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TRABAJO DE FIN DE GRADO

Grado en Odontología

PROTOCOLS TO PREVENT MARGINAL BONE LOSS IN DENTAL IMPLANTS

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ABSTRACT

Objective : The main objective is to study the implant parameters that influence marginal bone loss around osteointegrated implants, with the aim of preventing this phenomenon from the development of the treatment plan.

Methodology : An electronic research made on Pubmed and Medline, conducted to the selection of 38 articles that were discussed to analyze the influence of some parameters on marginal bone loss around implants.

Discussion of results : Marginal bone loss around implants has a multifactorial etiology, but there are parameters over which the practitioner has some leeway to limit bone loss. There is no consensus about an optimal implant length but implant diameter is a more influent parameter. Some implant design features, as the microthreads, have impact on crestal bone stability. Subcrestal implant position associated with platform-switching presents some advantages, as well as the internal connection, and the long abutments. Platform-switching concept allows a better bone preservation thanks to the inward reposition of the microgap and by improving the distribution of forces. When thin, the soft tissue can be thickened with grafts to achieve the thickness needed to prevent bone loss.

Conclusion : Lower bone loss is expected for implants with microthreads, wide diameter, internal connection, platform-switching, long abutments, and when the initial soft tissue thickness was of minimum 2mm.
Further studies would be needed to further improve protocols of prevention of marginal bone loss around implants.

Key words : marginal bone resorption, crestal bone loss, crestal bone stability, and/or platform switching, microgap, microthreads, implant position, internal connection, external connection, abutment disconnection, soft tissue thickness, soft tissue thicknening, abutment height.

RESUMEN

Objetivo : El objetivo principal es estudiar los parámetros del implante que influyen en la pérdida de hueso marginal alrededor de los implantes osteointegrados, con el fin de prevenir este fenómeno desde la elaboración del plan de tratamiento.

Metodología : Una investigación electrónica realizada en Pubmed y Medline, condujo a la selección de 38 artículos que fueron discutidos para analizar la influencia de algunos parámetros en la pérdida ósea marginal alrededor de los implantes.

Discusión de los resultados : La pérdida ósea marginal alrededor de los implantes tiene una etiología multifactorial, pero existen parámetros sobre los que el profesional tiene cierto margen de maniobra para limitar la pérdida ósea. No hay consenso sobre la longitud óptima del implante, pero el diámetro del mismo es un parámetro más influyente. Algunas características del diseño de los implantes, como las micro-roscas, influyen en la estabilidad del hueso crestal. La posición subcrestal del implante asociada al cambio de plataforma presenta algunas ventajas, así como la conexión interna y los pilares largos. El concepto de cambio de plataforma permite una mejor preservación del hueso gracias a la reposición hacia dentro del microgap y a la mejora de la distribución de las fuerzas. Cuando son delgados, los tejidos blandos pueden engrosarse con injertos para conseguir el grosor necesario para evitar la pérdida de hueso.

Conclusión : Se espera una menor pérdida ósea en los implantes con microrroscas, diámetro ancho, conexión interna, Platform-switching, pilares largos y cuando el grosor inicial del tejido blando era de un mínimo de 2 mm.
Se necesitan más estudios para mejorar los protocolos de prevención de la pérdida ósea marginal alrededor de los implantes.

Palabras clave : reabsorción ósea marginal, pérdida ósea crestal, estabilidad ósea crestal, y/o Platform-switching, microgap, micro-roscas, posición del implante, conexión interna, conexión externa, desconexión del pilar, grosor del tejido blando, engrosamiento del tejido blando, altura del pilar.

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INTRODUCTION

Dental implants have experienced a considerable boom since the 1980s and are now part of the therapeutic possibilities offered by dentists to cope with edentulism. Implant treatment has one advantage: except in cases of total edentulousness, restoration by implant supported prosthesis makes it possible to avoid mutilation of adjacent teeth which are often healthy.

These days, the survival rates for implant treatments on the long-term are very high, there are many clinical evidences of successful outcomes, and the complication rates are lower. (1)

Implants went through considerable evolutions in terms of materials, designs and techniques, thanks to the hindsight gained in clinical experience over time, that has enabled improvements. There is a constant evolution, new ideas and concepts are constantly emerging, in order to improve bone healing, stability, success rate, esthetics, to simplify the techniques, to broaden the field of possible indications.

Dental implants allow to restore function, comfort, and esthetics with even better results compared to removable prosthesis, and with a certain reliability, but they require a rigorous protocol.

1. OSTEOINTEGRATION

The implant therapy success relies on the principle of Osteointegration, initially highlighted by Branemark. (2) (3) It is the biological basis of Implantology, based on the necessity of obtaining a direct and functional connection at the interface between bone and implant without the presence of a fibrous component. Osteointegration is the result of direct bone regeneration on the implant, the actual definition being a direct functional anatomical junction of the reshaped bone with the surface of the implant. Osteointegration is manifested by the lack of implant mobility, and is visually appreciated, radiologically, by a direct bone contact with the surface of the implant. Maintaining this mechanical and biological stability is primordial for the success of the implant treatment on the long-term.

Osteointegration is based on two steps :

- Primary stability : the degree of mechanical anchoring obtained when the implant is put in place. It is influenced by the bone quality and volume, the surgical technique and the morphology of the implant.
- Secondary stability : the biological stability obtained after bone remodeling, when new areas of direct contact between bone and implant surface are established. As the bone remodeling progresses, secondary stability replaces primary stability, as shown in figure 1. (4)

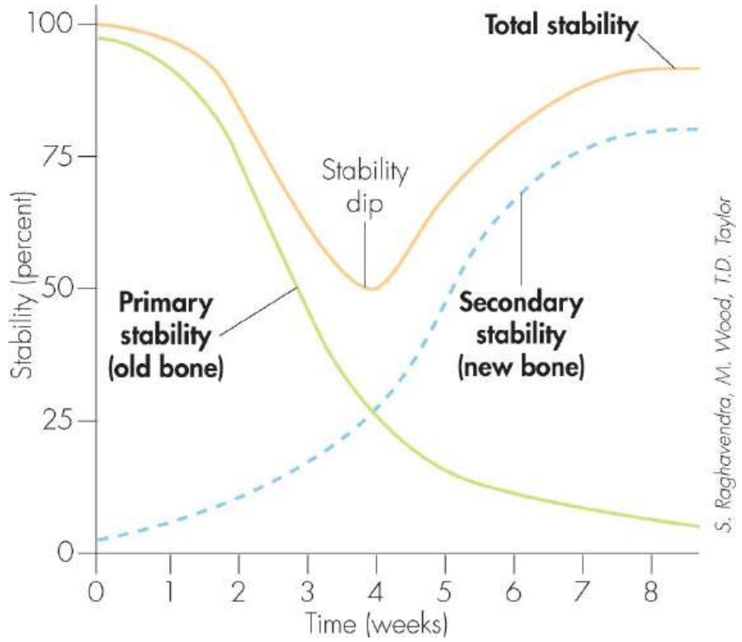

Figure 1 : Implant primary and secondary stability (94)

The interface between bone and implant surface will undergo many changes from implant placement to healing, and is susceptible to various factors such as biocompatibility of the implanted material, design and surface of the implant, surgical technique and skills of the surgeon, bone quality, loading, presence of trauma or micromovements, etc. (5) Osteointegration is achieved when adequate bone formation around the implant occurs. But when there is fibrous tissue formation in interposition between the bone and the surface of the implant, there is failure of osteointegration, and this phenomenon is called fibrointegration. It usually occurs in presence of trauma or micromovements.

Once osteointegration is established, it is relatively resistant, but some prolonged adverse conditions may lead to bone resorption, which may result in treatment failure and the loss of the implant. Crestal bone stability affects the implant survival, in terms of function and esthetics (especially in the anterior sector) : it is primordial for the success on the long-term.

Preservation of osteointegration depends mostly on the health of soft tissues surrounding the dental implant, and on the control of occlusal forces. Indeed, dental implants are associated with a good prognosis in the long term, but they are very susceptible to the biological environment and functional constraints. (6)

2. PERI-IMPLANT TISSUES

A. SOFT TISSUES

Soft tissue thickness has a role of protection of the peri-implant bone thanks to the “sealing”. Junctional epithelium is a protection mechanism against bacterial invasion. Indeed, in case of invasion of the biologic space, bone loss occurs to keep distance with the bacteria. The bigger the contact height, the better the peri-implant bone protection, keeping a bigger distance between oral bacteria and bone. (7)

Several soft tissue parameters must be taken into account before implant placement: horizontal soft tissue thickness, vertical or crestal soft tissue thickness covering the edentulous ridge (involved in the concept of biological width), soft tissue biotype, the amount of attached gingiva. It is found in the literature that the limit between thick of thin biotype is at 2mm. (8)

Biological space is the distance from the bottom (apical part) of the sulcus to the alveolar bone crest. It encompasses the attachment system around a tooth, that includes epithelial and conjunctive attachments. According to Lindhe and Berglundh, it measures 2.04mm with average values of 0.97mm for the junctional epithelium, and 1.07mm for the connective tissue. (9) These values were also confirmed by Gargiulo & Al. (10) These values vary depending on the individual, the presence of periodontal disease. The conjunctive attachment being constant, the variable part is the epithelial attachment.

Peri-implant soft tissues are different from peri-dental soft tissues, but with some similarities. Both epithelial attachments are composed of hemidesmosomes, but conjunctive attachment is richer in fibroblasts and poorer in collagen for a healthy tooth, being the opposite for implants. The orientation of collagen fibers are also different : the insertion being perpendicular to the tooth surface, and parallel to the implant surface without inserting fibers. Soft tissues around implants are poorly vascularized. Also, the root of a tooth is not in direct contact with bone due to the presence of the periodontal ligament that doesn’t exist in the direct interface between bone and implant. These differences show a weakened defense capacity of the peri-implant soft tissues, especially against bacterial plaque.

