and teeth could be reduced in every group 24 h after treatment; however, this reduction was not significant after 8 months.

Conclusions: Both treatment modalities led to an improvement of the clinical parameters and a temporary reduction of the microflora at implants with mucositis, but without significant inter-group differences after 8 months.

Despite numerous studies that have proved the long-term success of dental implants, there are hints of implant losses due to biological, iatrogenic, mechanical and functional complications (Esposito et al. 1998a, 1998b; Mengel et al. 2007a). Therefore, the risk factors and complications associated with implant loss are a primary topic of interest (Chuang et al. 2002; McDermott et al. 2003).

Regarding biological complications, several animal studies have indicated that plaque accumulation seems to be an important factor in the development of peri-implant disease (Berglundh et al. 1992; Schou et al. 1993). Plaque accumulation causes mucositis, which, according to the Consensus Statement of the 6th European Workshop of Periodontology, is defined as inflammation of the peri-implant soft tissue without any bone loss (Lindhe & Meyle 2008). Untreated mucositis can lead to peri-implantitis, an inflammatory process affecting the soft and hard tissues surrounding a dental implant in function resulting in loss of supporting bone. As with periodontitis the bacterial biofilm plays a major role in the etiology of

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CLINICAL ORAL IMPLANTS RESEARCH

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Effect of six different peri-implantitis disinfection methods on *in vivo* human oral biofilm

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Key words: antimicrobial agent, implant surface, oral bacteria, peri-implantitis

Abstract

Objective: The aim of this human *in vivo* pilot study was to evaluate the efficacy of six antimicrobial agents on the surface decontamination of an oral biofilm attached to titanium implants.

Design: For *in vivo* biofilm formation, we fixed titanium specimens to individual removable acrylic upper jaw splints (14 specimens in every splint), which were worn by four volunteers overnight for 12 h. The specimens were then treated with different antimicrobial agents for 1 min (Sodium hypochlorite, Hydrogen peroxide 3%, Chlorhexidingluconate 0.2%, Plax, Listerine, citric acid 40%). Afterwards, we quantified the total bacterial load and the viability of adhering bacteria by live or dead cell labelling in combination with fluorescence microscopy.

Results: The total bacterial load on the titanium surfaces was significantly higher after incubation in the control solution phosphate-buffered saline (PBS) than after disinfection in sodium hypochlorite, hydrogen peroxide, chlorhexidine, Plax, Listerine, and citric acid. Furthermore, a significantly lower ratio between dead and total adhering bacteria (bactericidal effect) was found after incubation in control PBS, Plax mouth rinse, and citric acid than after incubation in sodium hypochlorite, hydrogen peroxide, chlorhexidine, and Listerine.

Conclusions: All tested antiseptics seem to be able to reduce the total amount of microorganisms accumulating on titanium surfaces. Furthermore, sodium hypochlorite, hydrogen peroxide, chlorhexidine, and Listerine showed a significant bactericidal effect against adhering bacteria.

Nowadays, dental implants are one of the most frequently used treatment options in the replacement of missing teeth. Because of the increasing use of dental implants, dentists have to overcome implant failures more often, which may be furthered by loss of tissue resulting from local bacterial infections (peri-implantitis) (Roos-Jansaker et al. 2003; Socransky & Haffajee 2005; Pier-Francesco et al. 2006; Lindhe & Meyle 2008; Renvert et al. 2008). The oral microflora seems to be a defining factor for the success or the failure of a dental implant. As soon as an implant surface is exposed to the oral cavity, it becomes immediately covered by a protein layer – the salivary pellicle – and is colonized by oral microorganisms, forming a microbial biofilm (Mombelli 2002; Fürst et al. 2007; Elter et al. 2008; Kotsovilis et al. 2008; Salvi et al. 2008). Specific biofilms on dental implant surfaces are considered to play a key role in the pathogenesis of peri-implantitis (Scarano et al.

CLINICAL ORAL IMPLANTS RESEARCH

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The effect of chemotherapeutic agents on titanium-adherent biofilms

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Abstract

Objective: To assess the effectiveness of different chemotherapeutic agents on biofilm-contaminated titanium surfaces.

Material and methods: This study used a recently described biofilm model. In experiment 1, *Streptococcus mutans* biofilms grown on titanium discs were treated with (1) EDTA, (2) citric acid (CA), (3) cetylpyridium chloride, (4) Ardox-X, (5) hydrogen peroxide (H_2O_2), (6) chlorhexidine (CHX) and (7) water. In experiment 2, polymicrobial biofilms were treated with (1) CA, (2) Ardox-X, (3) H_2O_2, (4) Ardox-X followed by CA, (5) H_2O_2 followed by CA, (6) CHX and (7) water. Aliquots of the suspended biofilms were plated and incubated anaerobically to enable counts of the total remaining viable bacteria, which were expressed as CFUs. Following incubation, the amount of protein remaining in the treated *S. mutans* biofilms was quantified to assess the removal potency of each treatment agent.

Results: H_2O_2, Ardox-X and CA killed significantly more *S. mutans* compared with the other treatments. H_2O_2 and CA removed significantly more protein than water. CA and the combination treatments were significantly more effective against the polymicrobial biofilms than CHX, H_2O_2 and Ardox-X. The difference in the killing efficacy between CA alone and the combination treatments was not statistically significant.

Conclusion: Among the chemicals tested, CA demonstrated the greatest decontamination capacity with respect to both the killing and the removal of biofilm cells. This combination of effects is clinically desirable because it promotes biocompatibility and healing around a previously contaminated implant surface. These results should, however, be validated in *in vivo* studies.

In the last four decades, the development of osseointegrated titanium implants has led to great changes in the field of restorative dentistry. Consequently, the use of dental implants represents one of the most rapidly expanding areas of dentistry.

Peri-implant tissues, similar to periodontal tissues, are susceptible to bacterial infection. Bacterial colonization of implant surfaces occurs rapidly (van Winkelhoff et al. 2000; Quirynen et al. 2006; Fürst et al. 2007). *In vivo* studies have provided evidence that early colonization patterns differ between implant and tooth surfaces (Fürst et al. 2007). Nevertheless, it has been shown that the levels of colonization by various bacterial species in the teeth and implant abutments become equivalent 6 months after abutment connection (Leonhardt et al. 1993).

Plaque accumulation can induce inflammatory changes in the soft tissues surrounding oral implants (peri-implant mucositis), which may lead to the progressive destruction of the supporting bone (peri-implantitis) and, ultimately, to implant failure (Esposito et al. 2006). The inflammatory reaction of the peri-implant mucosa to early plaque formation is comparable to the reaction of the gingiva in both quantitative and qualitative aspects (Berglundh et al. 1991). In the presence of extended plaque accumulation, the peri-implant mucosa seems to be less capable than the gingiva of encapsulating the plaque-related lesion. As a result, tissue destruction is more pronounced around implants (Ericsson et al. 1992; Lindhe et al. 1992). Peri-implantitis has been found to affect anywhere from 12% (Fransson et al. 2005) to 43% (Roos-Jansåker et al. 2006) of dental implants. Peri-mucositis affects approximately 50% of implants (Zitzmann & Berglundh 2008).

The main differences in the microbial profiles of diseased compared with healthy implants are the higher levels of some known periodontal pathogens and the lower proportions of host-compatible bacteria (Shibli et al. 2008). To improve or preserve periodontal health around titanium implants, a reduction of the number of

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CLINICAL ORAL IMPLANTS RESEARCH

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Effect of glycine powder air-polishing as an adjunct in the treatment of peri-implant mucositis: a pilot clinical trial

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Key words: air-polishing, mechanical debridement, peri-implant mucositis

Abstract

Background: Glycine powder air-polishing (GPAP) has the potential to effectively erase biofilms and may improve the treatment efficacy of peri-implant mucositis. This pilot clinical trial evaluated the effect of GPAP as an adjunct in treating peri-implant mucositis.

Materials and methods: Twenty-four subjects having at least one implant with peri-implant mucositis were randomly assigned to test (12 subjects with 17 implants) and control (12 subjects with 16 implants) groups. Following baseline assessment, all subjects received oral hygiene instruction and non-surgical debridement. In the test group, the sites with probing depth (PD) $\geq$4 mm were additionally treated by GPAP for 5 sec. Clinical parameters were measured at 1-week, 1-month, and 3-month recall visits.

Results: At the 3-month visit, the mean reductions in PD at site level were 0.93 $\pm$ 0.93 mm and 0.91 $\pm$ 0.98 mm in the test and control groups, respectively ($P < 0.05$), and no significant difference existed between two groups. Mean bleeding score was also significantly reduced in both groups after the intervention. No complications or discomfort were reported during the study.

Conclusions: This pilot clinical trial suggests that non-surgical mechanical debridement may effectively control peri-implant mucositis, and adjunctive GPAP treatment seems to have a limited beneficial effect as compared with mechanical debridement alone. However, further clinical trials with a large sample size are needed to confirm this preliminary observation.

The cause–effect relationship between plaque and gingivitis was demonstrated during the 1960s in the experimental gingivitis study (Loe et al. 1965). Thirty years later, a similar study found that 3 weeks of accumulated plaque around implants could also lead to peri-implant mucositis (Pontoriero et al. 1994). Histological studies on soft tissue have shown that inflammatory infiltrations in the mucosa around implants and the gingiva around natural teeth share many features (Berglundh et al. 1992; Ericsson et al. 1992; Trejo et al. 2006). However, if plaque is present for a longer time such as 3 months, the inflammatory infiltration in the peri-implant mucosa would be almost three times greater than in the dentogingival unit (Ericsson et al. 1992; Heitz-Mayfield & Lang 2010). Studies on animal models have also shown bone loss induced by plaque, which are accumulated by ligature (Hurzeler et al. 1995; Marinello et al. 1995; Persson et al. 1996; Isidor 1997).

Due to lack of long-term investigation, the relationship between peri-implant mucositis and peri-implantitis remains obscure. However, according to some experts, peri-mucositis, which appears to be a sign of host response to bacterial burden, might be the precursor for peri-implantitis (Heitz-Mayfield et al. 2011; Lang et al. 2011). Therefore, early diagnosis and intervention are of great clinical importance in management of peri-implant infections. Nevertheless, few clinical studies have examined the procedure for treating peri-implant mucositis (Heitz-Mayfield & Lang 2004; Renvert et al. 2008; Maximo et al. 2009; Thone-Muhling et al. 2010; Heitz-Mayfield et al. 2011). Although clinical improvement can be gained through mechanical debridement, there is still quite a high proportion of sites with deep pocket and bleeding tendencies on probing (Ciancio et al. 1995; Strooker et al. 1998; Porras et al. 2002; Lindhe & Meyle 2008; Thone-Muhling et al.