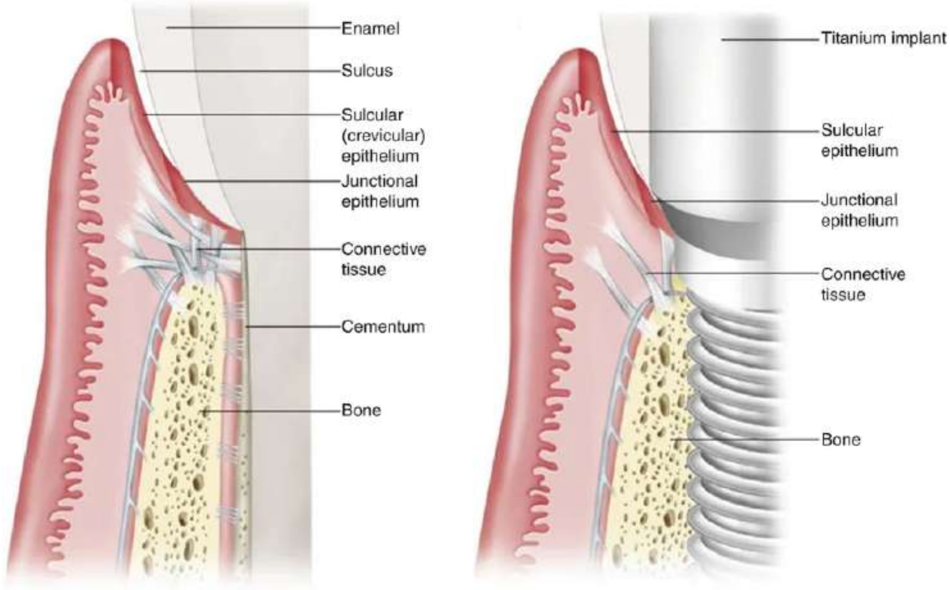

Figure 2 : Comparative scheme of soft and hard tissue around teeth and implants (95)

Peri-implant soft tissues result from a healing process following the surgical placement of an implant. The formation of biological width starts when the implant is exposed to the oral environment with the healing abutment, the prosthetic abutment or the provisional restoration. Biological space around implants corresponds to the distance from the alveolar bone crest to the outer surface of the peri-implant mucosa. It includes sulcular epithelium, junctional epithelium and connective tissue, with measurements of 2.14mm of epithelial attachment (sulcular and junctional epithelium), and 1.66mm of connective tissue, so a biological width of 3.8mm. Indeed, the epithelial attachment is longer on implants, being almost the double than on a healthy tooth.

According to Berglundh & Lindhe, a minimum vertical width of 3.5 mm for the peri-implant mucosa is required to allow a correct formation of attachment tissues and to limit bone resorption and the establishment of angular bone defect. Indeed, because

of the existence of a microgap at the junction between the abutment and the platform of the implant, the biological space forms apically to this microgap, so a minimum width is required.
The literature supports the influence of vertical soft tissue thickness and crestal bone stability. Also, it was proposed in a study realized by Tomasi & Al, an optimal vertical soft tissue thickness at about 4mm in terms of function and esthetics. (11)

B. BONE

Bone assessment is important in the preparation of the treatment planning, since bone factors have direct impact on primary stability and so on the success of the treatment. (12) Bone is assessed in terms of quantity and quality. A classification was proposed by Lekholm U, Zarb GA. (13) (14)

- Bone quantity or volume is classified in 5 groups from A to E, in relation with jaw shape and bone resorption :
  - Group A : without bone resorption
  - Groups B and C : with bone resorption
  - Groups D and E : with basal bone resorption

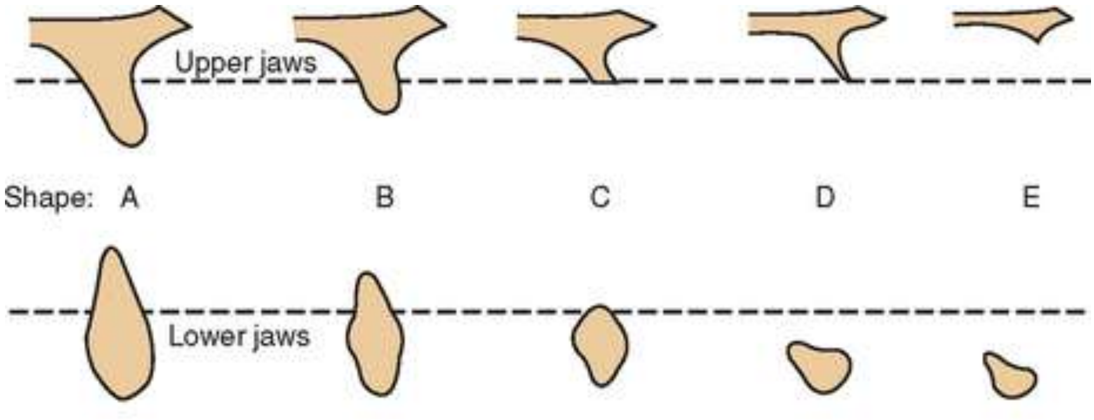

Figure 3 : Lekholm and Zarb classification of bone loss in the edentulous jaws (14)

- Bone quality or density, is classified in 4 groups from type I to type IV
  - Type I : almost only homogeneous compact/cortical bone
  - Type II : thick cortical bone surrounding very dense trabecular bone
  - Type III : thin cortical bone surrounding dense trabecular bone
  - Type IV : very thin cortical bone surrounding low density trabecular bone

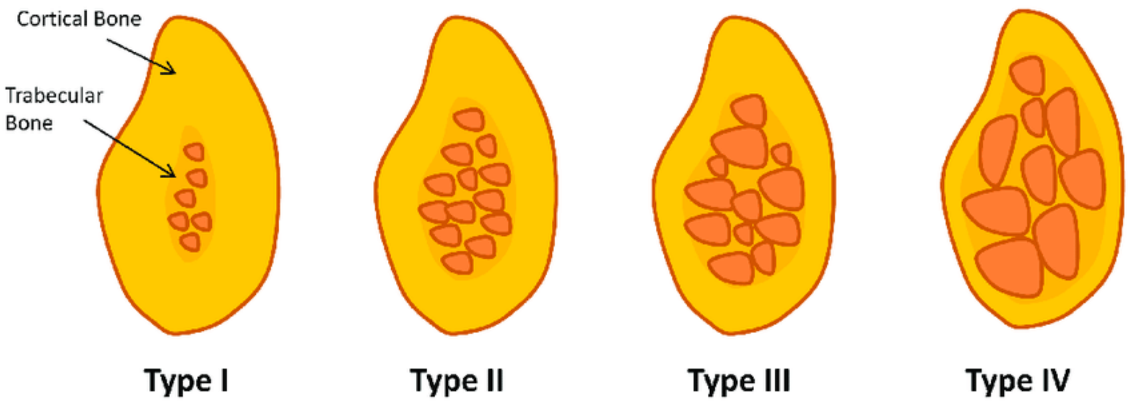

Figure 4 : Lekholm and Zarb classification of bone quality (96)

Studies evaluated bone parameters and their effects on stress distributions around the implant: a greater cortical bone thickness and bone density reduce stress concentration around the implant and give a higher chance of survival rate. (15)
Implant placed on poor quality bone such as type IV have a higher risk of failure. Indeed, due to the low density, stability of the implant is difficult to achieve with type IV bone. The type II is ideal due to its cortical / trabecular bone ratio. The type I has the highest proportion of cortical bone; this high density allows to obtain a good implant stability or anchorage, but the low vascularization limits bone remodeling and therefore makes osteointegration more difficult.

However, a study conducted by Ibanez et al found a correlation between marginal bone loss and the proportion of cortical bone : unlike the majority of the literature, this study showed lower results of marginal bone loss for type IV than for type II or I. (16) High trabecular bone proportion would facilitate repartition of stress through the bone avoiding microfractures and so the marginal bone loss around the implant.

3. MARGINAL BONE LOSS

A physiological bone loss appears after functional loading, despite a successful osteointegration. The existence of this phenomenon represents a consensus in the literature.
Marginal bone loss around implants is the bone loss area circumscribed between the distance from the outer edge of the implant platform to the first visible crestal bone, in

a vertical and horizontal way. It has a multifactorial etiology, and can initially appear in response to surgical trauma, invasion of the biological width due to the prosthesis and imbalance of osteointegration. (17) (18)

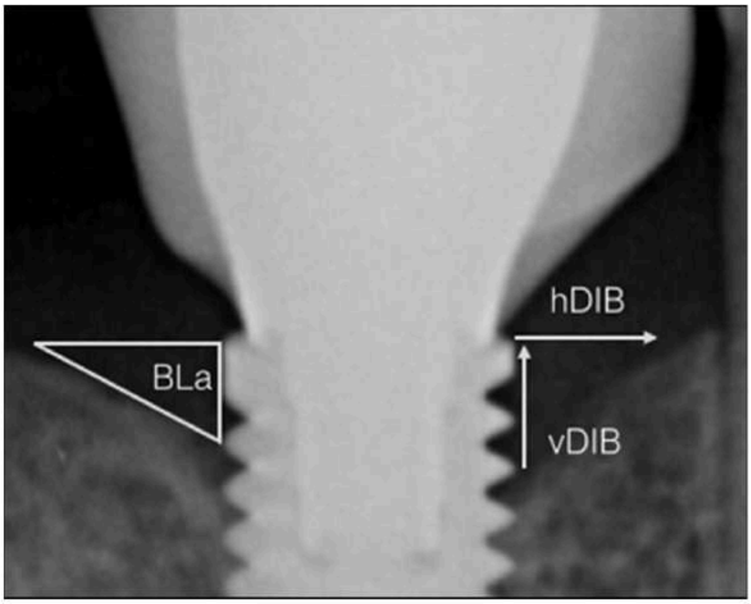

Figure 5 : Marginal bone loss area around implant (86)

The values commonly accepted are a 1.5mm of initial marginal bone loss in the year after the prosthetic loading of the implant, and a maximum of 0.2mm of annual marginal bone loss in the following years. These values were suggested by Albrektsson et al in his criteria of success. (19) According to Palmer, the acceptable marginal bone loss would be of maximum 2mm over a period of 5 years after loading. (20)

This accepted crestal bone loss evocated by Albrektsson should be questioned nowadays since it has been suggested that it’s possible to reduce these values thanks to literature background, progress and evolution of implant design.

4. RISK FACTORS FOR MARGINAL BONE LOSS AROUND IMPLANTS

Marginal bone loss around implants is one of the major issues related to implant treatments. When developing the treatment plan, the dentist that is considering placing dental implants must assess and take into consideration the general condition of the patient, it means the host characteristics, but also the environmental factors and local parameters. These are parameters over which the dentist has little or no influence, but which can impact the successful outcome of the treatment.

When developing the treatment plan, the dentist considering the placement of implants must assess the general condition of the patient (pathologies, systemic diseases, etc.) as well as all the parameters or general triggering factors that increase the patient's susceptibility to develop a peri-implant infection.

A. RISK FACTORS RELATED TO THE HOST

- **Genetics and host susceptibility** : specific immune response of the patient can have a role in bone loss : pro-inflammatory cytokines promote inflammation and bone resorption. A high level of pro-inflammatory cytokines may play a role in the severity of periimplantitis. There could be an association between interleukin-1 polymorphism and peri-implantitis but studies are still insufficient. (21)

- **Diabetes** : Diabetes is a risk factor that influences the risk of treatment failure. In diabetes, a failure in production or utilization of insulin prevents the uptake and metabolization of glucose within the cells. The hormone then accumulates in the blood causing hyperglycemia. Chronic hyperglycemia can be the cause of many complications : vascular and renal complications, healing alterations, xerostomia increasing the risk of caries and periodontal diseases. Gingival inflammation is due to an increase in pro-inflammatory cytokines. This inflammatory reaction has been recognized to be more prominent in patients with uncontrolled diabetes. These patients present with a higher prevalence of periodontitis and periimplantitis. A bad metabolic control in diabetic patient impacts also negatively osteointegration. Indeed, it is associated with a deficient and delayed bone formation around the implant. The bone loss progression is increased, due to the augmentation in osteoclasts. Diabetes is a risk factor because of the risk of healing alteration and of infection. However, if the diabetes is controlled, the risk is lower, and antibiotic prophylaxis may be performed to minimize the risk of infection. Controlling the balance of diabetes is essential to the success of implant treatment. (22) (23) (24) (25)

- **Hypertension** : It is an important parameter to take into account, even if the patient is well controlled with medication. It has an impact on post-surgery recovery since it can lower and delay the healing capacity, especially due to a bad oxygen delivery to the cells. Also, antihypertensive medications may influence the peri-implant tissue especially on the risk of periimplantitis. (26)

- **<u>Osteoporosis</u>** : Osteoporosis is a disease affecting bone mass and quality, where it is observed a reduced density and bone structure alterations : indeed the risk of bone fracture is higher and osteoporotic patients present higher rate of implant loss. This condition is more common in women, especially older than 50 years old. Bisphosphonates administered orally are the drug of choice for the treatment of osteoporosis, reducing osteoclastic activity, and bone remodeling. A possible adverse effect of Bisphosphonate therapy is the osteonecrosis of the jaw, but it is frequent in patients for whom bisphosphonates are administered intravenously. According to some studies, osteointegration would be affected by osteoporosis, but literature states that implant treatment can be performed in patients with osteoporosis. Also the treatment plan can be adapted with for example larger implant diameter, surface treatment, etc. Analysis of bone quality is primordial for the treatment planning. (27) (28)

- **<u>History of cervico-facial irradiation</u>** : Radiotherapy has impact on epithelium, skin, mucous membrane, but it also affects the salivary glands, with the effect of a decrease and modification of salivary secretion (hyposialia), xerostomia, and therefore has an impact on caries and periodontal diseases incidence. At the muscular and articular level, the presence of trismus and fibrosis can be observed. Osteo-radionecrosis is a risk associated to irradiation therapy, due to alteration of osseous vascularization, the higher susceptibility to infection, and the altered healing capacity. That is why it was for a long time considered an absolute contraindication for implant placement. In the context of implant placement in an irradiated patient, bone remodeling is altered due to the altered vascularization and the diminution of osteoblasts. Osteointegration is therefore compromised. Implant failure rate is higher in irradiated bone. However it has been demonstrated through studies that osteointegration is possible in irradiated bone, but it is slower. The factors of radiation dose and time in the expectation of success : the more the dose and the time of radiotherapy increase, the more the implant failure rate increases. To consider implant placement, the patient should be considered cured of cancer and many precautions must be taken because the risk is high. (29) (30) (31)

- **Bisphosphonate treatment** : Bisphosphonates are used for preventive and curative treatment for Osteoporosis, Paget's disease, Cancer, etc. Osteonecrosis of the jaw is an adverse effect that can occur in patients under Bisphosphonate therapy : the risk is high when Bisphosphonates are administered intravenously, but lower for oral treatment. Surgeries affecting bone can trigger this adverse reaction. According to the AAOMS[1], for dental implant treatment, in patients under oral bisphosphonates treatment, for more than 4 years or with risks factors such as diabetes or tobacco, it is recommended to interrupt the treatment at least 2 to 3 months before implant surgery. In patients under Bisphosphonate treatment administered intravenously, implant placement is an absolute contraindication. (32) (33)

[1] AAOMS : American Association of Oral and Maxillofacial Surgeons

B. ENVIRONMENTAL FACTORS

- **Tobacco** : tobacco is a very important behavioral parameter. It has been widely demonstrated in the literature that it is a risk factor for failure in implant treatments. Studies show inflammatory complications, reduced vascularization, delay and alteration in healing with altered clot formation, and increased bone loss by alteration of osseous metabolism. Nicotine and other components such as Carbon monoxide affect the osteoblast's activity and the immune response, provoking alteration in bone healing and increasing the patient's susceptibility to infection. Tobacco therefore compromises osteointegration, increases the rate of bone loss, and puts patients at risk of developing peri-implantitis. (34) The frequency and duration of smoking have been shown to have an impact on the level of complications, and in particular on the quantity and rate of bone loss : for heavy smokers (more than 20 cigarettes per day), it was reported a significantly increased marginal bone loss compared to non-smokers, patients who stopped smoking, and occasional / light smokers. For these patients, a significantly lower success rate of dental implants is expected. Studies consider that smoking cessation is required 1 week before surgery, and for up to 8 weeks after implant placement. (35) However, as it was said before, the consumption of tobacco has deleterious effect on the overall success of osteointegrated implants, and interruption of smoking is the best option to promote the success of the treatment on the long-term.

- **Stress** : there is no direct clinical evidence between psychological stress and marginal bone loss around implants but influence parafunctional habits, oral hygiene, patient behavior etc, that will increase the risk of developing periodontal disease, inflammation and bone resorption. (36)

- **Alcohol** : There are few studies that investigate a direct causal link between alcohol consumption and bone loss around osteointegrated implants. However, it has been shown that patients with a frequent and significant consumption of alcohol show a higher prevalence of periodontitis due to plaque and pH modification. A study conducted by P. Galindo Moreno in 2005 shows that bone loss around osteointegrated implant is increased in patients drinking more than 10g of alcohol per day. (37) However, more studies are needed, as the patients in the study conducted by P. Galindo Moreno were also smokers. Moreover, alcoholism can be associated to behaviors such as poor oral hygiene, and thus increasing bone loss and failure of the implant treatment. (38)

- **Bruxism and other parafunctional habits** : Bruxism and other parafunctional habits can considerably complicate a treatment plan in dentistry, due to the application of excessive forces, and non-axial loads on teeth, prosthesis and implants, for long periods. The implants do not have an occlusal overload adjustment system, as can be the case for natural teeth with the periodontal ligament. From this parafunctional habit can originate significant dental wear, muscle and joint pain, loss of attachment and mobility. The intensity of the forces generated impacts the success of the implant treatment on the long term.

Indeed, in addition to the fractures that can take place (fractures of the prosthesis, screw, abutment, etc.), micromovements will cause bone microfractures, leading to a loss of osteointegration, and to bone resorption along the surface of the implant, especially due to a concentrated stress at the marginal bone around the implant. Failures and complications are common with bruxist patients. Bruxism is a complex parafunctional habit, that has a multifactorial etiology. It often requires a multidisciplinary approach with occlusal splints, psychological and pharmacological treatment. (39) Bruxism can be seen as a contraindication to implant treatment, but treatment can be considered in some cases if precautions are taken, for example occlusal forces should follow the axis of the implant. It's recommended to use implants with a wider diameter for a better repartition of the forces and a better resistance to fracture. Adequate occlusal scheme is primordial for a good distribution of the forces, and occlusal equilibration can be performed. Occlusal splints may be recommended for optimal load distribution and to prevent prosthesis fractures. (40)

C. LOCAL RISK FACTORS

- **Oral hygiene and plaque control**: Presence of plaque is an important factor that causes the development of biofilm around teeth and implants. Implants are very susceptible to plaque related diseases. Indeed, studies showed a strong correlation between peri-implant bone loss associated to periimplantitis and poor oral hygiene. In addition to general poor oral hygiene, the lack of accessibility to hygiene around prostheses can also induce the development of periimplantitis. (41)

- **<u>History of periodontal diseases</u>** : Studies show higher rates of bone resorption in the presence of periodontal diseases. Indeed, patients with a previous history of periodontal disease, or patients with present active periodontal disease have a higher risk of developing a periimplantitis, due to the bacterial flora present in the mouth. However, a history of periodontitis is not a contraindication to implant placement, if the patient could be treated, and strictly follows the maintenance protocol and hygienic measures. Indeed, studies have shown that patients with residual pockets show a higher prevalence of peri-implant bone loss. That's why patients with active periodontal disease or residual pockets require periodontal treatment, stabilization, and a good maintenance and follow-up before starting the implant treatment. (41) (42)

- **<u>Influence of soft tissue thickness</u>** : The study of the soft tissue thickness before implant placement can be important for the prognosis, and the expectations for marginal bone loss. Studies demonstrated a strong correlation between peri-implant bone loss and soft tissue thickness : thick peri-implant soft tissues are associated with smaller marginal bone loss around implants. It's an important factor for marginal bone stability. (7) (8) (43) According to a study conducted by T. Berglundh and J. Lindhe (9), a minimum peri-implant mucosa thickness is required to limit bone resorption and the establishment of angular bone defect. In patient with thin vertical soft tissues, the situation should be corrected to ensure crestal bone stability. A minimum of 3mm of vertical soft tissue thickness should be present to limit bone loss. (44)

An increase of the soft tissue thickness can be considered, especially with a graft that showed good results on the long-term. (45)

- **Bone quantity and quality** assessment is important in the treatment planning, since it has direct impact on primary stability and on the implant survival rate. (12)

- **Adequate prosthetic space** : the available interocclusal distance and crown height space must be assessed because it influences the possibility of treatment, the choice of materials and prosthetic solutions, for example a minimum of 8 mm is necessary for a cement-retained implant prosthesis. (46)

- **Limited mouth opening** : the professional have to evaluate if enough space is available to perform the surgery.

- **Proximity of anatomical structures** : it must be taken into account in the treatment planning for example for the choice of implant length and diameter, for the respect of distances between implants and with remaining teeth.

5. <u>DECLENCHING FACTORS OF MARGINAL BONE LOSS</u>

Implants are associated with a very good prognosis on the long term. But they are very susceptible to the biological environment and functional constraints. Infectious process and occlusal overload are the main factors involved in the explanation of marginal bone loss around implants.

- **<u>Occlusal factor</u>** : Implant surface is in direct contact with bone, implants do not have an occlusal overload adjustment system that allows shock absorption, as it is the case for natural teeth with the periodontal ligament that have mechanoreceptors. For implants, occlusal stress is directly transmitted to the bone, so an adequate distribution of forces is necessary.

  Occlusal overloads such as interferences, prematurities, parafunctional activities, are susceptible to provoke bone loss around implant, and therefore represent a risk factor in the development of periimplantitis.

  It was demonstrated that occlusal overload can cause mechanical or prosthetic complications such as screw fracture, implant fractures, chipping, etc, but also biological complications such as marginal bone loss. (45) (47)

  There is a consensus on the fact that it disturbs the formation of osteointegration, affecting the secondary stability of the implant at a cellular level, and leading to fibrointegration.