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The Effect of Subgingival Ozone and/or Hydrogen Peroxide on the Development of Peri-implant Mucositis: A Double-Blind Randomized Controlled Trial

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Edward Lynch, BDentSci, MA, PhD[3]

Purpose: *This double-blind randomized controlled trial assessed the effect of subgingival ozone (O_3, gaseous ozone, HealOzone MK II, Kavo) and/or hydrogen peroxide (H_2O_2) on the development of peri-implant mucositis.* ***Materials and Methods:*** *Twenty subjects (mean age, 60 ± 7.7 years) with 80 implants (4 implants each) were recruited. First, a 2-week pretrial phase took place to achieve healthy gingiva. Subsequently, partial gum shields were constructed for the experimental area (around the 4 implants); subjects were asked to refrain from brushing in that area by wearing the gum shield. The following treatments were randomly applied (for 60 seconds) to implant sites on days 0, 7, and 14: (1) air (O_2) and saline (0.9% NaCl) (control group), (2) O_2 and H_2O_2 (3%), (3) O_3 and saline, and (4) O_3 and H_2O_2. Plaque, gingival, and bleeding indices were recorded on days 0, 7, 14, and 21.* ***Results:*** *Significant differences were seen among the treatments ($P < .01$) in plaque ($F = 16.68$), modified gingival ($F = 7.86$), and bleeding ($F = 18.42$) indices. O_3 + saline and O_3 + H_2O_2 produced optimum gingival health scores and were equally effective and the most effective in controlling bleeding (mean score = 0.05), while O_2 + saline was the least effective (mean score = 0.56).* ***Conclusion:*** *Ozone showed great potential for management of peri-implant mucositis.* Int J Oral Maxillofac Implants 2013;28:1483–1489. doi: 10.11607/jomi.3168

Key words: *dental implants, hydrogen peroxide, ozone, peri-implant mucositis*

Regardless of gingival health and subgingival microbiology, the inflammatory cytokines produced within peri-implant tissues may be different from those of the natural gingiva.[1] Further, not all implants remain healthy; for various reasons, some develop inflammation of the gingiva, which is known as peri-implant mucositis. The prevalence of this condition is about 80% in subjects and about 50% around implant sites[2,3] and poses a management problem for dental professionals. Without proper home maintenance or a dentist's intervention, peri-implant mucositis may progress to an inflamed gingiva with associated bone loss around the implant, ie, peri-implantitis, which is seen in 28% to 56% of subjects[3–5] and in 12% to 43% of implant sites.[3,5] This can affect the treatment outcome and, ultimately, lead to failure of the implant. The increasing popularity of implant treatment makes the reduction of peri-implant mucositis important.

A decrease in the prevalence and burden of peri-implant mucositis requires the application of effective interventions. Ozone (O_3), a powerful antimicrobial and oxidizing agent, has been shown to be safe and effective in managing caries lesions in teeth,[6–10] whereas hydrogen peroxide (H_2O_2) is effective for the whitening of teeth.[11] The use of O_3 and/or H_2O_2 to reduce plaque, swelling, and bleeding around previously clinically healthy gingiva surrounding implants has not been investigated in a randomized clinical trial. The present randomized clinical trial therefore used clinical indices (Plaque Index [PI],[12] Bleeding Index [BI],[13] and modified Gingival Index [mGI][14]) to quantify the experimentally induced peri-implant mucositis around implants and evaluate the effectiveness of gaseous O_3 and/or H_2O_2 for reduction of peri-implant mucositis. The null hypothesis was as follows: The subgingival application of O_3 or air with either saline or H_2O_2 does not reduce the development of experimental peri-implant mucositis, as quantified by PI, BI, and mGI scores.

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REVIEW ARTICLE

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Clinical efficacy of antibiotics in the treatment of peri-implantitis

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Objective: The aim of the present study was to review the pertinent literature with reference to the clinical efficacy of antibiotics in the treatment of peri-implantitis. **Methods:** To address the focused question 'Are locally and systemically delivered antibiotics useful in the treatment of peri-implantitis?' PubMed/Medline and Google-scholar databases were explored from 1992 until February 2013 using a combination of the following keywords: 'antibiotic,' 'dental implant,' 'inflammation,', 'peri-implantitis' and 'treatment'. Letters to the editor, case-reports and unpublished data were excluded. **Results:** Ten studies were included. In six studies, peri-implantitis was treated using a non-surgical approach (scaling and root planing), whereas in four studies, a surgical approach was adopted for treating peri-implantitis. In three studies systemic antibiotics were administered and in six studies locally delivered antibiotics were used for treatment. One study used the oral route for antibiotic delivery. In three studies, minocycline hydrochloride was locally delivered as an adjunctive therapy to non-surgical mechanical debridement of infected sites. Nine studies reported that traditional peri-implantitis treatment with adjunct antibiotic therapy reduces gingival bleeding, suppuration and peri-implant pocket depth. In one study, despite surgical debridement of infected sites and systemic antibiotic cover, nearly 40% of the implants failed to regain stability. There was no placebo or control group in eight out of the nine studies included. **Conclusion:** The significance of adjunctive antibiotic therapy in the treatment of peri-implantitis remains debatable.

Key words: *Antibiotic, dental implant, inflammation, peri-implantitis, treatment*

INTRODUCTION

It is well-known that dental implants can osseointegrate and remain functionally stable in healthy as well as medically compromised individuals[1–14]; however, the risk of complications occurring following implant placement cannot be disregarded[13,14]. Risk factors associated with peri-implant complications include inadequate primary stability at the time of implant placement, occlusal trauma, fractured components, pain, local and systemic infections, neuropathy and tobacco smoking[15–17]. Peri-implantitis (PI) is an inflammatory condition characterised by loss of supporting bone in the tissues surrounding the implant[18]. In general, the frequency of PI has been reported to be 5–8% for various implant systems[19]. Clinical signs of PI include gingival bleeding, suppuration, increased pocket depth (PD) and implant mobility; whereas alveolar bone loss can be observed on radiographs[18,20,21]. In addition, studies have also shown a similarity in bacterial flora associated with PI and periodontitis[8,22–24].

Various treatment regimes for PI have been proposed in the literature. These include plaque control regimens, mechanical debridement of the affected areas, irrigation with antiseptic agents [such as chlorhexidine (CHX), saline and 10% hydrogen per oxide], surgical flap access into infected peri-implant tissues and laser therapy[8,9,25,26].

As it is known that bacteria can transfer from periodontally involved teeth to an implant, and that the microbes associated with PI resemble those of

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Journal of Clinical Periodontology

Topical minocycline microspheres *versus* topical chlorhexidine gel as an adjunct to mechanical debridement of incipient peri-implant infections: a randomized clinical trial

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Renvert S, Lessem J, Dahlén G, Lindahl C, Svensson M. Topical minocycline microspheres versus *topical chlorhexidine gel as an adjunct to mechanical debridement of incipient peri-implant infections: a randomized clinical trial. J Clin Periodontol 2006; 33: 362–369. doi: 10.1111/j.1600-051X.2006.00919.x.*

Abstract

Aim: This randomized clinical trial presents a 12-month follow-up of the clinical and microbiological results after application of minocycline microspheres as an adjunct to mechanical treatment of incipient peri-implant infections compared with an adjunctive treatment using 1% chlorhexidine gel application.

Material and Methods: Thirty-two subjects with probing depth ⩾4 mm, combined with bleeding and/or exudate on probing and presence of putative pathogenic bacteria were given oral hygiene instructions and mechanical treatment of infected areas adjacent to implants. The subjects were then randomly assigned adjunctive subgingival antimicrobial treatment using either chlorhexidine gel or minocycline microspheres. Sixteen patients in the minocycline group and 14 in the chlorhexidine group completed the study. Follow-up examinations were carried out after 10 days, 1, 2, 3, 6, 9 and 12 months.

Results: The adjunctive use of minocycline microspheres resulted in improvements of probing depths and bleeding scores, whereas the adjunctive use of chlorhexidine only resulted in limited reduction of bleeding scores. For the deepest sites of the treated implants in the minocycline group, the mean probing depth was reduced from 5.0 to 4.4 mm at 12 months. This study could not show any significant difference in the levels of bacterial species or groups at any time point between the two antimicrobial agents tested. The present findings encourage further studies on adjunctive use of minocycline microspheres in the treatment of peri-implant lesions.

Conclusions: The use of a local antibiotic as an adjunct to mechanical treatment of incipient peri-implantitis lesions demonstrated improvements in probing depths that were sustained over 12 months.

Key words: antiseptics; arestin; chlorhexidine; local antibiotics; minocycline; peri-implantitis; peri-implant mucositis; treatment

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The concept that bacteria play a major role in the aetiology of peri-implant mucositis and peri-implantitis is well documented (Berglundh et al. 1992, Pontoriero et al. 1994, Augthun & Conrads 1997, Salcetti et al. 1997, Mombelli & Lang 1998, Quirynen et al. 2002). Mombelli (2002) reviewed the role of bacteria in causation of peri-implantitis and found support for the concept that the microflora present in the oral cavity before implant placement influence the

Mechanical and Repeated Antimicrobial Therapy Using a Local Drug Delivery System in the Treatment of Peri-Implantitis: A Randomized Clinical Trial

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Background: Peri-implantitis is an inflammatory process caused by microorganisms affecting the tissues around an osseointegrated implant in function, resulting in a loss of supporting bone. Limited data exist regarding the treatment of peri-implantitis. The aim of this study was to assess the clinical and microbiologic outcome of repeated local administration of minocycline microspheres, 1 mg, in cases of peri-implantitis.

Methods: Thirty-two subjects with at least one implant with a probing depth ≥4 mm combined with bleeding and/or exudate on probing and the presence of putative pathogenic bacteria were included in the study. At baseline, subjects were randomly assigned to receive local minocycline microspheres (17 subjects and 57 implants) or chlorhexidine gel (15 subjects and 38 implants) following debridement. Treatments were performed on three occasions: baseline and days 30 and 90. Follow-up examinations were conducted at 10 days and at 1, 3, 6, 9, and 12 months.

Results: The use of minocycline resulted in significant improvements in probing depths compared to chlorhexidine at days 30, 90, and 180 ($P = 0.5$, $P = 0.01$, and $P = 0.04$, respectively). For the deepest sites of the minocycline-treated implants, the mean probing depth reduction was 0.6 mm at 12 months. Regarding bleeding on probing, significant differences between groups, based on all four sites at the implants, were found at days 30, 90, 180, 270, and 360. Both treatments resulted in a marked reduction in the indicator bacteria.