  But this biomechanical parameter can be controversial : according to some authors, there is a lack of correlation between loss of osteointegration and occlusal overload, because once achieved, osteointegration is very resistant to occlusal overload. (48) (49) Indeed, it can be observed a densification of the peri-implant bone when subjected to occlusal overload (50) , and the number of peri-implantitis of occlusal origin would be much higher, especially on the most posterior implants where the occlusal forces are the greatest. But in certain situations, such as bad bone quality and insufficient bone volume, the influence of occlusal overload is observed. (51)

Thus, there is no consensus on the exact mechanics by which occlusal overload causes marginal bone loss, but the role of inflammation of soft tissues is clearly shown, and occlusal overload can lead to marginal bone loss in the presence of inflammation of the mucosa.

It must be remembered that occlusion plays a very important role in Implantology, and it is essential that it is well controlled.

- **<u>Peri-implantitis</u>** : Peri-implantitis is a pathological condition affecting the peri-implant tissues. It is a destructive inflammatory process, characterized by inflammation in the peri-implant soft tissues, bleeding on probing, deep pockets, suppuration and progressive loss of supporting bone. This set of complications of biological origin is similar to periodontal disease. There is a progressive evolution from mucositis (reversible inflammatory reaction without bone damage) to periodontitis. The persistence of unresolved mucositis rapidly evolves into peri-implantitis. (52) The formation of dental plaque and the accumulation of bacteria in the peri-implant groove are the main factors triggering the induction of inflammatory lesions in the adjacent mucosa. (53) It is well exposed in the literature that maintaining in good health the tissues surrounding the implant is imperative for the protection of underlying bone, and so for the success on the long term of the implant treatment.

6. IMPLANT PARAMETERS INFLUENCING MARGINAL BONE LOSS AROUND IMPLANTS

Unlike the previously mentioned factors, there are some parameters over which the dentist has a certain flexibility which allows him to make choices in order to prevent or limit the risk of marginal bone loss around implants. These parameters are therefore part of a prevention protocol of marginal bone loss around implants.

A. IMPLANT-ABUTMENT CONNECTION

There are different types of connection to join the implant-abutment system.

- The external connection (usually hexagonal, on the model of the Branemark implant) : it is the oldest type of connection and is characterized by an hexagon that surmount the implant platform and fits into the abutment
- The internal connection : it exists several design such as the hexagon, octagon (usually hexagonal). For this type of connection, the abutment fits into the implant, which constitutes the female part.
- The conical internal connection (Morse taper) : this type of internal connection can be considered apart. The principle consists of the interlocking of two cones, whose friction locks the system, called “wedging effect” : the abutment is

screwed in, the connection rotates generating a friction which will "block" the abutment on the implant.

These different types of connection behave differently from a biological and mechanical point of view. The distribution of forces is different. The type of connection influences the amount of marginal bone loss. The choice of the type of connection is therefore part of a strategy to prevent marginal bone loss around implants. (54)

B. PLATFORM-SWITCHING

Platform-switching is a concept that was highlighted by Lazzara (55), and appeared by accident in the 1980s due to due to the absence on the market of an abutment that would match wide diameter implants. This concept consists in associating an implant with a smaller diameter abutment.

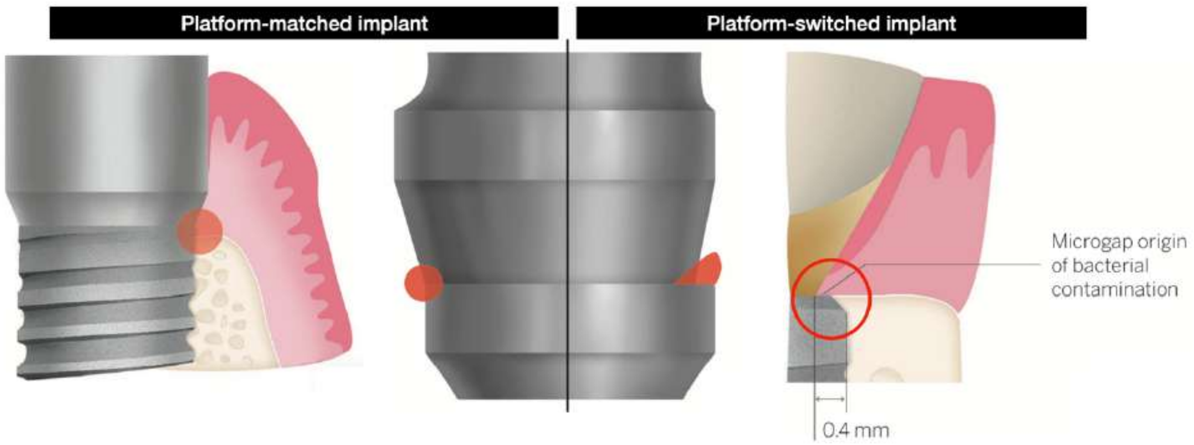

Figure 6 : platform switched and platform-matched implants (78)

This mismatch between the abutment and the implant platform will allow the implant-abutment interface to be moved centrally, away from the bone to reduce bone resorption by limiting the spread of bacterial infiltration as well as better redistributing the occlusal forces.

C. OTHER PARAMETERS

Other parameters such as implant length and diameter may also influence the marginal bone loss, as well as the position of the implant in horizontal, sagittal and vertical plane. The position of the implant has several impacts, both functionally and aesthetically, as it influences the stability of the soft and hard tissues of the implant. (56)

There are some rules to respect in order to limit the appearance of complications, aesthetic defects, or even failure of the treatment. In the same way, soft tissues thickness and abutment height must be considered with a view to preventing bone loss.

Other prosthetic parameters also have an influence on marginal bone loss, such as the type of prosthesis (cemented or screw-retained, in particular because of the presence of cement), the angulation of the abutment (straight or angulated), etc.

OBJECTIVE

The purpose of this writing work was to cover and understand a sufficient number of parameters, causes and risk factors associated to marginal bone loss around implants, to be able to elaborate protocols of prevention based on scientific evidence.
Marginal bone loss around implants has a multifactorial etiology. The mechanisms and risk factors involved are many and varied : it involves host related factors, parameters linked to the operator (experience and surgical technique), but also among others some factors directly related to the implant itself. Patient related factors (systemic conditions, environmental factors, etc.) are already well covered in the existing literature, with a lot of published reviews and studies. That is why it was decided to focus this writing work on the implant parameters affecting the marginal bone loss around implants with, as orientation, the prevention directly from the treatment planning.

Main objective : to study the implant parameters that influence marginal bone loss around osteointegrated implants, with the aim of preventing this phenomenon from the development of the treatment plan.
Secondary objectives :

- to study some aspects of the implant design
- to study the influence of the position of the implant
- to study the impact of the implant-abutment connection
- to study the influence of Platform-switching
- to study the impact of soft tissue thickness
- to study the influence of abutment height

METHODOLOGY

For this project, sources were selected by using the most scientific and impartial sources of information as possible such as governmental website, scientific articles or public website not controversed by any brand. The authors of the selected studies don't have any conflict of interest related to their studies and reviews.

For the 1st stage of selection, a primary electronic research of articles in the university library website (Biblioteca CRAI Dulce Chacon de la Universidad Europea de Madrid), on Pubmed and Medline, was conducted in October 2020, using the Key words : "MBL", "marginal bone resorption", "crestal bone loss", "dental implants", "peri-implantitis", "overloading", "tissue thickness".

Articles were included if :

- Correspondence with the subject was found by reading the title and the abstract, with adequately registered data regarding marginal bone loss around implants
- Articles was written in English or Spanish
- Only the articles of maximum 10 years old (published after 2010) were included
- Articles from individual papers, major journals, or published in international peer-reviewed literature

This basic search resulted 147 of potentially relevant papers.

For the 2nd stage of selection, the abstracts and full texts of the preselected studies of the 1st stage were further evaluated according to specific inclusion and exclusion criteria to select only the relevant papers :

- Assessment of factors related to implant characteristics, other than patient related factors (pathologies, systemic conditions, genetics …)

- Exclusion of papers dealing with implants related to locally or systematically compromised sites and conditions

It was taken into account that not all articles don't have the same level of influence in the impact of their results : case reports don't have the same incidence than randomized controlled trials or systematic analysis, just as the results obtained from studies on animals must be put into perspective.

For the 2nd stage, a total of 104 papers had to be excluded and a total of 43 papers fulfilled the inclusion criteria.

During the research work, some key words were added to extend the selection of studies, such as : "platform switching", "microgap", "machined neck", "machined collar", "microthreads", "implant position", "internal connection", "external connection", "abutment disconnection", "soft tissue thickness" , "soft tissue thicknening", "abutment height",etc.

Finally, after further research and filtering on the basis of the inclusion and exclusion criteria, it resulted (final review) the selection of 38 articles : 17 for the results analysis completed by 21 articles for the discussion.

The decision was made to produce summary tables, sorted by themes, to synthesis the information and facilitate the writing work. These tables allowed to highlight : titles, authors, date of publication, population, implant characteristics (such as number of implant placed, type of connection, platform switching, position of implant, etc.), some important results, elements of discussion and conclusion.

A reflection on the objectives was carried out, and the decision was taken to focus the work of discussion on the parameters related to the implant characteristics in the prevention of marginal bone loss, since the factors related to patient's characteristics (pathologies, systemic diseases, genetics) and environmental risk factors (tobacco, stress..) are already very present in the literature.

A detailed plan was drawn up and discussed in order to cover sufficient parameters influencing marginal bone loss around osteointegrated implants.

During the writing of the review, the reference management software Mendeley was used, in connection with the processing software Word, in order to manage citations and bibliographic references.

RESULTS

1. THE IMPLANT DESIGN

A. MICROTHREADS

A systematic review proposed by W. Niu and published in 2016, included 5 randomized clinical trials for the synthesis, and 3 articles for the systematic review to differentiate the impact of roughened microthreaded neck and polished neck, and the influence microthreads on marginal bone loss. (57)

Results from the Systematic review by Niu (57), showing the influence of the microthreads on marginal bone loss				
STUDIES	**COMPARISONS**	**CHARACTERISTICS**	**MBL 1 year after loading (in mm)**	**CONCLUSIONS**
Bratu et al (2009)	Comparison of roughened microthreaded and polished neck	Polished neck	1.47 ± 0.4	Microthreads help to reduce MBL
		Rough microthreaded	0.69 ± 0.25	
Kang et al (2012)	Comparison implants with roughened neck, but with or without microthreads	Rough	0.15 ± 0.14	Microthreads size doesn't influence marginal bone loss
		Rough microthreaded	0.13 ± 0.14	
Lee et al	Comparison implants with roughened neck, but with or without microthreads	Rough	0.28 ± 0.19	Microthreads help to reduce MBL
		Rough microthreaded	0.14 ± 0.11	
Song et al	Comparison implants with roughened neck, but with or without microthreads	Rough without microthread at the top 0.5mm	0.30 ± 0.22	Microthreads help to reduce MBL
		Rough with microthread at the top	0.16 ± 0.19	
Nickenig et al (2013)	Comparison of roughened microthreaded and polished neck	Polished neck	0.8	Microthreads help to reduce MBL
		Rough microthreaded	0.4	

It is well known that marginal bone loss has a multifactorial etiology, and in most studies, cofounding factors were not excluded. But it was concluded in 4 of the Randomized Clinical Trials that a roughened neck with microthreads have a positive effect on marginal bone loss limitation. On the contrary, Kang et al concluded implant neck threads don't have an impact on marginal bone preservation.