Conclusions: The use of a repeated local antibiotic as an adjunct to the mechanical treatment of peri-implantitis lesions demonstrated improvements in probing depths that were significantly different from controls and were sustained for 6 months. The adjunctive use of minocycline microspheres is beneficial in the treatment of peri-implant lesions, but the treatment may have to be repeated. *J Periodontol 2008;79:836-844.*

KEY WORDS

Antiseptics; chlorhexidine; microbiology; minocycline; mucositis; treatment.

Peri-implantitis is defined as an inflammatory process affecting the tissues around an osseointegrated implant in function, resulting in a loss of supporting bone.[1] A few years ago, follow-up studies infrequently reported on the incidence of peri-implantitis, leading the profession to believe that this was a rare phenomenon in implant patients.[2] However, recent data indicate that peri-implantitis is a common clinical entity after 10 years of function.[3,4] Because implants have become a common clinical treatment alternative for lost teeth, the number of cases of peri-implantitis will most likely increase in the future.

The infectious etiology of peri-implantitis is evident.[5-9] Some reports[10,11] indicated a healing potential of peri-implant tissues following suppression of the peri-implant microbiota. Because mechanical cleansing around implants is hampered by threads and often a rough surface structure, the use of mechanical debridement alone might not be sufficient to suppress the microflora to a level associated with healing and healthy clinical situations. In a recent publication by Karring et al.,[12] a new ultrasonic device using a hydrodynamic flow technique‖ failed to show better

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Adjunctive local antibiotic therapy in the treatment of peri-implantitis

II: clinical and radiographic outcomes

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Key words: antibiotics, cumulative interceptive supportive therapy (CIST), inflammation, local drug delivery, oral implants, peri-implantitis

Abstract

Aim: To monitor over 12 months clinical and radiographic changes occurring after adjunctive local delivery of minocycline microspheres for the treatment of peri-implantitis.

Material and methods: In 25 partially edentulous subjects, 31 implants diagnosed with peri-implantitis were treated. Three weeks after oral hygiene instruction, mechanical debridement and local antiseptic cleansing using 0.2% chlorhexidine gel, baseline (Day 0) parameters were recorded. Minocycline microspheres (Arestin®) were locally delivered to each implant site with bone loss and a probing pocket depth (PPD) $\geq$ 5 mm. Rescue therapy with Arestin® was allowed at Days 180 and 270 at any site exhibiting an increase in PPD $\geq$ 2 mm from the previous visit. The following clinical parameters were recorded at four sites/implant at Day 0, 10, 30, 60, 90, 180, 270 and 360: PPD, clinical attachment level (CAL), bleeding on probing (BOP) and plaque index (PII).

Results: Six implants in six subjects were either rescued or exited because of persisting active peri-implantitis. Successful implants showed a statistically significant reduction in both PPD and percentage of sites with BOP between baseline and Day 360 ($P<0.05$). At mesial implant sites, the mean PPD reduction amounted to 1.6 mm (95% CI: 0.9–2.2 mm, $P<0.001$) and was accompanied by a statistically significant reduction of the BOP value ($P<0.001$). Binary regression analysis showed that the clinical parameters and smoking history could not discriminate between successfully treated and rescued or exited implants at any observation time point.

Conclusion: Non-surgical mechanical treatment of peri-implantitis lesions with adjunctive local delivery of microencapsulated minocycline led to positive effects on clinical parameters up to 12 months.

As introduced at the first European Workshop on Periodontology in Ittingen, Switzerland, peri-implant diseases were defined as a collective term for inflammatory processes in the tissues surrounding an osseointegrated implant (Albrektsson & Isidor 1994). Peri-implant mucositis was defined as a reversible inflammatory process in the soft tissues surrounding a functioning implant, whereas peri-implantitis is an inflammatory process characterized by additional loss of peri-implant bone. The formation of a subgingival biofilm has been shown in animal experiments and clinical studies to be the pivotal etiological factor for the initiation of peri-implant inflammation and subsequent loss of marginal bone (Lindhe et al. 1992; Lang et al. 1993; Schou et al. 1993a, 1993b).

While the incidence of peri-implantitis appears to be low, the increasing use of oral implants in reconstructive dentistry may

CLINICAL ORAL IMPLANTS RESEARCH

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Anti-infective therapy of peri-implantitis with adjunctive local drug delivery or photodynamic therapy: six-month outcomes of a prospective randomized clinical trial

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Key words: dental implants, laser, local antibiotics, local drug delivery, peri-implantitis, photodynamic therapy, surface decontamination

Abstract

Objective: To compare the adjunctive clinical effects in the non-surgical treatment of peri-implantitis with either local drug delivery (LDD) or photodynamic therapy (PDT).

Material and methods: Forty subjects with initial peri-implantitis, i.e. pocket probing depths (PPD) 4–6 mm with concomitant bleeding on probing (BoP) and marginal bone loss ranging from 0.5 to 2 mm between delivery of the reconstruction and pre-screening appointment were randomly assigned to two treatment groups. All implants underwent mechanical debridement with titanium curettes, followed by a glycine-based powder airpolishing. Implants in the test group (n = 20) received adjunctive PDT, whereas minocycline microspheres were locally delivered into the peri-implant pockets of control implants (n = 20). At sites with residual BoP, treatment was repeated after 3 and 6 months. The primary outcome variable was the change in the number of sites with BoP. Secondary outcome variables were changes in PPD, in clinical attachment level (CAL), and in mucosal recession (REC).

Results: After 3 months, implants of both groups yielded a statistically significant reduction ($P < 0.0001$) in the number of BoP-positive sites compared with baseline (LDD: from 4.41 ± 1.47 to 2.20 ± 1.28, PDT: from 4.03 ± 1.66 to 2.26 ± 1.28). After 6 months, complete resolution of mucosal inflammation was obtained in 15% of the implants in the control group and in 30% of the implants in the test group ($P = 0.16$). After 3 months, changes in PPD, REC, and modified Plaque Index (mPII) were statistically significantly different from baseline ($P < 0.05$). No statistically significant changes ($P > 0.05$) occurred between 3 and 6 months. CAL measurements did not yield statistically significant changes ($P > 0.05$) in both groups during the 6-month observation time. Between-group comparisons revealed no statistically significant differences ($P > 0.05$) at baseline, 3 and 6 months with the exception of the mPII after 6 months.

Conclusions: In cases of initial peri-implantitis, non-surgical mechanical debridement with adjunctive use of PDT is equally effective in the reduction of mucosal inflammation as with the adjunctive use of minocycline microspheres up to 6 months. Adjunctive PDT may represent an alternative treatment modality in the non-surgical management of initial peri-implantitis. Complete resolution of inflammation, however, was not routinely achieved with either of the adjunctive therapies.

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Peri-implantitis has been defined as an inflammatory process that affects the soft tissues surrounding an osseointegrated implant in function with concomitant loss of supporting marginal bone (Albrektsson & Isidor 1994). Peri-implant mucositis, in contrast, is a reversible inflammatory reaction of the mucosa adjacent to an implant without bone loss (Albrektsson & Isidor 1994; Salvi et al. 2012). Colonization of oral implant surfaces with bacterial biofilms occurs rapidly (van Winkelhoff et al. 2000; Quirynen et al. 2006; Fürst et al. 2007; Salvi et al. 2007). The biofilm development seems to play an important role in altering the biocompatibility of the implant surface and, thus enhancing peri-implant disease development (Mombelli & Lang 1998). The composition of bacterial

CLINICAL ORAL IMPLANTS RESEARCH

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Anti-infective therapy of peri-implantitis with adjunctive local drug delivery or photodynamic therapy: 12-month outcomes of a randomized controlled clinical trial

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Key words: clinical research, clinical trials, drug delivery, laser, microbiology, pharmacology, wound healing

Abstract

Objective: The objective of the study is to compare the clinical, microbiological and host-derived effects in the non-surgical treatment of initial peri-implantitis with either adjunctive local drug delivery (LDD) or adjunctive photodynamic therapy (PDT) after 12 months.

Materials and Methods: Forty subjects with initial peri-implantitis, that is, pocket probing depths (PPD) 4–6 mm with bleeding on probing (BoP) and radiographic bone loss ≤2 mm, were randomly assigned to two treatment groups. All implants were mechanically debrided with titanium curettes and with a glycine-based powder airpolishing system. Implants in the test group ($N = 20$) received adjunctive PDT, whereas minocycline microspheres were locally delivered into the peri-implant pockets of control implants ($N = 20$). At sites with residual BoP, treatment was repeated after 3, 6, 9 and 12 months. The primary outcome variable was the change in the number of peri-implant sites with BoP. Secondary outcome variables included changes in PPD, clinical attachment level (CAL), mucosal recession (REC) and in bacterial counts and crevicular fluid (CF) levels of host-derived biomarkers.

Results: After 12 months, the number of BoP-positive sites decreased statistically significantly ($P < 0.05$) from baseline in both groups (PDT: 4.03 ± 1.66–1.74 ± 1.37, LDD: 4.41 ± 1.47–1.55 ± 1.26). A statistically significant ($P < 0.05$) decrease in PPD from baseline was observed at PDT-treated sites up to 9 months (4.19 ± 0.55 mm to 3.89 ± 0.68 mm) and up to 12 months at LDD-treated sites (4.39 ± 0.77 mm to 3.83 ± 0.85 mm). Counts of *Porphyromonas gingivalis* and *Tannerella forsythia* decreased statistically significantly ($P < 0.05$) from baseline to 6 months in the PDT and to 12 months in the LDD group, respectively. CF levels of IL-1β decreased statistically significantly ($P < 0.05$) from baseline to 12 months in both groups. No statistically significant differences ($P > 0.05$) were observed between groups after 12 months with respect to clinical, microbiological and host-derived parameters.

Conclusions: Non-surgical mechanical debridement with adjunctive PDT was equally effective in the reduction of mucosal inflammation as with adjunctive delivery of minocycline microspheres up to 12 months. Adjunctive PDT may represent an alternative approach to LDD in the non-surgical treatment of initial peri-implantitis.

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Outcomes from long-term studies with a mean follow-up of at least 10 years indicated that the use of titanium dental implants represents a predictable treatment approach for the prosthetic rehabilitation of fully (Ueda et al. 2011; Frisch et al. 2012) and partially (Buser et al. 2012; Dierens et al. 2012) edentulous patients. Peri-implant inflammatory processes (e.g. bleeding and/or suppuration) associated with radiographic bone loss (i.e. peri-implantitis), however, have been shown to occur more frequently in periodontally susceptible patients (Hardt et al. 2002; Karoussis et al. 2003; De Boever et al. 2009; Matarasso et al. 2010; Roccuzzo et al. 2010, 2012) and tobacco smokers

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Sustained release of doxycycline for the treatment of peri-implantitis: randomised controlled trial

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KEYWORDS
Peri-implantitis;
Implant;
Local antimicrobial;
Atridox™

Summary

With the increased use of osseointegrated implants and with many implants functioning for a long time, the treatment of peri-implantitis has become important. Animal studies and clinical case reports have shown that the principle of guided bone regeneration can be applied to the surgical treatment of moderate to profound loss of bone around the implant, but we have found no published clinical studies. Patients and methods: Twenty-eight patients whose ages ranged from 25 to 78 years and who had a total of 48 peri-implant defects were examined at baseline (week 0) and after 18 weeks. This included the recording of bleeding on probing, pocket probing depths, and probing attachment levels at six sites for each tooth. For 2–18 weeks before week 0 all patients had been treated for peri-implantitis, including motivation, instruction in oral hygiene, and implant scaling with a hand plastic instrument. They were then randomly allocated to continue with this treatment or to have in addition mechanical debridement and local application of Atridox™ which slowly release doxycycline. Results: Patients treated with Atridox™ showed a significantly greater gain in mean (S.D.) probing attachment levels than those not treated with Atridox. Only subjects treated with Atridox had a significant gain in mean bleeding on probing ($P = 0.001$). Application of the biodegradable sustained release device after initial periodontal treatment resulted in a significant gain in mean probing attachment levels in the Atridox™ group and a significant reduction in pocket probing depths. There was also a significant difference in mean probing attachment levels (0.6 mm).

Introduction

Improved techniques of osseointegration in the past few decades have led to considerable im-

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Treatment of peri-implantitis by local delivery of tetracycline

Clinical, microbiological and radiological results

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Key words: Peri-implantitis, tetracycline, microbiology, infection

Abstract: The purpose of this study was to investigate the clinical, microbiological and radiological effects of peri-implantitis therapy by local delivery of tetracycline. In 25 partially edentulous patients, 30 implants with radiographic evidence of circumferential bone loss, and peri-implant probing depths ≥5 mm were treated with polymeric tetracycline HCl-containing fibers. Clinical and microbial parameters were recorded at baseline, and 1, 3, 6, and 12 months (M) after treatment. Standardized radiographs were obtained at baseline, M3, and one year after treatment. Two patients were discontinued from the study after 180 days because of persisting active peri-implantitis with pus formation. The remaining subjects showed a significant decrease of mean peri-implant probing depth from 6.0 to 4.1 mm (M1, $P<0.001$), which was maintained over 12 months. In comparison to baseline, the bleeding tendency was significantly reduced after one month, and thereafter ($P<0.001$). No significant recession of the mucosal margin was noted. The radiologically determined distance from the shoulder of the implant to the bottom of the bony defect decreased slightly, but not significantly, from 5.2 to 4.9 mm. At M1, M3 and M6, mean total anaerobic cultivable bacterial counts were significantly lower than at baseline ($P<0.001$). A significant decrease in frequency of detection was noted for *Prevotella intermedia/nigrescens*, *Fusobacterium* sp., *Bacteroides forsythus*, and *Campylobacter rectus* ($P<0.01$). *Actinobacillus actinomycetemcomitans*, *Porphyromonas gingivalis*, and *Eikenella corrodens* had very low baseline frequencies that could not be significantly suppressed further.
In conclusion, therapy of peri-implantitis by local delivery of tetracycline had a positive effect on clinical and microbiological parameters.

Several lines of evidence indicate that accumulation of bacteria on implant surfaces plays an important role in the etiology of peri-implantitis, an inflammatory condition affecting the tissues around osseointegrated implants, leading to loss of supporting bone (for review, see Mombelli 1999). Consequently, the suppression of these bacteria is indispensable to obtain healing. Elimination of bacterial deposits on implant surfaces is not always easy. The parts of implants intended to be in direct contact to the supporting bone often have a roughened surface or threads to improve resistance to mechanical load. These surfaces can become contaminated as a consequence of bone loss and pocket formation. To enhance the effect of debridement on such surfaces, the adjunctive use of chemical antimicrobial agents has been advocated. It has been possible to show that mechanical debridement of peri-implant pockets and systemic administration of ornidazole improved clinical conditions (Mombelli & Lang 1992). In dogs, local debridement, combined with systemic amoxi-

Evidencia microbiana de la periimplantitis, factores de riesgo coadyuvantes, diagnóstico y tratamiento según los protocolos científicos

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Franch F, Luengo F, Bascones A. *Evidencia microbiana de la periimplantitis, factores de riesgo coadyuvantes, diagnóstico y tratamiento según los protocolos científicos.* Av Periodon Implantol. 2004; 16, 3: 143-156.

RESUMEN

Se presenta un trabajo de revisión sobre periimplantitis, comenzando con el desarrollo de los conceptos básicos de la anatomía periimplantar y los criterios de osteointegración, se hace un estudio sobre la evidencia microbiológica de la patología periimplantaria y la patogenia de la misma, conjuntamente con los factores de riesgo que afectan al proceso inflamatorio y destructivo de los tejidos periimplantarios. Continua el trabajo exponiendo los parámetros clínicos que muestra la enfermedad, como desarrollar el diagnostico y que posibilidades terapéuticas y de mantenimiento basadas en los protocolos científicos se pueden aplicar.

PALABRAS CLAVE

Periimplantitis, Infección periimplantaria, Factores de riesgo, Tratamiento de la periimplantitis

Aceptado para publicación: Abril 2004

INTRODUCCIÓN

Con la irrupción de la implantología en la práctica de la odontoestomatología, la osteointegración, se ha convertido en un método para le rehabilitación de pacientes desdentados total o parcialmente.

Durante los últimos años, se ha demostrado con estudios, los resultados a largo plazo de la integración tisular y ósea de los implantes dentales (1; 3; 13; 29; 33; 47)

A pesar de los resultados satisfactorios, los tejidos que soportan los implantes osteointegrados son susceptibles a patologías que pueden llevar a la pérdida del implante (23; 40)

Diversos factores de riesgo aparecen detrás de dichas situaciones, con lo que debemos valorar, hábitos tabáquicos,(8) calidades óseas (32) factores sistémicos, riesgos ocasionados por trauma quirúrgico y contaminación bacteriana durante la inserción, o incluso una mala distribución de fuerzas que generen sobrecarga. Todos estos últimos tópicos, están relacionados con la perdida prematura del implante. En cambio, hay factores que se relacionan más, con la pérdida tardía de los implantes. En ellos, se ven involucrado el medioambiente de la cavidad oral y la capacidad del propio individuo para mantener un equilibrio con el mismo. Son parámetros similares a las lesiones periodontales asociadas a dientes y están íntimamente relacionadas con la carga microbiana de la placa bacteriana.

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Antimicrobial treatment of peri-implant infections

Mombelli A, Lang NP. Antimicrobial treatment of peri-implant infections. Clin Oral Impl Res 1992: 3: 162–168.

The purpose of this study was to investigate the possibility of antimicrobial treatment of peri-implant infections associated with a periodontitis-like subgingival microbiota. Nine partially or fully edentulous patients with titanium hollow cylinder implants were selected which showed loss of bone and probing depths ≥5 mm on one or several implants after at least 6 months following installation. They also yielded subgingival microbial samples with $\geq 10^6$ CFU/ml, including ≥20% gram-negative anaerobic bacteria. The treatment included mechanical cleaning, irrigation of all peri-implant pockets >3 mm with 0.5% chlorhexidine and systemic antimicrobial therapy (1000 mg ornidazole for 10 consecutive days). After therapy, bleeding scores decreased immediately and, over a one-year observation period, remained significantly lower than before treatment. A significant gradual reduction in mean probing depths was detected over this one-year period; only one case showed no improvement of local probing depth. Microbiological parameters indicated an instantaneous quantitative and qualitative change following treatment. Subsequently, several of these parameters tended to shift back towards pretreatment values. In the second half of the observation period, however, this tendency was reversed, and levels significantly different from baseline were eventually established. This study demonstrated that treatment aiming at reducing the subgingival bacterial mass and suppressing the anaerobic segment had a beneficial effect in patients suffering from peri-implantitis.

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Key words: peri-implantitis – microbiology – titanium – implant – osseointegration – ornidazole – chlorhexidine

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One of the possible problems of patients treated with oral osseointegrated implants is pocket formation and bone loss in the peri-implant area. If this condition progresses, it may eventually lead to the loss of the implant. We have previously shown that pockets around failing implants often contain spirochetes and high numbers of gram-negative anaerobic rods, including *Prevotella intermedia* (formerly called *Bacteroides intermedius*) and *Fusobacterium sp. (Mombelli et al. 1987). This finding* has been confirmed by other authors (Wahl & Schaal 1989, Sanz et al. 1990, Alcoforado et al. 1991). Gram-negative anaerobic rods are suspected pathogens in periodontitis and orofacial infections (Crawford 1984, Van Steenbergen et al. 1991). The question, therefore, arises of whether these bacteria are implicated in the development of peri-implant pathology, and whether clinical conditions can be improved by suppressing or eliminating these organisms from sites with peri-implant infections. Broad-spectrum antimicrobials, but also agents effective only against a limited segment of the microbiota have proven to be a valuable adjunct to mechanical treatment of recurrent periodontal disease (Goené et al. 1990; Gusberti et al. 1988; Kornman & Karl 1982; Lundström et al. 1984; Mombelli et al. 1989; Moskow & Tannenbaum 1991; Van Winkelhoff et al. 1989). This condition is comparable to progressive loss of support around osseointegrated implants inasmuch as mechanical interventions alone are insufficient in halting the disease process. Some implants are provided with threads or with rough surfaces to improve osseointegration. *These features render mechanical management* of peri-implant infections impractical. Once exposed to bacterial colonization, the coarse texture facilities growth and prevents removal of bacterial plaque by mechanical means.

Since imidazole compounds are mainly active against anaerobic bacteria, substances of this group, such as metronidazole or ornidazole, offer the possibility of selectively influencing the anaerobic microbiota of peri-implant infections. Ornidazole has emerged as a drug with similar antibacterial properties as metronidazole (Wüst 1977) with the advantage of increased half-life of elimination from plasma (14.4 h versus 8.4 h for metronidazole) (Schwartz & Jeunet 1976), allowing a simplifi-

CLINICAL ORAL IMPLANTS RESEARCH

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Antibiotic resistance in human peri-implantitis microbiota

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Key words: peri-implantitis, antibiotic resistance, submucosal microbiota, *in vitro*

Abstract

Objectives: Because antimicrobial therapy is often employed in the treatment of infectious dental implant complications, this study determined the occurrence of *in vitro* antibiotic resistance among putative peri-implantitis bacterial pathogens.