Another systematic review conducted by S. T. Lovatto was published in 2018, with 10 others randomized controlled clinical trials. Important variations of marginal bone loss between the studies was reported. But It was observed that implants with microthreads in the neck presented lower bone loss values compared to implants with straight or smooth neck. Also, differences were observed between different implant shapes. Indeed, marginal bone loss after 1 year was lower for cylindrical implants (0.12 mm with a range of 1.32 mm) than for tapered implants (0.14 mm with a range of 1.66 mm), but these differences in the results were not considered significant. (58)

A non-randomized retrospective study proposed by Z. Ormianer and published in 2016, regrouped 3 types of implants : (59)

- Group A : 388 spiral implants (SPI) with progressive thread design with tapered body and core, and a double lead thread design, with a wide step between threads (Lead = 2.1mm, pitch = 1.05)
- Group B : 911 dual fit implants (DFI) with progressive thread as in group A, but with smaller lead (Lead = 1.2mm, pitch = 0.6mm)
- Group C : 62 arrow implants with single lead V-thread design (pitch = lead)

	A	**B**	**C**
Mean marginal bone loss (mm)	2.02 ± 1.70	2.10 ± 1.73	1.90 ± 1.40

It was concluded that the thread design influence bone loss over time. More bone loss was observed in group B compared to group A, but better bone preservation was obtained for the V-thread design. It was concluded that smaller marginal bone loss is associated with larger pitch, deeper apical threads, and narrower implant core.

B. IMPLANT LENGTH AND DIAMETER

A systematic review of 3 randomized controlled trials and 2 non-RCT was realized by A. Monje, and published in 2013, with the following results : (60)

Results from the Systematic review by Monje (60), showing the influence of the Implant length on marginal bone loss				
STUDIES	**IMPLANT LENGTH (mm)**	**IMPLANT DIAMETER (mm)**	**CONNECTION**	**MEAN MARGINAL BONE LOSS (mm)**
Esposito et al (2011)	5	6	Internal	0.97 ± 0.56
Telleman et al (2011)	8.5	4.1 - 5	Internal	0.74 ± 0.61
Gulje et al (2012)	6	4	Internal	0.2 ± 0.22
	11	4	Internal	0.41 ± 0.46
Romeo et al (2006)	8	3.75 – 4.1	External	1.6 ± 1.5
	10	3.75 – 4.1	External	1.7 ± 1.4
Rossi et al (2010)	6	4.1 – 4.8	External	0.75 ± 0.71

Similar marginal bone loss values were obtained for short implant (< 10 mm) and conventional implants (> 10 mm), meaning implant length would not influence marginal bone loss around short implants. But these results are not significant and sufficient to confirm or exclude the influence of implant length on marginal bone loss around implants. More articles with longer follow up are needed.

A review article proposed by E. Borie, and published in 2014, evaluates the impact of implant diameter and length on marginal bone stress. (61)

Stress distribution in surrounding bone might be influenced by various factors such as the implant position and angulation, implant-abutment, bone quantity and quality, implant design. There are differing opinions in the literature about the possible influence of implant length on marginal bone loss around implants.

Results from the review by Borje (61), showing the influence of the Implant length on marginal bone loss	
C. Bourauel et al (2012)	Short implants have smaller contact area with bone, and less homogeneous stress distribution
JH. Rubo et al (2010)	By increasing of 10mm the implant length, there is a decrease in stress of 14%
C.S. Pietri et al (2005)	By increasing the length, the stress reduces on the bone ridge for narrow and tapered implants
Pierrisnard et al (2003)	Shear stress associated with oblique forces is concentrated on the first 7mm No differences associated to implant length
J.P. Geng et al (2004)	Implant length don't impact bone loss
Kong et al (2009)	increasing implant length can reduce bone stress on bone

But there is a consensus in the literature about the diameter of the implant : diameter is a more influent parameter, compared to implant length. Diameter influence the stress distribution : implants with increased diameter have a larger contact area with bone. So for a same load, stress in the marginal bone of wider implant is smaller than for narrower implants.

2. THE IMPLANT POSITION

The positioning of the implant is considered along 3 axes: horizontal (mesio-distal), sagittal (vestibulo-lingual) and vertical (apico-coronal). The question of optimal positioning arises because it plays a decisive role in the stability of the soft and hard tissues, and therefore in the success of the treatment.

A. HORIZONTAL POSITION

An animal study conducted by N. Elian and published in 2011, focused on the influence of inter-implant distance on bone loss. 72 platform-switched implants with internal abutment morse taper where placed in 12 minipigs : 3 implants with inter distance of 3mm on one side, and 3 implants with inter-distance of 2 mm on the other side. (62)
8 weeks after implant placement, similar bone levels were obtained in both groups :

BONE LOSS (in mm)	2mm group	3mm group
Vertical bone loss	0.48 ± 0.52 mm	0.31 ± 0.68 mm
Horizontal bone loss	0.31 ± 0.30 mm	0.57 ± 0.51 mm

Platform-switching may allow clinicians to place adjacent implants closer than 3 mm thanks to the internal repositioning of the microgap, without affecting inter-implant crestal bone height, but studies with longer follow-up periods are necessary to confirm this idea.

A retrospective study conducted by X. Vela, and published in 2012 focused on the influence of the distance tooth-implant by analyzing the marginal bone loss around 70 platform-switched implants placed at a distance inferior at 1.5 mm of the adjacent tooth, the mean distance being 0.99 mm ± 0.35 mm. On average, the marginal bone loss was of 0.36 ± 0.26 mm horizontally, and 0.46 ± 0.37 mm vertically. The results showed that Platform-switching allows to place implants with a distance tooth-implant of 1mm, while preserving the crestal bone level. It is especially important for areas with limited mesio-distal space, such as anterior sector.(63)

B. VERTICAL POSITION

A systematic review elaborated by N. Palacios-Garzon, and published in 2019, included 16 studies : 9 randomized control trials and 7 non-randomized control trials. The objective was to study the influence of implant vertical position (sub-crestal and crestal level) on the marginal bone loss. (64)

It was observed controversial results, as shown in the table below :

Results from the Systematic review by Palacios-Garzon (64), showing the impact of crestal and sub-crestal implant position on marginal bone loss		
Romanos et al (2015)	Non-RCT	No significant results
Al amri et al (2017)	Non-RCT	No significant results
Pellicer et al (2016)	RCT	Bigger MBL for subcrestal position
Palaska et al (2016)	RCT	No significant results
Nagarajan et al (2015)	Non-RCT	No significant results
De Siqueira et al (2017)	RCT	No significant results
Koutouzis et al (2014)	RCT	No significant results
Koh et al (2011)	RCT	No significant results
Vervaeke et al (2018)	RCT	Smaller MBL for subcrestal position
Kutan et al (2015)	RCT	Bigger MBL for subcrestal position
Ercoli et al (2017)	Non- RCT	No significant results
Veis et al (2010)	Non- RCT	No significant results

Degidi et al (2011)	Non- RCT	Smaller MBL for subcrestal position
Al Amri et al (2007)	RCT	No significant results
Kim et al (2017)	Non- RCT	Bigger MBL for subcrestal position
Fickl et al (2010)	RCT	Smaller MBL for subcrestal position

It appeared there was no significant differences for most of the studies between the 2 positions studied (subcrestal and crestal). In three studies, it was observed a bigger marginal bone loss around implants placed in subcrestal position, compared to crestal implants. For other 3 studies, it was the opposite.

No significant conclusion was proposed because of variations in studies, implant parameters, protocols, measurements, etc.

3. IMPLANT-ABUTMENT CONNECTION

A. INFLUENCE OF THE TYPE OF IMPLANT-ABUTMENT CONNECTION

Studies focused on the influence of the type of implant-abutment connection on the marginal bone loss. A systematic review of 11 randomized clinical trial and 3 prospective studies was proposed by R. Caricasulo in 2018, to evaluate the influence of the connection type on marginal bone loss after loading. (54) All studies compared at least the impact of two different types of connection on the marginal bone preservation : one external and one internal connection (internal conical or hexagonal). For all the studies, the external connections had platform-matched abutment. The studies conducted by Kielbassa, Arnhart and Cooper compared 3 types of connection, but the study proposed by Cooper compared external connection to internal connection (with platform-matching and platform-switching). One study conducted by Hsu et al

(2016) compared the influence of platform-switching on the marginal bone loss around implants with internal connection (some with platform-matching, and some with platform switching).

Results from the Systematic review by Caricasulo (54), showing the Influence of the connection on marginal bone loss					
Authors	Number of implants	Connection	Platform switching	MBL (in mm)	Conclusion
Crespi et al (2009)	34	External		0.78 ± 0.45	No significant differences
	30	Morse taper	PS	0.73 ± 0.52	
Kielbassa et al (2009)	117	Conical	PS	0.95 ± 1.37	No significant differences
	82	External		0.64 ± 0.97	
	126	Internal		0.63 ± 1.18	
Pieri et al (2011)	19	Morse taper	PS	0.19 ± 0.17	Lower MBL values with Morse Taper connection
	19	Internal		0.49 ± 0.25	
Arnhart et al (2012)	84	Conical	PS	0.89 ± 1.65	No significant differences
	66	External		0.16 ± 1.06	
	86	Internal		0.85 ± 1.32	
Koo et al (2012)	20	External		0.29 ± 0.35	Higher MBL values with external connection
	20	Internal	PS	-0.07 ± 0.21	
Peñarrocha-Diago et al (2012)	69	External		0.38 ± 0.51	Higher MBL values with external connection
	72	Internal	PS	0.12 ± 0.17	
Gultekin et al (2013)	52	Conical	PS	0.35 ± 0.13	Lower MBL values with conical connection
	52	Internal		0.83 ± 0.16	
Pozzi et al (2012)	44	Conical	PS	0.51 ± 0.34	Lower MBL values with conical connection
	44	External		1.10 ± 0.52	
Pozzi et al (2014)	44	Conical	PS	0.67 ± 0.39	Lower MBL values with conical connection
	44	External		1.24 ± 0.47	
Cooper et al (2015)	53	Conical	PS	0.22 ± 0.28	Lower MBL values with conical connection
	53	Internal		1.20 ± 0.64	
	50	Internal	PS	1.32 ± 1.01	
Esposito et al (2015)	173	External		0.98	No significant differences
	154	Internal	PS	0.85	
Esposito et al (2016)	96	External		1.13	No significant differences
	107	Internal	PS	1.21	
Hsu et al (2016)	13	Internal	PS	0.21 ± 0.56	Better bone preservation with platform-switched implants
	13	Internal		0.74 ± 0.47	
Pessoa et al (2016)	12	External		1.17 ± 0.44	Better bone preservation with Morse taper connection
	12	Morse taper	PS	0.17 ± 0.54	

Even if the results obtained by Crespi, Arnhart, Kielbassa and Esposito were not considered significant, in all the studies analyzed the results showed that lower values of marginal bone loss were obtained with internal conical connection, and the highest values of bone loss were attributed to external connection. However, the extent of marginal bone loss did not affect the survival rate and external connection is reliable on the long term. Only 1 study conducted by Arnhart showed better results for external connection, but it was not considered significant.