Methods: Submucosal biofilm specimens were cultured from 160 dental implants with peri-implantitis in 120 adults, with isolated putative pathogens identified to species level, and tested *in vitro* for susceptibility to 4 mg/l of doxycycline, 8 mg/l of amoxicillin, 16 mg/l of metronidazole, and 4 mg/l of clindamycin. Findings for amoxicillin and metronidazole were combined *post-hoc* to identify peri-implantitis species resistant to both antibiotics. Gram-negative enteric rods/pseudomonads were subjected to ciprofloxacin disk diffusion testing.

Results: One or more cultivable submucosal bacterial pathogens, most often *Prevotella intermedia/nigrescens* or *Streptococcus constellatus*, were resistant *in vitro* to clindamycin, amoxicillin, doxycycline, or metronidazole in 46.7%, 39.2%, 25%, and 21.7% of the peri-implantitis subjects, respectively. Only 6.7% subjects revealed submucosal test species resistant *in vitro* to both amoxicillin and metronidazole, which were either *S. constellatus* (one subject) or ciprofloxacin-susceptible strains of gram-negative enteric rods/pseudomonads (seven subjects). Overall, 71.7% of the 120 peri-implantitis subjects exhibited submucosal bacterial pathogens resistant *in vitro* to one or more of the tested antibiotics.

Conclusions: Peri-implantitis patients frequently yielded submucosal bacterial pathogens resistant *in vitro* to individual therapeutic concentrations of clindamycin, amoxicillin, doxycycline, or metronidazole, but only rarely to both amoxicillin and metronidazole. Due to the wide variation in observed drug resistance patterns, antibiotic susceptibility testing of cultivable submucosal bacterial pathogens may aid in the selection of antimicrobial therapy for peri-implantitis patients.

Peri-implantitis is a destructive biological complication affecting dental implants after successful intraoral placement and prosthetic restoration [Zitzmann & Berglundh 2008]. Peri-implantitis presents as an inflammatory lesion of peri-implant soft and hard tissues, characterized by increased peri-implant probing depths, bleeding on probing and/or suppuration, progressive peri-implant marginal bone loss, and ultimately, dental implant mobility and loss [Heitz-Mayfield 2008; van Winkelhoff et al. 2009]. Peri-implantitis is estimated to occur in 10.7–47.2% of dental implant patients after 10 years of post-treatment observation (de Waal et al. 2012). A multitude of risk factors have been associated with the onset and progression of peri-implantitis, including submucosal presence of various bacterial species, *Archaea*, yeasts, and herpesviruses (Faveri et al. 2011; Jankovic et al. 2011; Mombelli & Décaillet 2011]; inadequate oral hygiene [Heitz-Mayfield 2008; Serino & Ström 2009]; smoking [Heitz-Mayfield 2008]; excessive occlusal forces [Isidor 2006; Chambrone et al. 2010]; contamination, corrosion, and residual dental cement on submucosal implant surfaces [Mouhyi et al. 2009; Wilson 2009]; history of periodontitis on adjacent natural teeth [Safii et al. 2010]; poorly controlled diabetes mellitus [Heitz-Mayfield 2008]; and host carriage of IL-1RN gene polymorphisms [Laine et al. 2006].

Because the etiopathogenesis of peri-implantitis is not well delineated, it is not surprising that the most effective treatment for peri-implantitis has yet to be conclusively identified [Esposito et al. 2012]. However, studies and case reports in both animal models and humans have reported arrest of

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Case Report

Non-surgical treatment of peri-implantitis with the adjunctive use of an 810-nm diode laser

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Abstract:

An 810-nm diode laser was used to non-surgically treat a 7-mm pocket around an implant that had five threads of bone loss, BoP+, and exudate, and the patient was followed up for 5 years. Non-surgical treatment, home care reinforcement, clinical indices records, and radiographic examination were completed in two consecutive 1-h appointments within 24 h. The patient was monitored frequently for the first 3 months. Subsequently, maintenance debridement visits were scheduled at 3-month intervals. The patient had a decreased probing pocket depth and a negative BoP index compared to initial clinical data, and the results were stable after 1 year. After 5 years of follow-up visits, there appeared to be rebound of the bone level radiographically. Within the limits of this case report, conventional non-surgical periodontal therapy with the adjunctive use of an 810-nm diode laser may be a feasible alternative approach for the management of peri-implantitis. The 5-year clinical and radiographic outcomes indicated maintenance of the clinical improvement.

Key words:

Diode laser, inflammation, non-surgical periodontal treatment, peri-implantitis, periodontal maintenance

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INTRODUCTION

Peri-implantitis is inflammation of the peri-implant supporting tissue, which can lead to progressive loss of supporting bone, if untreated.[1]

A history of periodontitis, poor oral hygiene, and smoking are considered risk factors for peri-implant diseases.[2] It is of paramount importance to treat periodontitis of the residual dentition prior to implant placement. A higher implant failure rate and elevated number of sites with peri-implant bone loss were documented in periodontally compromised patients who did not adhere to comprehensive supportive periodontal therapy. Customized and correctly performed supportive periodontal therapy is essential to enhance the long-term outcome of implant therapy.[2]

The outcome of non-surgical periodontal treatment (NSPT) of peri-implantitis is unpredictable. Although minor beneficial effects of laser therapy on peri-implantitis have been shown, this method requires further evaluation.[2]

The diode laser is not an ablative instrument and can directly contact the implant surfaces without inducing melting, cracking, or crater formation.[3] The 810-nm diode laser, when used in accordance with appropriate parameters, does not damage titanium surfaces, which is useful when uncovering submerged implants,[4] and can be used to treat bacterial induced peri-implantitis.[4]

The use of laser treatment in periodontal therapy is an emerging therapeutic option, although little reliable evidence suggests that it can effectively treat peri-implantitis.[5]

CASE REPORT

A 45-year-old male presented with pain and swelling at a mandibular implant site (Nobel Biocare, SW). Clinical examination revealed a deep pocket [7-mm pocket depth (PD)] and bleeding on probing [Figure 1], with suppuration and gingival inflammatory edema at the implant site. The patient was in good general health, did not take any medications, and was an occasional smoker (4-5 cigarettes/day).

No occlusal trauma or parafunctional habits were detected.

A periapical radiograph demonstrated bone loss of five fixture threads on the most distal mandibular left implant, when compared to the original radiograph [Figure 2].

The patient was eventually scheduled for periodontal surgery to treat the inflammatory

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Effect of Nd:YAG, Ho:YAG, Er:YAG, CO_2, and GaAlAs Laser Irradiation on Surface Properties of Endosseous Dental Implants

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Heinz Duschner, Univ-Prof Dr rer nat, Dr med dent habil[3]/Bernd d'Hoedt, Univ-Prof Dr med dent[4]

Purpose: *To analyze potential surface alterations in endosseous dental implants induced by irradiation with common dental lasers.* ***Materials and Methods:*** *Sandblasted and acid-etched, plasma-sprayed, hydroxyapatite-coated, and smooth titanium discs were irradiated using Nd:YAG, Ho:YAG, Er:YAG, CO_2, and GaAlAs lasers at various power settings. The specimens were examined by scanning electron microscopy and energy dispersive spectroscopy.* ***Results:*** *In an energy-dependent manner, the pulsed YAG lasers induced partial melting, cracking, and crater formation on all 4 surfaces. Within the energy range applied, the CO_2 laser caused surface alterations on the hydroxyapatite and plasma coatings as well as in the acid-etched surface. GaAlAs laser irradiation did not damage any of the surfaces. Energy dispersive spectroscopy revealed an altered chemical compound of the surfaces with regard to titanium, oxygen, and silicon.* ***Discussion:*** *The clinical application of most common dental laser systems can induce implant surface alterations. Relevant factors are not only the laser system and power setting, but also the application system.* ***Conclusion:*** *The results of the study indicate that Nd:YAG and Ho:YAG lasers are not suitable for use in decontamination of implant surfaces, irrespective of the power output. With the Er:YAG and CO_2 laser, the power output must be limited so as to avoid surface damage. The GaAlAs laser seems to be safe as far as possible surface alterations are concerned.* (Int J Oral Maxillofac Implants 2002;17:202–211)

Key words: *energy dispersive spectroscopy, implant surface alteration, peri-implantitis, scanning electron microscopy*

In addition to undisturbed osseointegration and an adequate prosthetic design, implant maintenance is crucial for long-term prognosis. Bacterial inflammation and infection of the peri-implant tissue induce bone loss and jeopardize clinical success. Most titanium implants feature a rough surface to increase areas of implant-bone contact and anchorage force in alveolar bone.[1] Surface roughness, however, makes elimination of bacteria from implants difficult. Several treatment regimens have been proposed for cleaning and decontamination of implant surfaces. Plastic curettes are probably best for manual removal of peri-implant plaque.[2] Metal curettes, as well as the application of ultrasonic scalers, induce surface alteration in implants and are therefore contraindicated.[3] Bactericidal chemicals such as chlorhexidine digluconate or iodine solutions are useful adjuncts in the treatment of peri-implantitis. Sterilization and cleaning of implant surfaces by means of lasers has been suggested.[4,5] However, the bactericidal potential of some laser systems on roughened surfaces requires considerable scientific investigation. Results published to date are very promising.[6,7] Moreover, dental

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AAP-Commissioned Review

Lasers in Periodontics: A Review of the Literature

Charles M. Cobb*

Background: Despite the large number of publications, there is still controversy among clinicians regarding the application of dental lasers to the treatment of chronic periodontitis. The purpose of this review is to analyze the peer-reviewed research literature to determine the state of the science concerning the application of lasers to common oral soft tissue problems, root surface detoxification, and the treatment of chronic periodontitis.

Methods: A comprehensive computer-based search combined the following databases into one search: Medline, Current Contents, and the Cumulated Index of Nursing and Allied Health. This search also used key words. In addition, hand searches were done for several journals not cataloged in the databases, and the reference lists from published articles were checked. All articles were considered individually to eliminate non-peer-reviewed articles, those dealing with commercial laser technology, and those considered by the author to be purely opinion articles, leaving 278 possible articles.

Results: There is a considerable conflict in results for both laboratory studies and clinical trials, even when using the same laser wavelength. A meaningful comparison between various clinical studies or between laser and conventional therapy is difficult at best and likely impossible at the present. Reasons for this dilemma are several, such as different laser wavelengths; wide variations in laser parameters; insufficient reporting of parameters that, in turn, does not allow calculation of energy density; differences in experimental design, lack of proper controls, and differences in severity of disease and treatment protocols; and measurement of different clinical endpoints.