In the end, it was observed a better bone preservation with internal connection implants compared to external connection, and Platform-switching has a positive impact on marginal bone preservation, no matter the connection type it was applied to.

In a study conducted by J. Szymanska and published in 2017, it was assessed the marginal bone loss around implants in 28 patients over 46 months: 91 implants with conical Morse Taper connection (group I) and 149 implants with internal hexagonal connection (group II), both types being present in each patient. Radiographic assessment was performed with orthopantomograms. (65)

Results from the study by Szymanska (65) showing the influence of the connection on marginal bone loss - Comparison between Conical Morse Taper and Internal hexagonal connections		
Observation period	MBL (mm) /month for Conical Morse Taper connection	MBL (mm) /month for Internal hexagonal connection
Before loading	0.112	0.123
After loading	0.010	0.030

From implant placement to loading, there was no significant differences. During the time period from loading to the 46th month, marginal bone loss was significantly greater for the group II with internal hexagonal connection. At the 46th month after loading the difference in MBL between the 2 groups was of 0.696mm. In the end, better bone preservation was observed with conical Morse Taper implant-abutment connection compared to internal hexagonal connection.

B. <u>INFLUENCE OF THE NUMBER OF ABUTMENT DIS-RECONNECTIONS</u>

Some studies have examined the influence of the number of disconnections and reconnections of abutments on the peri-implant marginal bone loss.

A systematic review was proposed by T. Koutouzis in 2017. (66) It includes 6 randomized controlled clinical studies and 1 controlled clinical trial.

Various types of connection system were used, but all with platform switching.

The studies conducted by Degidi, Grandi chose to evaluate four abutment dis-reconnections, Luongo and Grandi (in another study) evaluated three abutment dis-reconnections, Koutouzis focused on two abutment dis-reconnections.

For the randomized clinical trial conducted by Canullo (67), the number of abutment dis-reconnection was not as clear as for the others : A 25 patients were included, they received a post-extractive implant of wide diameter, and they were reparted as follows:

- Provisional abutment group (PA) : 10 patients received a platform-switched provisional abutment with a provisional crown. After 3 months, impressions with coping-transfer was done, abutments were disconnected and reconnected several time to obtain the definitive prosthesis restoration
- Definitive abutment group (DA) following the “one abutment-one time concept” : 15 patients received a platform-switched definitive abutment with a provisional

crown. After 3 months, definitive restoration was placed with metal prefabricated copings, without any abutment disconnection.

Results from the Systematic review by Koutouzis (66), showing the influence of the number of abutment dis-reconnection on marginal bone loss			
Studies	Number of abutment disconnections	Mean MBL changes	
		Multiple abutment placement group	Final abutment placement group
Canullo et al (2010)	Not clear	0.55 ± 0.09 mm	0.34 ± 0.07 mm
Degidi et al (2011)	4	0.15 ± 0.28 mm	0.07 ± 0.27 mm
Grandi et al (2012)	4	0.43 ± 0.02 mm	0.09 ± 0.02 mm
Koutouzis et al (2013)	2	0.28 ± 0.16 mm	0.13 ± 0.20 mm
Grandi et al (2014)	3	0.58 ± 0.11 mm	0.11 ± 0.06 mm
Degidi et al (2014)	4	0.75 ± 0.11 mm	0.71 ± 0.1 mm
Luongo et al (2015)	3	0.09 ± 0.2 mm	0.08 ± 0.16 mm

For all studies, smaller marginal bone loss was observed in the final abutment placement group, and greater bone loss was observed when associated to multiple abutment dis-reconnections, being the highest with 3 and 4 disconnections.

A Randomized controlled trial, published in 2019, was conducted by L. Praça on 24 patients with single unit implants and screw-retained prosthesis. (68)

They were randomly separated into 2 groups :

- Definitive Abutment group (DEF) in which implants and definitive abutments (divergent design) were connected at the same time
- Healing Abutment group (HEA) in which the protocol includes 3 disconnections and reconnections of the straight healing abutments with initially a straight and narrow healing abutment, and then a divergent healing abutment

In both groups divergent abutments have the same diameter and divergent design, but different height. The results of marginal bone loss obtained with radiographic analysis are shown in the table below :

Bone loss changes	**HEA group**	**DEF group**
0 – 2 months	-0.355 ± 0.102 mm	-0.696 ± 0.120 mm
2 – 6 months	-0.648 ± 0.135 mm	-0.112 ± 0.113 mm
0 – 12 months	-1.009 ± 0.140 mm	-0.759 ± 0.100 mm
0 – 24 months	-0.808 ± 0.148 mm	-0.608 ± 0.097 mm

There are no overall significant differences between the two groups, but some significant differences between 0-2 months and 2-6 months, with the most important values of bone loss in the first 6 months.

4. PLATFORM SWITCHING CONCEPT

Studies evaluated the influence of the Platform Switching concept on the marginal bone loss around implants.

A systematic review produced by Santiago et al and published in 2016 includes 25 studies : 17 randomized controlled trials, and 8 controlled prospective studies. All studies analyzed the influence of platform-switching on marginal bone loss over periods ranging from 1 to 5 years. For some studies, the type of implant-abutment connection system was not known, but 9 studies used internal connection, 2 chose external hexagonal, and 1 was with Morse taper. (69)

Results from the Systematic review by Santiago (69), showing the influence of the Implant length on marginal bone loss				
Authors	Studies	Implant-abutment diameter difference on each side (mm)	Marginal bone level changes (mm)	Conclusion
Canullo et al (2010)	RCT	Control group : 0 G1 : 0.25 G2 : 0.5 G3 : 0.85	CG : 1.49 ± 0.54 G1 : 0.99 ± 0.42 G2 : 0.82 ± 0.36 G3 : 0.56 ± 0.31	Statistically significant results : less bone loss with platform-switching
Canullo et al (2009)	RCT	CG : 0 G1 : 0.85	CG : 1.19 ± 0.35 G1 : 0.3 ± 0.16	Statistically significant results : less bone loss with platform-switching
Canullo et al (2011)	RCT	Control group : 0 G1 : 0.25 G2 : 0.5 G3 : 0.85	CG : 1.358 ± 0.3939 G1 : 0.832 ± 0.3939 G2 : 0.486 ± 0.2242 G3 : 0.375 ± 0.1234	Statistically significant results : less bone loss with platform-switching
Cappiello et al (2008)	Prospective	CG : 0 G1 : 0.4	CG : 0.95 ± 0.32 G1 : 1.67 ± 0.37	Statistically significant results : less bone loss with platform-switching
Crespi et al (2009)	Prospective	NC	CG : 0.73 ± 0.52 G1 : 0.78 ± 0.45	No statistically significant results
Dursun et al (2014)	Prospective	CG : 0 G1 : 0.37	CG : 0.76 ± 0.41 G1 : 0.84 ± 0.36	No statistically significant results
Enkling et al (2011)	RCT	0.35	CG : 0.58 ± 0.55 G1 : 0.53 ± 0.35	No statistically significant results
Fernandez Formoso et al (2012)	RCT	NC	CG : 2.23 ± 0.22 G1 : 0.68 ± 0.88	Statistically significant results : less bone loss with platform-switching
Hurzeler et al (2007)	Prospective	0.45	CG : 2.02 ± 0.49 G1 : 0.22 ± 0.53	Statistically significant results : less bone loss with platform-switching
Kielbassa et al (2009)	RCT	NC	CG : 0.63 ± 1.18 IH : 0.95 ± 1.37 EH : 0.64 ± 0.97	No statistically significant results
Pieri et al (2011)	RCT	0.35	CG : 0.51 ± 0.24 G1 : 0.2 ± 0.17	Statistically significant results : less bone loss with platform-switching
Pozzi et al (2014)	RCT	NC	CG : 1.15 ± 0.34 G1 : 0.68 ± 0.34	Statistically significant results : less bone loss with platform-switching
Prosper et al (2009)	RCT	0.25 (mandible) 0.35 (maxilla)	CG : 0.193 ± 0.474 G1 : 0.055 ± 0.234	Statistically significant results : less bone loss with platform-switching
Telleman et al (2014)	RCT	0.35 or 0.4	CG : 0.85 ± 0.65 G1 : 0.53 ± 0.54	Statistically significant results : less bone loss with platform-switching

Telleman et al (2012)	RCT	0.35 or 0.4	CG : 0.73 ± 0.48 G1 : 0.51 ± 0.51	Statistically significant results : less bone loss with platform-switching
Trammell et al (2009)	RCT	0.45	CG : 1.19 ± 0.58 G1 : 0.99 ± 0.53	Statistically significant results : less bone loss with platform-switching
Vandeweghe and De Bruyn (2012)	RCT	1	CG : 0.94 ± 0.42 G1 : 0.66 ± 0.47	Statistically significant results : less bone loss with platform-switching
Vigolo and Givani (2009)	Prospective	0.5	CG : 1.1 ± 0.3 G1 : 0.6 ± 0.2	Statistically significant results : less bone loss with platform-switching
Enkling et al (2013)	RCT	0.35	CG : 0.74 ± 0.57 G1 : 0.69 ± 0.43	No statistically significant results
Del Fabbro et al (2015)	Prospective	0.5, 0.75, 1.25	CG : 0.48 ± 0.26 G1 : 0.33 ± 0.19	Statistically significant results : less bone loss with platform-switching
Glibert et al (2014)	Prospective	0.45	CG : 1.02 ± 0.14 G1 : 0.63 ± 0.18	Statistically significant results : less bone loss with platform-switching
Meloni et al (2014)	RCT	0.35	CG : 0.93 ± 0.26 G1 : 0.84 ± 0.23	No statistically significant results
Pozzi et al (2014)	RCT	0.2	CG : 1.29 ± 0.42 G1 : 0.83 ± 0.27	Statistically significant results : less bone loss with platform-switching
Wang et al (2015)	Prospective	0.6	CG : 0.19 ± 0.16 G1 : 0.04 ± 0.08	No statistically significant results
Guerra et al (2014)	RCT	0.3, 0.35	CG : 0.69 ± 0.68 G1 : 0.40 ± 0.46	Statistically significant results : less bone loss with platform-switching

It was observed a greater bone loss for the control group in all studies. On average, over all the studies included in this review, the bone loss around implants with platform-switching is 0.57mm, and for implants with matching abutment-platform diameter, the bone loss is 0.98mm. In the comparison of marginal bone loss between platform-switched and platform-matched implants : the mean difference is of -0.41mm in favor of platform-switching. It was concluded that the platform-switching concept allows better marginal bone preservation.

Moreover, in the RCT conducted by Canullo in 2009, the influence of the degree of mismatching was analyzed : a significant inverse correlation was observed between marginal bone loss and the diameter mismatching : the more the mismatching, the lower the marginal bone loss.

5. SOFT TISSUE THICKNESS

A systematic review and meta-analysis proposed by F. Suarez in 2016 included 13 articles to analyze the influence of soft tissue thickness on marginal bone loss.
In the meta-analysis 5 articles were included : 4 articles placed the limit between thin and thick at 2mm (articles by Linkevicius et al, and by Puisys and Linkevicius). Jeong used the threshold of 3mm. Moreover, Linkevicius (2015) and Puisys and Linkevicius (2015) analyzed also thin soft tissues thickened with allograft. (7)

Results from the Systematic review by Suarez (7), showing the impact of the soft tissues thickness on marginal bone loss		
Studies	Thick soft tissues	Thin soft tissues
Linkevicius et al (2009)	1.59 ± 0.56 mm	1.83 ± 0.52 mm
Linkevicius et al (2009)	0.175 ± 0.11 mm	1.445 ± 0.26
Linkevicius et al (2009)	0.24 ± 0.36 mm	1.35 ± 0.33 mm
Linkevicius et al (2015)	0.39 ± 0.09 mm	1.73 ± 0.11 mm
Puisys and Linkevicius (2015)	0.39 ± 0.09 mm	1.18 ± 0.08 mm
Jeong et al (2011)	0.3 ± 0.6 mm	0.3 ± 0.2 mm

It was observed a better marginal bone preservation when initial soft tissues are thick. The differences of results between the groups were more significant for the studies that set the threshold between thin and thick soft tissues at 2 mm. It can be concluded that for a soft tissue thickness of less than 2mm, the risk of marginal bone loss increases.

Another Prospective clinical trial was proposed by T. Linkevicius in 2015. (70) The objective was to study the possible preservation of crestal bone stability after soft tissue thickening with allogenic membrane. The patient sample was divided in 3 groups according to the soft tissue thickness, with a threshold of 2mm to determine the biotype. The following results were obtained after 1 year:

Results from the prospective clinical trial by Linkevicius (70), showing the amount of marginal bone loss associated with different types of soft tissue thickness			
	Thin soft tissues	Thin soft tissues thickened with allogenic membrane	Thick soft tissues
Mesial bone loss	-1.65 ± 0.08 mm	-0.31 ± 0.05 mm	-0.44 ± 0.06 mm
Distal bone loss	-1.81 ± 0.06 mm	-0.34 ± 0.05 mm	-0.47 ± 0.07 mm

The differences between the thickened and thick soft tissues were not considered significant. But it was observed a more important marginal bone loss in patients with initial thin soft tissues, It was concluded that the thickening of the soft tissues compensated the thinness of the initial biotype, allowing a better bone preservation.

6. ABUTMENT HEIGHT

A systematic review and meta-analysis was proposed by Chen in 2019, to study the influence of abutment height on marginal bone loss. For that purpose, 14 articles were included in the systematic review to compare the effects of short and long abutments on bone loss. (71)

Most of the studies observed a better bone level preservation with long abutment (>2mm), and bigger amount of bone loss with short abutment (<2mm). Indeed, according to Blanco et al (2018), with a short abutment, the distance between the bone and the crown-abutment interface is shorter, the bone being closer to a bacterial reservoir. However, in the studies of Tan et al (2010) and Herrero-Climent (2014), more bone loss was associated to long collar. These results are questionable as the implants were positioned subcrestally, and additional bone loss was due to other factors (implant position), acting simultaneously.

It was concluded that marginal bone loss is determined by the height of the abutment, and that a longer abutment allows to preserve marginal bone.

A retrospective study conducted by Spinato and published in 2018, focused on a possible optimal abutment height to prevent marginal bone loss. (72) 2 groups were differentiated : 25 patients with platform-switched implants, and 26 patients with matching implant-abutment diameter. Marginal bone loss was evaluated on a period of 12 months after loading. 1 year after loading, the following results were obtained :

Results from the retrospective study by Spinato (72)		
	Platform-switched implants	Conventional implants
Mesial MBL	0.30 ± 0.34 mm	0.78 ± 0.68 mm
Distal MBL	0.38 ± 0.37 mm	0.90 ± 0.67 mm
Mesial abutment height	1.88 ± 0.78 mm	1.67 ± 1.04 mm
Distal abutment height	1.87 ± 0.84	1.66 ± 1.05 mm

The results show that the shorter the height, the greater the bone loss. Indeed, an inverse relation was found between the marginal bone loss and the abutment height : by increasing the abutment height, the risk of marginal bone loss decreases.

Spinato suggested that the minimum abutment height necessary to avoid marginal bone loss is of 2.5 mm for implants with platform-switching.

DISCUSSION

1. IMPLANT DESIGN

Implants undergone changes of design through the time in order to increase success rate through increased stability and decreased marginal bone loss.

Implant design and surface have impact on primary stability, on the osteointegration process, and on the marginal bone preservation. Many implants are available on the market with different diameters, lengths, shape, surfaces, connections.

In the literature, some limitations appear due to the lack of homogeneity in studies design, sample selection, etc. Harmonization is needed to be able to perform direct comparison. (57) (58) (59)

Regarding the implant length, there is no consensus in the literature about the possible influence of implant length on marginal bone loss around implants and about an optimal implant length. (61) According to some articles, short implants present a higher failure rate. In other studies, short implants present fewer complications. But factors vary between studies, making it impossible to validate this hypothesis. Longer-term studies are necessary to draw conclusions.

Short implants can be a solution in cases of insufficient bone volume, limited mouth opening, proximity with some anatomical structures (i.e. inferior alveolar nerve), reducing the risk of complication and avoiding bone augmentation procedures or sinus lift procedure. Moreover, marginal bone loss around short implants may have more impact on implant stability. Short implants have a smaller contact surface with the bone, that’s why having adequate bone is even more important for short implants.

Regarding the implant diameter, it can be an important parameter especially in cases of insufficient amount of bone, where increasing implant diameter can compensate the limited implant length and increase the implant-bone contact surface.

This parameter has an important impact on marginal bone loss, especially knowing that the greater stress concentration is located at the cervical area of the implant.

By increasing the diameter, we obtain a better primary stability, better resistance to fracture. Wider diameter implants have a bigger contact surface with the bone, reducing the stress for marginal bone and improving its distribution. Diameter is a more influent parameter, compared to implant length. Implant length does not have as much influence on the force distribution as the diameter. The diameter influences the stress distribution : implants with increased diameter have a larger contact area with bone. So, for a same load, stress in the marginal bone of wider implant is smaller than for narrower implants. (60) (61) (73)

Microthread is a design parameter that allows to increase the contact surface between the implant and the bone, improving the primary stability and the distribution of forces. It has influence for the healing period and on the long term. Microthreads at crestal level (implant neck) help to reduce marginal bone loss because they produce compression on the crestal bone, and reduce shear stress. (59)

There are various types of threads designs. 4 parameters define the thread : the pitch, the lead, the shape and the depth. The more influent parameter is the pitch. A small pitch means a bigger number of threads, and so a bigger contact surface between bone and implant. In the same way, the lead influences the contact surface. The shape influence also the stress distribution. Thread depth influence the surface area : by increasing the depth, the surface is increased.

Lower marginal bone loss is associated with larger pitch, deeper apical threads, and narrower implant core.(59) The use of rough surfaced microthreaded implants is recommended to maintain crestal bone levels. (57) (58)

Regarding the microstructure, several types of implant surface exist, created by addition or subtraction techniques such as Titanium plasma sprayed, Etched surface, Titanium oxide blasted, Hydroxyapatite coated. It gives a roughness aspect to the surface, increasing the contact surface between implant and bone, and improves the osteointegration. Better results were obtained with blasting/etched surfaces, compared to machined surface in the crestal area. But roughened surface can provide niches for bacterial colonization, and so can have negative effect on the long-term marginal bone loss. (78)

2. IMPLANT POSITION

Despite the requirements of soft tissue thickness to avoid bone resorption for the reestablishment of the biological width, some other measurements have to be respected.

The position of the implant has several impacts, both functionally and aesthetically, as it influences the stability of the soft and hard tissues of the implant.

There are rules to respect in order to limit the appearance of complications, aesthetic defects, or even failure of the treatment.

A. HORIZONTAL POSITION

Horizontally, the mesio-distal positioning of the implant depends on the clinical context. Between the implant and the adjacent tooth, it is commonly accepted that a certain distance must be respected : a minimal interproximal distance of 1.5 mm must be maintained (taking into account the periodontal ligament) to limit crestal bone loss. This distance allows a correct bone remodeling since it has been estimated that the bone lysis extends over 1.5 mm. (74) The respect of this rule allows the preservation of the interproximal crestal bone, and thus the maintenance of the papilla, which represents an important esthetic factor. If the interproximal distance is too small, the vascularization will be decreased, and complications will appear such as bone resorption and external radicular resorption. Indeed, in the elaboration of the treatment plan, the choice of the implant diameter in relation to the minimum space required to place the implant is made as follows: minimum space = implant diameter + 2 x 1.5mm. Attention should be paid to neighboring anatomical structures such as the roots of adjacent teeth which may sometimes be converging.

When placing multiple adjacent implants, an inter-implant distance of 3mm must be maintained to preserve the interproximal bone crest and avoid further bone loss. (75) Once again, the crestal bone level influence the position of marginal soft tissues, and a loss of crestal bone leads to a diminution in bone support for the papilla. Studies have shown an absence of papilla in case of inter-implant distance lower than 3mm. (76) Due to the lower vascularization, the distance to respect is greater than in the presence of a tooth.

However, it appears possible to be able to slightly reduce theses distances (inter-implant and with adjacent teeth) thanks to platform-switching. This concept allows an inward shift of the microgap, increasing the distance between bone and bacteria. According to the studies conducted by N. Elian and X. Vela, platform-switching would allow to place adjacent implants closer than 3 mm and to reduce the distance tooth-implant to 1mm. (62) (63)

In the literature, there is no consensus on the optimal distance to adopt, and more studies are needed with longer term follow up. (77)

B. SAGITTAL POSITION

In the sagittal plane, especially for the anterior sector, the distance between the implant and the vestibular cortical plate must be minimum 2mm to maintain good vascularization, to allow adequate bone remodeling, but also to preserve the biological space. The objective is to obtain a good soft tissue support and avoid resorption of the vestibular bone wall. (78)

C. VERTICAL POSITION

The vertical position of the dental implant influences the marginal bone loss around implants. More parameters come into consideration when choosing the vertical positioning of the implant, in particular the periodontal biotype, the available occlusal height, the implant design, aesthetic expectations (anterior or posterior area), the patient's ability and motivation to maintain oral hygiene, etc.