Conclusions: Based on this review of the literature, there is a great need to develop an evidence-based approach to the use of lasers for the treatment of chronic periodontitis. Simply put, there is insufficient evidence to suggest that any specific wavelength of laser is superior to the traditional modalities of therapy. Current evidence does suggest that use of the Nd:YAG or Er:YAG wavelengths for treatment of chronic periodontitis may be equivalent to scaling and root planing (SRP) with respect to reduction in probing depth and subgingival bacterial populations. However, if gain in clinical attachment level is considered the gold standard for non-surgical periodontal therapy, then the evidence supporting laser-mediated periodontal treatment over traditional therapy is minimal at best. Lastly, there is limited evidence suggesting that lasers used in an adjunctive capacity to SRP may provide some additional benefit. *J Periodontol 2006;77:545-564.*

KEY WORDS

Bacteria; calculus; chronic periodontitis; lasers; periodontics; root.

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Periodically, the Board of Trustees of the American Academy of Periodontology identifies the need for review of the literature on a specific topic and requests the Editor-in-Chief of the Journal of Periodontology *to commission such a review. The selected author is solely responsible for the content, and the manuscript is peer reviewed, like all other* Journal *articles. The Academy's Board of Trustees does not review or approve the manuscript prior to publication, and the content of the review should not be construed as Academy policy.*

Based on Albert Einstein's theory of spontaneous and stimulated emission of radiation, Maiman developed the first laser prototype in 1960.[1] Maiman's device used a crystal medium of ruby that emitted a coherent radiant light from the crystal when stimulated by energy. Thus, the ruby laser was created. Shortly thereafter, in 1961, Snitzer[2] published the prototype for the Nd:YAG laser. The first application of a laser to dental tissue was reported by Goldman et al.[3] and Stern and Sognnaes,[4] each article describing the effects of the ruby laser on enamel and dentin. However, the current relationship of

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ORIGINAL ARTICLE

Effect of 308-nm excimer laser light on peri-implantitis-associated bacteria—an in vitro investigation

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Abstract Dental implants are becoming increasingly important in prosthodontic rehabilitation. Bacterial infections, however, can induce bone loss and jeopardize clinical success. Recent literature has demonstrated that infrared CO_2 laser light is suitable for the decontamination of exposed implant surfaces. The aim of the present study was to investigate the influence of 308-nm excimer laser irradiation on peri-implantitis-associated bacteria in vitro. In this study, a XeCl excimer laser (308 nm) was used (Summit Technology, Boston, USA). Both aerobe (*Streptococcus mutans*, *S. sanguis*, *Actinomyces naeslundii*) and anaerobe microorganisms (*A. odontolyticus*, *Prevotella melaninogenica*) were tested. According to previous studies, a constant energy of 0.8 J/cm^2 and a constant frequency of 20 Hz were used for all irradiations. Colony-forming units after laser irradiation were counted. Excimer laser irradiation showed significant influence on the growth of all microorganisms. As compared to *S. mutans* and *S. sanguis*, *A. naeslundii* demonstrated higher sensitivity to laser irradiation. Anaerobe microorganisms, in contrast, demonstrated that a total of 200 pulses were sufficient to reduce the replication of these germs for more than 99.9%. Excimer laser irradiation (λ = 308 nm) can significantly reduce both aerobe and anaerobe microorganisms. Depending on the parameters chosen, 200 pulses are sufficient for sterilization. New studies are necessary to evaluate if this wavelength is more of value in the treatment of peri-implantitis than other wavelengths or conventional therapies.

Keywords Implant dentistry · Excimer laser · Peri-implantitis

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Introduction

Dental implants are becoming increasingly important in prosthodontic rehabilitation. Although osseointegration provides implant stability, the marginal soft tissue conditions adjacent to implants seem to be important for the long-term result. Bacterial infections, however, can induce bone loss and jeopardize clinical success. Several treatment options have been proposed for the decontamination of exposed implant surfaces including laser light. However, apparently, not all laser systems available in dentistry are of value in this regard.

Block et al. [1] reported that the potential to melt the surface and even to remove the surface layer from plasma-coated titanium implants exists for Nd:YAG laser irradiation. Moreover, Park et al. [2] described that unnecessary thermal injury to the peri-implant tissues and the supporting bone can occur when Nd:YAG laser light is used near endosseous implants. From these results, it was concluded that use of Nd:YAG lasers in peri-implant gingival surgery should be considered inherently "unsafe" for such procedures [3].

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Neodymium:yttrium aluminum garnet laser irradiation with low pulse energy: a potential tool for the treatment of peri-implant disease

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Key words: bacterial contamination, Nd:YAG laser, surface properties, titanium implant

Abstract: Bacterial contamination may seriously compromise successful implant osteointegration in the clinical practice of dental implantology. Several methods for eliminating bacteria from the infected implants have been proposed, but none of them have been shown to be an effective tool in the treatment of peri-implantitis. In the present study, we investigated the efficacy of pulsed neodymium:yttrium aluminum garnet laser irradiation (Nd:YAG) in achieving bacterial ablation while preserving the surface properties of titanium implants. For this purpose, suspensions of *Escherichia coli* or *Actinobacillus (Haemophilus) actinomycetemcomitans* were irradiated with different laser parameters, both streaked on titanium implants, and in broth medium. It was found, by light and atomic force microscopy, that Nd:YAG laser, when used with proper working parameters, was able to bring about a consistent microbial ablation of both aerobic and anaerobic species, without damaging the titanium surface.

A substantial body of evidence has shown that bacterial contamination of dental implants plays a central role in the development of peri-implant disease and failing implant (Rams & Link 1983; Ruona et al. 1991; Nouneh et al. 2001). Owing to their localization, dental implants are, in fact, exposed to a huge variety of aerobic and anaerobic microorganisms forming the bacterial oral flora. Therefore, several methods for decontaminating the implant surface, such as citric acid, air-powered abrasive treatments, mechanical cleaning with metal and plastic curettes or ultrasonic scalers (Fox et al. 1990; Rhulin et al. 1994), in combination with the concomitant effects of local and systemic antibiotics administration, have been proposed for the treatment of peri-implantitis (Dörthudak et al. 2001). However, none of these methods have turned out to be an effective method for eliminating bacteria from contaminated implant surfaces (Mouhyi et al. 1998, 2000) and, in particular, some of the recommended methods have been reported to modify and even damage the morphological properties of implant surfaces (Bergendal et al. 1990; Koka et al. 1992; Zablotsky et al. 1992). In the last decade, the excellent effects of the laser light in cleaning different implant surfaces have been widely reported (Kreisler et al. 2002). Despite its antimicrobic property, concerns have been raised against the use of laser treatment, especially in view of the high energy required for the bactericidal effect and the potential heat development. In fact, irradiation with the lasers commonly used in the dental practice, the neodymium:yttrium aluminum garnet (Nd:YAG) and carbon dioxide (CO_2) lasers, has been shown to bring about a notable increase in the implant temperature, and concomitantly a significant impairment in

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Anti-infective therapy with an Er:YAG laser: influence on peri-implant healing

Anton Sculean†, Frank Schwarz and Jürgen Becker

In addition to conventional treatment modalities (mechanical and chemical), the use of lasers has been increasingly proposed for the treatment of periodontal and peri-implant infections (i.e., cleaning and detoxification of implant surfaces). Preliminary results from basic studies have pointed to the high potential of the Erbium-doped: Yttrium, Aluminum and Garnet (Er:YAG) laser. Furthermore, preliminary clinical data indicate that treatment with this kind of laser may positively influence peri-implant healing. The aim of this research update is to evaluate, based on the currently available evidence, the use of an Er:YAG laser for the treatment of peri-implant infections and to indicate its potential as a new treatment modality.

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KEYWORDS:
dental implant, experimental and clinical trials, laser/therapeutic use, peri-implantitis, periodontitis

Pathogenesis: correlation between periodontal & peri-implant infections

The term periodontal disease in its strictest sense refers to both gingivitis and periodontitis [1]. Gingivitis is an inflammatory condition of the soft tissues surrounding the teeth and is a direct immune response to the dental microbial plaque building up on teeth. It is modified by several factors such as smoking, certain drugs and hormonal changes that occur in puberty and pregnancy [2]. Certain drug therapies such as nifedipine and cyclosporin can result in gingival overgrowth in approximately 30% of individuals taking these medications. Chronic gingivitis is commonly seen in individuals who refrain from oral hygiene procedures for between 10 and 20 days [3]. Periodontitis follows gingivitis and is also influenced by the individual's immune and inflammatory response. It is initiated by microbial plaque; however, it occurs in only a subset of the population. Periodontitis involves the destruction of the supporting structures of the teeth, including the periodontal ligament, bone and soft tissues, which in turn may cause tooth loss [1]. Similarly, the host response to biofilm formation on the implant includes a series of inflammatory reactions which initially occur in the soft tissue but which may subsequently progress and lead to loss of supporting bone. Peri-implant mucositis is a term used to describe reversible inflammatory reactions in the mucosa adjacent to an implant. Peri-implantitis is defined as an inflammatory process that affects the tissues around an osseointegrated implant in function and results in loss of supporting alveolar bone [4]. The prevalence of peri-implantitis in humans is difficult to estimate but may vary between 2 and 10% of all implants inserted [5,6]. Indeed, clinical studies have demonstrated that peri-implantitis may lead to implant failure and loss. Recent findings from a multicenter study including 159 patients and 558 implants revealed that during the second and third year, as many as 2% of the remaining implants failed, and failure occurred more frequently in subjects with a high degree of plaque accumulation [7]. The response of the gingiva and peri-implants mucosa to early and more long standing periods of plaque formation was analyzed both in experimental animal [8,9] and human studies [10]. During the course of the study, it was observed that similar amounts of plaque formed on the tooth and implant segments of the dog dentition. The composition

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Clinical evaluation of an Er:YAG laser for nonsurgical treatment of peri-implantitis: a pilot study

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Key words: chlorhexidine, clinical trial, dental implant, laser/therapeutic use, mechanical debridement, peri-implantitis

Abstract: The aim of this controlled, parallel design clinical study was to compare the effectiveness of an Er:YAG laser (ERL) to that of mechanical debridement using plastic curettes and antiseptic therapy for nonsurgical treatment of peri-implantitis. Twenty patients with moderate to advanced peri-implantitis lesions were randomly treated with either (1) an ERL using a cone-shaped glass fiber tip at an energy setting of 100 mJ/pulse and 10 pps (ERL), or (2) mechanical debridement using plastic curettes and antiseptic therapy with chlorhexidine digluconate (0.2%) (C). The following clinical parameters were measured at baseline, 3 and 6 months after treatment by one blinded and calibrated examiner: Plaque index (PI), bleeding on probing (BOP), probing depth (PD), gingival recession (GR) and clinical attachment level (CAL). At the baseline examination, there were no statistically significant differences in any of the investigated parameters. Mean value of BOP decreased in the ERL group from 83% at baseline to 31% after 6 months ($P<0.001$) and in the C group from 80% at baseline to 58% after 6 months ($P<0.001$). The difference between the two groups was statistically significant ($P<0.001$, respectively). The sites treated with ERL demonstrated a mean CAL change from 5.8 $\pm$ 1 mm at baseline to 5.1 $\pm$ 1.1 mm ($P<0.01$) after 6 months. The C sites demonstrated a mean CAL change from 6.2 $\pm$ 1.5 mm at baseline to 5.6 $\pm$ 1.6 mm ($P<0.001$) after 6 months. After 6 months, the difference between the two groups was statistically not significant ($P>0.05$). Within the limits of the present study, it was concluded that (i) at 6 months following treatment both therapies led to significant improvements of the investigated clinical parameters, and (ii) ERL resulted in a statistically significant higher reduction of BOP than C.

Microbial colonization has been implicated to be the main causative factor in the pathogenesis of implant failures (Mombelli et al. 1988; Becker et al. 1990; Alcoforado et al. 1991). The presence of bacteria on implant surfaces may lead to an inflammation of the peri-implant mucosa, and, if left untreated, the inflammation spreads apically and results in bone resorption, which has been named peri-implantitis (Albrektsson & Isidor 1994). Therefore, the removal of bacterial plaque is a crucial step in the therapy of peri-implant infections (Mombelli & Lang 1994). However, decontamination of rough implant surfaces is difficult to achieve. Both mechanical and chemical methods have been recommended in order to accomplish these goals (Parham et al. 1989; Fox et al. 1990; Mombelli & Lang 1992; Rühling et al. 1994; Ericsson et al. 1996; Schenk et al. 1997; Augthun et al. 1998). The results from recent *in vitro* studies have indicated that mechanical debridement of implant surfaces may be

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ORIGINAL ARTICLE

Nonsurgical treatment of moderate and advanced periimplantitis lesions: a controlled clinical study

Frank Schwarz · Katrin Bieling · Martin Bonsmann · Thilo Latz · Jürgen Becker

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Abstract The aim of this controlled, parallel design clinical study was to evaluate the effectiveness of an Er:YAG (erbium-doped:yttrium, aluminum, and garnet) laser for nonsurgical treatment of periimplantitis lesions. Twenty patients, each of whom displayed at least one implant with (a) moderate and (b) advanced periimplantitis (n=40 implants; IMZ, ITI, Spline Twist, ZL-Duraplant, Camlog), were randomly instrumented nonsurgically using either (1) an Er:YAG laser (100 mJ/pulse, 10 Hz) device (LAS) or (2) mechanical debridement using plastic curettes and antiseptic therapy with chlorhexidine digluconate (0.2%) (C). The following clinical parameters were measured at baseline, 3, 6, and 12 months after treatment: plaque index, bleeding on probing (BOP), probing depth, gingival recession, and clinical attachment level (CAL). Mean BOP improved significantly in both groups at 3, 6, and 12 months (a− lesions: P<0.001 and b− lesions: P<0.01, respectively). After 3 and 6 months, the mean reduction of BOP was significantly higher in the LAS group when compared to the C group (a− and b− lesions: P<0.01 and P<0.05, respectively). At 3 and 6 months, both groups revealed significant CAL gains at a− and b− lesions (P<0.01, respectively). In both groups, however, the mean CAL at a− and b− lesions was not significantly different from the respective baseline values at 12 months (P>0.05, respectively). Although treatment of periimplantitis lesions with LAS resulted in a significantly higher BOP reduction than C, its effectiveness seemed to be limited to a period of 6 months, particularly at b− lesions.

Keywords Dental implant · Periimplantitis · Nonsurgical treatment · Laser/therapeutic use · Clinical trial

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Introduction

Today, the term periimplant disease is collectively used to describe biological complications in implant dentistry, including periimplant mucositis and periimplantitis. While periimplant mucositis includes reversible inflammatory reactions located solely in the mucosa adjacent to an implant, periimplantitis was defined as an inflammatory process that affects all tissues around an osseointegrated implant in function resulting in a loss of the supporting alveolar bone [1]. Because microbial colonization plays a major etiological role [6, 32], it was assumed that the removal of bacterial plaque biofilms from the implant surface is a prerequisite for the therapy of periimplant infections [29, 42]. In recent years, several maintenance regimens and treatment strategies (i.e., mechanical, chemical) have been proposed for the treatment of periimplant infections [14, 28, 35]. Mechanical debridement is usually performed using specific instruments made out of materials less harder than titanium (i.e., plastic curettes, polishing with rubber cups) to avoid a roughening of the metallic surface which in turn may favor bacterial colonization [3, 13, 25, 34]. Because mechanical methods alone have been proven to be insufficient in the elimination of bacteria on roughened implant surfaces, the adjunctive use of chemical agents

Bactericidal Effect of the Er:YAG Laser on Dental Implant Surfaces: An In Vitro Study

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Background: The aim of the in vitro study was to examine the bactericidal effect of an Er:YAG laser on common dental implant surfaces.

Methods: Seventy-two titanium platelets with 3 different surfaces—sandblasted and acid-etched (SA), titanium plasma-sprayed (TPS), and hydroxyapatite-coated (HA)—were incubated with a suspension of *Streptococcus sanguinis* (ATCC 10556). Irradiation at pulse energies of 60 and 120 mJ and a frequency of 10 pps was performed on a computer-controlled XY translation stage. After laser treatment the specimens were sonicated and the bacterial growth examined by counting colony forming units on blood agar plates. Temperature elevations during irradiation were investigated using K-type thermocouples. Laser treated implant surfaces were analyzed by means of electron microscopy.

Results: Compared to non-irradiated specimens, mean bacterial reductions of 99.51% (SA), 98.39% (HA), and 99.6% (TPS) at a pulse energy of 60 mJ and 99.92% (SA), 99.85% (HA), and 99.94% (TPS) at 120 mJ were calculated. At these laser parameters, no excessive temperature elevations or morphological implant surface alterations were detected.

Conclusions: Even at low energy densities, the Er:YAG laser has a high bactericidal potential on common implant surfaces. Clinical studies are justified to evaluate the applicability and efficacy of the Er:YAG laser in the treatment of peri-implantitis. *J Periodontol 2002;73:1292-1298.*

KEY WORDS

Lasers/therapeutic use; dental implants/microbiology; peri-implant diseases/prevention and control.

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Peri-implant infection results in inflammation of the surrounding soft tissues and can induce a breakdown of the implant-supporting bone (Figs. 1 and 2). Bacterial adherence to implant surfaces is a complex process not yet fully understood.[1,2] Several physical and biological factors seem to influence the adhesion process. Surface roughness plays a major role in the colonization process, sheltering the microorganisms from removal by salivary flow and oral hygiene procedures.[3-5] The surface-free energy of the bacterium, the ionic strength of the surrounding liquid medium, and the distance of the bacterium from the surface affect non-specific electrostatic interaction between the cells and the colonized substratum.[4,6,7] Further studies indicate that different strains have different affinities to implant surfaces and that the type of organism, concentration, and growth phase together with surface characteristics influence the colonization process.[8-13] Compared to biofilms on other biomaterials, such as indwelling catheters and contact lenses, the communities of organisms on implant surfaces are very difficult to eradicate. Several treatment regimens have been proposed for cleaning and decontamination of implant surfaces. Plastic curets are probably best for manual removal of peri-implant plaque,[14] as metal curets and the application of ultrasonic scalers induce surface alteration in implants and are, therefore, contraindicated.[15] Bactericidal chemicals such as chlorhexidine digluconate or iodine as well as local and systemic administration of antibiotics are a

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Journal of Clinical Periodontology

Treatment of peri-implantitis using an Er:YAG laser or an air-abrasive device: a randomized clinical trial

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Renvert S, Lindahl C, Roos Jansåker A-M, Persson GR. Treatment of peri-implantitis using Er:YAG laser or an air-abrasive device: a randomized clinical trial. J Clin Periodontol 2011; 38: 65–73. doi: 10.1111/j.1600-051X.2010.01646.x

Abstract

Background: Non-surgical peri-implantitis therapies appear to be ineffective. Limited data suggest that ER:YAG laser therapy improves clinical conditions. The present study aimed at comparing the treatment effects between air-abrasive (AM) and Er:YAG laser (LM) mono-therapy in cases with severe peri-implantitis.

Materials and methods: Twenty-one subjects in each group were randomly assigned to one time intervention by an air-abrasive device or an Er:YAG laser. Clinical data were collected before treatment and at 6 months. Data analysis was performed using repeat univariate analysis of variance controlling for subject factors.

Results: No baseline subject characteristic differences were found. Bleeding on probing and suppuration decreased in both the groups ($p<0.001$). The mean probing depth (PPD) reductions in the AM and LM groups were 0.9 mm (SD 0.8) and 0.8 mm (SD $\pm$ 0.5), with mean bone-level changes (loss) of -0.1 mm (SD $\pm$ 0.8) and -0.3 mm (SD $\pm$ 0.9), respectively (NS). A positive treatment outcome, PPD reduction ≥ 0.5 mm and gain or no loss of bone were found in 47% and 44% in the AM and LM groups, respectively.

Conclusions: The clinical treatment results were limited and similar between the two methods compared with those in cases with severe peri-implantitis.

Key words: air-abrasive; bone loss; intervention; laser; non-surgical; peri-implantitis

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Over the last decades, dental implants have become a commonly used treatment alternative to other dental procedures. The prognosis of implant therapy in dentistry is perceived to be very good. The survival rates of dental implants after 10 years in function are in the range of 95% (Roos-Jansåker et al. 2006a). Nevertheless, infections adjacent to implants occur. The term peri-implant mucositis was proposed for reversible inflammation of the soft tissues surrounding implants, and if such an inflammation is combined with loss of bone, it is referred to as peri-implantitis (Albrektsson & Isidor 1994, Lindhe & Meyle 2008). Peri-implantitis, if not successfully treated, may lead to complete disintegration and implant loss (Esposito et al. 1999, Quirynen et al. 2002, Leonhardt et al. 2003). Data suggest that the prevalence of peri-implantitis is in the range of 16–25% (Fransson et al. 2005, Roos-Jansaker et al. 2006b, Koldsland et al. 2010). With an increasing population with dental implants, the prevalence of implant-related infections would most likely increase and cause major challenges to therapy.

The primary aetiology of implant mucositis and peri-implantitis is considered to be bacterial infections. After installation in the oral cavity, bacterial colonization occurs rapidly on oral implant surfaces (Quirynen et al. 2006, Fürst et al. 2007, Salvi et al. 2008), and the development of a tightly fixed layer of plaque binds to the implant surface as a biofilm (Lamont & Jenkinson 2000).

The goal in non-surgical therapy of peri-implant mucositis and peri-implantitis is to eliminate or significantly reduce the amounts of oral pathogens in the pockets around implants to a level

Conflict of interest and sources of funding statement

None of the authors have a conflict of interest. All authors met the authorship requirements listed by the ICJME guidelines.

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Microbiologic Results After Non-Surgical Erbium-Doped:Yttrium, Aluminum, and Garnet Laser or Air-Abrasive Treatment of Peri-Implantitis: A Randomized Clinical Trial

G. Rutger Persson,*†‡§ Ann-Marie Roos-Jansåker,‖ Christel Lindahl,*‖ and Stefan Renvert*‖¶#

Background: The purpose of this study is to assess clinical and microbiologic effects of the non-surgical treatment of peri-implantitis lesions using either an erbium-doped:yttrium, aluminum, and garnet (Er:YAG) laser or an air-abrasive subgingival polishing method.

Methods: In a 6-month clinical trial, 42 patients with peri-implantitis were treated at one time with an Er:YAG laser or an air-abrasive device. Routine clinical methods were used to monitor clinical conditions. Baseline and 6-month intraoral radiographs were assessed with a software program. The checkerboard DNA–DNA hybridization method was used to assess 74 bacterial species from the site with the deepest probing depth (PD) at the implant. Non-parametric tests were applied to microbiology data.

Results: PD reductions (mean ± SD) were 0.9 ± 0.8 mm and 0.8 ± 0.5 mm in the laser and air-abrasive groups, respectively (not significant). No baseline differences in bacterial counts between groups were found. In the air-abrasive group, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *Staphylococcus anaerobius* were found at lower counts at 1 month after therapy ($P < 0.001$) and with lower counts in the laser group for *Fusobacterium nucleatum naviforme* ($P = 0.002$), and *Fusobacterium nucleatum nucleatum* ($P = 0.002$). Both treatments failed to reduce bacterial counts at 6 months. *Porphyromonas gingivalis* counts were higher in cases with progressive peri-implantitis ($P < 0.001$).

Conclusions: At 1 month, *P. aeruginosa*, *S. aureus*, and *S. anaerobius* were reduced in the air-abrasive group, and *Fusobacterium* spp. were reduced in the laser group. Six-month data demonstrated that both methods failed to reduce bacterial counts. Clinical improvements were limited. *J Periodontol 2011;82:1267-1278.*

KEY WORDS

Clinical trial; infection control; laser; microbiology.

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The infectious etiology of peri-implantitis is well established.[1-6] Data suggest that the prevalence of peri-implantitis is in the range of 16% to 25%.[7-9] If not successfully treated, peri-implantitis may lead to a complete disintegration and implant loss.[10-12] The current principles for the treatment of peri-implantitis were primarily derived from principles established for the therapy of periodontitis.[13] However, recent studies[4,5,14-17] that evaluated non-surgical intervention using traditional methods of subgingival mechanical debridement did not demonstrate significant clinical improvements or significant microbiologic changes. Thus, other effective methods for the treatment of peri-implantitis by managing the infection must be established.

Data from an in vitro study[18] suggested that, at low-energy densities, the erbium-doped:yttrium, aluminum, and garnet (Er:YAG) laser had a high bactericidal potential on common implant surfaces without causing morphologic changes of the implant surface or inducing excessive heat. Favorable formation of new bone was observed from a histologic analysis[19] in animal experimental peri-implantitis studies demonstrating that a laser-treated implant surface

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Elimination of bacteria on different implant surfaces through photosensitization and soft laser

An *in vitro* study

Haas R, Dörtbudak O, Mensdorff-Pouilly N, Mailath G. Elimination of bacteria on different implant surfaces through photosensitization and soft laser. An *in vitro* study.
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Microbiologic examinations of implants have shown that certain microorganisms described as periodontal pathogens may have an influence on the development and the progression of peri-implant disease. This experimental study aimed to examine the bactericidal effect of irradiation with a soft laser on bacteria associated with peri-implantitis following exposure to a photosensitizing substance. Platelets made of commercially pure titanium, either with a machined surface or with a hydroxyapatite or plasma-flame-sprayed surface or with a corundum-blasted and etched surface, were incubated with a pure suspension of *Actinobacillus actinomycetemcomitans* or *Porphyromonas gingivalis* or *Prevotella intermedia*. The surfaces were then treated with a toluidine blue solution and irradiated with a diode soft laser with a wave length of 905 nm for 1 min. None of the smears obtained from the thus treated surfaces showed bacterial growth, whereas the smears obtained from surfaces that had been subjected to only one type of treatment showed unchanged growth of every target organism tested ($P<0.0006$). Electron microscopic inspection of the thus treated platelets revealed that combined dye/laser treatment resulted in the destruction of bacterial cells. The present *in vitro* results indicate that lethal photosensitization may be of use for treatment of peri-implantitis.

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Key words: lethal photosensitization – peri-implantitis – periodontal pathogens – soft laser

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Healthy peri-implant soft and hard tissues are crucial to the long lasting functioning of a dental restoration supported by implants. Because of their location in the oral cavity, dental implants are inevitably exposed to oral bacterial flora (Nakagawa et al. 1996).

Bacterial adherence and colonization are considered key factors in the pathogenesis of biomaterial-centered infections (Gristina 1987). It has been shown that different implant materials may facilitate selective adherence during early plaque formation (Ruona et al. 1991) and surface characteristics of implants appeared to influence oral plaque attachment *in vitro* (Wu-Yuan et al. 1995). Surface roughness turned out to be more important than surface free energy of the material for adherence of oral bacteria to different implant materials (Nakazato et al. 1989; Wu-Yuan et al. 1995).

Microbiologic findings regarding the microflora of failing implants indicate that bacteria implicated as pathogens in periodontal disease may play a role in the development of peri-implant disease. *Staphylococci spp., Capnocytophages* and Spirochetes (Rams et al. 1983; Mombelli et al. 1987, 1988), gram negative anaerobic rods (Sanz et al. 1990), *Fusobacteria spp.* (Mombelli et al. 1987, 1995), *Porphyromonas gingivalis, Prevotella intermedia* (Mombelli et al. 1987; Becker et al. 1990; Mombelli et al. 1995; Sbordone et al. 1995) and *Actinobacillus actinomycetemcomitans* (Becker et al. 1990; Alcoforado et al. 1991) could be cultured in increased proportions from failing implants, irrespective of whether there had been a bacterial or a biomechanical reason for peri-implant disease. Treatment of failing implants should

Nonsurgical antimicrobial photodynamic therapy in moderate vs severe peri-implant defects: A clinical pilot study

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Objective: Recent review articles have shown that open debridement is more effective in the treatment of peri-implantitis than closed therapy. However, surgery may result in marginal recession and compromise esthetics. The purpose of this study was to assess the efficacy of nonsurgical antimicrobial photodynamic therapy (aPDT) in moderate vs severe defects. **Method and Materials:** The study encompassed 16 patients with a total of 18 ailing implants. Ten of these implants showed moderate bone loss (< 5 mm; Group 1) and eight implants severe defects (5 through 8 mm; Group 2). All implants received aPDT without surgical intervention. At baseline and 2 weeks, 3 months, and 6 months after therapy, peri-implant health was assessed including sulcus bleeding index (SBI), probing depth (PD), distance from implant shoulder to marginal mucosa (DIM), and clinical attachment level (CAL). Radiographic evaluation of distance from implant to bone (DIB) allowed comparison of peri-implant hard tissues after 6 months. **Results:** Baseline values for SBI were comparable in both groups. Three months after therapy, in both groups, SBI and CAL decreased significantly. In contrast, after 6 months, CAL and DIB increased significantly in Group 2, not in Group 1. However, DIM-values were not statistically different 6 months after therapy in both groups. **Conclusion:** Within the limits of this 6-month study, nonsurgical aPDT could stop bone resorption in moderate peri-implant defects but not in severe defects. However, marginal tissue recession was not significantly different in both groups at the end of the study. Therefore, especially in esthetically important sites, surgical treatment of severe peri-implantitis defects seems to remain mandatory. *(Quintessence Int 2013;44:609–618; doi: 10.3290/j.qi.a29505)*

Key words: antibacterial photodynamic therapy, laser, peri-implantitis

Peri-implantitis is an inflammatory process around an implant, characterized by soft tissue inflammation and loss of supporting marginal bone.[1] Recent literature has summarized that peri-implantitis can be found in between 28% and 56% of subjects and between 12% and 43% of implant sites.[1,2] Due to the fact that a continually increasing number of patients are treated with dental implants, the frequency of peri-implant complications will rise over the long term.[3]

The primary goal of peri-implantitis treatment is to stop the progression of inflammation, which requires decontamination of the implant surface and, finally, augmentation of the defect. Conservative, resective, and regenerative treatment in conjunction with various methods of additional surface decontamination has been proposed.[4-6] However, based on these reports it appears that this goal is difficult to achieve.[2] At present, there is no reliable evidence suggesting which could be the most effective intervention for treating peri-implantitis.[7]

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Mechanical, chemical and laser treatments of the implant surface in the presence of marginal bone loss around implants

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Purpose: The objective of this review was to summarise current evidence with regard to the decontamination of implant surfaces by mechanical, chemical and physical methods in the presence of marginal bone loss arising from peri-implant infections.

Materials and methods: A PubMed search identified studies and publications dealing with 'peri-implantitis', 'treatment', 'surface decontamination', 'laser application' 'air-abrasive treatment' and 'photodynamic therapy'. Only studies in international peer-reviewed journals were selected for further evaluation; case reports were not included.

Results: Several therapeutic approaches were identified such as mechanical treatment, antiseptics and air-abrasive treatment, photodynamic treatment, and laser applications. Since treatment of infected surfaces with air-powder ± citric acid, gauze soaked with saline + citric acid or gauze soaked with chlorhexidine led to similar results in experimental studies, cotton pellets with saline may be adequate for cleaning micro-rough surfaces. Antimicrobial photodynamic therapy can effectively reduce the prevalence of pathogens on implant surfaces, but the clinical benefits remain unknown. The increase in temperature of the implant surface caused by the CO_2 laser poses a risk. The Er:YAG laser is considered to possess the best properties for implant surface decontamination. *In vivo*, no single method of surface decontamination (chemical agents, air abrasives or lasers) was found to be superior. In several animal experiments, thorough cleaning of the infected implant surfaces and implantation of these previously infected devices into freshly prepared sites resulted in re-osseointegration, while currently there are no controlled clinical trials where re-osseointegration has been demonstrated in patients.

Conclusions: For decontamination of the infected implant surfaces, rinsing with saline (or cleaning with cotton pellets soaked with sterile saline) and air-abrasive treatment seem to work. Laser decontamination of the surface does not improve healing results. Non-surgical therapy of implants with peri-implantitis does not lead to successful treatment outcomes.

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