Limitations inherent to the analyzed studies reduced the impact of the results. Indeed, there is a lack of standardization : different implant protocols, different implant depth position (supra-crestal, crestal, sub-crestal), different connection systems, different surfaces. These differences in parameters may have influenced the results. Others studies more standardized with long-term follow up are needed. (64)

The possibilities of implant placement depth are related with the implant design. The ideal is to respect the manufacturer instructions.
We can differentiate tissue level implants and bone level implants. Tissue level implants have their implant-abutment connection at the level of the gum. The polished collar will be visible, that is why, for esthetic reasons, it is not recommended.
It was suggested by Linkevicius, in order to improve the esthetic aspect, to place implants without polished components, at bone level, with platform switching and internal conical connection. (78)

Bone level implants can be placed supracrestally, crestally or subcrestally. Supra-crestal position of the implant allows to keep the microgap away from the bone, maintaining a good distance between the bacteria and the bone, and avoiding bacterial microleakage. That’s why it is the position recommended for implants without platform-switching. Nevertheless, the risk of developing periimplantitis may be higher due to the direct contact between the rough surface of the implant and the soft tissues. A supra-crestal implant with polished neck would allow to keep the microgap away from the bone without exposing the soft tissues to the rough surface. (64)

Crestal position is a possibility if the vertical soft tissue thickness is adequate. The gap is not kept away from the bone, unless platform switching is used.

For the sub-crestal position, there is no consensus on whether it is associated with greater marginal bone loss or not. But for some authors, subcrestal implant position is associated with a lower risk of having, on the long term, exposure of the implant. (79)

On one hand, the microgap is located under the bone crest level, increasing the risk of bacterial leakage, and so the risk of marginal bone loss; but on the other hand, the stability is increased, especially if conical connection and platform-switching are used.

Implants placed subcrestally should be platform-switched implants, to increase the distance between the bone and bacteria. However, a depth higher than 3mm is not recommended. Indeed, a too deep placement increase the risk of bone loss.(78)

This position allows, especially in esthetic areas, to obtain an adequate emergence profile and gingival mask. This implant position can be chosen to avoid a steep emergence profile in cases of short clinical crowns. It can be also a solution in some cases where vertical soft tissue thickness is insufficient.

Due to handling difficulty, it is possible to place an intermediate abutment, to shift the impressions and prosthetic procedures to the abutment level.

3. THE CONNECTION

A. INFLUENCE OF THE TYPE OF IMPLANT-ABUTMENT CONNECTION

It is well understood that the connection system is a parameter influencing the marginal bone loss around implants since biomechanical and biological consequences are related to the type of connection. (80) (81)

From a biomechanical point of view, the differences in the extent of the contact area between the abutment and the implant influence the distribution of the forces. The external connection having a shorter contact zone, a higher stress is reported in the peri-implant area. With internal connection, stress is better distributed, and load is centralized and transmitted apically, reducing the effect on marginal bone. As it was observed in the systematic review elaborated by Caricasulo (54), internal connection allows a better bone preservation. Also internal connection system are more stable and face fewer complications, compared to external connection system that are more susceptible to complications due to micromovements, such as screw loosening and component fracture.

From a biological point of view, it exists an accumulation of inflammatory cells at the implant-abutment interface. Internal connection, and especially conical internal connection have a better implant-abutment interface (80), reducing the risk of bacterial invasion into the bone. Indeed, the misfit value is lower for internal connection, despite some heterogeneity in the values in the literature due to the heterogeneity in evaluation methods. (81)

Conical internal connections are more stable. The larger surface contact between implant and abutment improve the system stability and the sealing. Implants associated to this type of connection face fewer biological and mechanical complications, and marginal bone loss around implants is reduced. (55) It is recommended to prefer internal connection implant especially if additional risk factors can influence marginal bone loss. (80)

However, despite its poorer stability, higher susceptibility to complications, and its association with increased marginal bone loss, external connection is reliable over time. (56) And there is no affectation of the survival rate linked to the connection type.

Some limitations appear in the analyzed articles. There is a lack of homogeneity between the studies in terms of protocols, implant design, surface texture, implant position (healed or fresh-extraction site), platform-switching, time of loading, follow-up periods. Uncontrolled factors related to patient was not taken into account, with the exception of the study conducted by J. Szymanska in which both type of implant system were placed in each patient, so the patient parameters didn't influence the results. (65) Differences in evaluation methods appeared, and studies mostly used a conventional 2D radiographic analysis, with only mesial and distal appreciation of marginal bone loss.

The bone loss results obtained with internal connection systems, compared to external connection, were improved by the use of platform switching. Platform switching may be a more important factor than the type of connection. (82)

Indeed, Vandeweghe and Bruyn compared the marginal bone loss values obtained around implant with external hexagonal connection with and without platform switching. It resulted that even for external connection implants, bone loss was smaller when it was associated to platform switching. (83)

Also, Intermediate abutment may be necessary for the prosthesis placement. They can be used to transform an internal connection into an external connection. It is well known that the use of intermediate abutments influence the distribution of forces. (84) It would be interesting to focus on the impact of intermediate abutment on marginal bone loss on the long term.

B. INFLUENCE OF THE NUMBER OF ABUTMENT DIS/RECONNECTIONS

The number of disconnections – reconnections has an influence on the crestal bone stability. Repeated disconnections-reconnections would be associated with a higher marginal bone loss, compared to protocols of single connection of abutments (immediate positioning of abutment and implant). The greater the number of disconnections, the greater the resulting bone loss. Protocols of treatment that reduce the number of dis-reconnections may help to limit marginal bone loss around implants. (66) (67) (68)

But there is a lack of standardization between the studies, with a variability in the protocols (number of dis-reconnections), surgical sites (fresh alveolar socket or healed site that imply differences in bone remodeling), location of the implants, variations in implant and abutment design (diameter, divergence), presence of other influencing factors such as tobacco. Also, the evolution of soft tissue was not always examined. These variations can explain some variations of marginal bone loss between the studies.

Since disconnections interfere with the adhesion of soft tissues, which can cause repeated injuries of the mucosal barrier, possible penetration of microorganisms, additional bone loss due to the readaptation of the biological space, it is therefore recommended to reduce the handling, avoiding disconnection of the abutment as suggested by the "one abutment-one time" concept. (67)

4. PLATFORM SWITCHING CONCEPT

The use of the Platform switching concept showed a significant influence on the marginal bone loss, since higher levels of bone preservation was observed with platform-switched implants (69). It appeared that the degree of Platform-switching is inversely proportional to the bone loss, which means that the greater the mismatching, the lower the marginal bone loss. (85) And according to T. Linkevicius, a minimum mismatch of 0.4 mm is required for platform switching to be effective. (78)

However, there are some limitations that can explain the different rates of bone loss between the studies analyzed. Some limitations are due to the realization of mostly conventional radiographic assessments that allow only the appreciation of mesial and distal values of marginal bone loss, and not the vestibular and lingual sides. There is also a lack of homogeneity between the studies analyzed, especially in terms of surgical protocol, implant design and connection, some used long implants (Canullo, Tramemell, Kielbasa, Pozzi…). Also, in some studies (Canullo et al 2010), the abutment diameters remain unchanged, but it was the implant platform diameter that was increased between the study groups to create the mismatch. (69) And it was shown that implant diameter has influence on the marginal bone loss. (86) Despite these limitations, and according to the literature, better preservation of marginal bone loss can be attributed to Platform-switching.

In the literature, the process by which platform-switching help to reduce marginal bone loss remains unclear. Some authors advocated for biological theory, but later it was shown that it was also associated to biomechanical reasons. (69)

First, a biological theory allowed to give an explanation to the impact of this concept to the bone loss. Due to the mismatch of diameters, the interface between implant and abutment is smaller, and is repositioned inwardly, as well as the microgap. So the horizontal distance increases between the inflammatory cells due to bacterial colonization and the marginal bone. The platform-switching allows the biological width repositioning, and a good mucosal sealing.

The biomechanical theory supports a reduction of stress at the implant-bone interface and a better distribution of the forces lead to a diminution of the microfractures in the marginal bone, limiting the marginal bone loss.

Some model analyzes were realized to understand the mechanism by which the platform switching concept influence the marginal bone loss around implants. (87) (88) (89)

K Juanes et al (87) studied the distribution of oblique and axial forces on a 3D finite element model in an article published in 2015, with 2 implants of 4.1mm diameter, one with an abutment of 4.1mm (matching implant-abutment diameters), another one with an abutment of 3.2mm diameter. Results showed that Platform-switching reduces the maximum stress level of axial loads in the cortical bone by 36%. With oblique loads, this concept allowed a reduction of 41% of the maximum stress level in the cortical bone. The values obtained in the trabecular bone were not considered significant.

Another study on two 3D finite element models was conducted by Se-Young Moon et al in 2017 (88), with 2 wide diameter implant : one connected to a wide diameter abutment, and the other one using the platform-switching concept, connected to a regular diameter abutment. It was observed that stress area was mainly located at the contact area between the abutment and the implant platform in both models, with higher values for the abutment. Indeed, in the platform switching model it was observed higher stress values, especially for the abutment (830 MPa) for which values were 8 times greater than for the matching implant-abutment model (107.41 MPa). For the abutment screw, higher stress values was observed (340 MPa) compared to the matching model (28.19MPa).

In the same way, another study conducted by Tabata et al in 2011 (89) used 3D finite element models with external hexagonal implant system and :

- Regular platform group (RP) : matching 4.1mm implant diameter with a regular 4.1mm UCLA abutment diameter
- Platform switching group (PS) : 5 mm wide implant diameter with a regular 4.1mm UCLA abutment diameter

- Wide platform group (WP): 5mm wide implant diameter with 5 mm UCLA abutment diameter

Results showed that most stress was concentrated at implant abutment connection, implant neck and in the peri-implant bone. Less intense stress and better distribution was associated with Platform Switching group (PS) and Wide Platform group (WP), compared to the Regular Platform group (RP), showing the influence of wider implant diameter. Even better results were obtained for the PS group, compared to the WP group, showing the efficacity of the platform-switching concept. But for the PS group, it was observed an increase of the stress values on the abutment screw.

Some limitations appeared due to the experimental nature of these experimental studies, the differences in methods, the difficulty in reproducing complex structures and the simplification of some parameters in the implant design (use of glue, rings instead of micro-threads). But despite these limitations, it was validated that the inward shifting of the loads at the interface implant-abutment limits stress at the margin of the implant platform. It was also observed that this modification in the repartition of forces shift the higher stress level inward, increasing stress on the abutment and on the screw. Centralizing stress can provoke mechanical complications such as abutment screw deformation, screw loosening, or component fractures. According to Tabata et al (89), since the loads don't reach the yield limit of Titanium (620-725 MPa), platform-switched implants are not more susceptible to screw fractures. However, it would be good to have longitudinal clinical trials to rule out this possible susceptibility to fractures due to repeated forces on the long term.

5. SOFT TISSUE THICKNESS

Despite a certain heterogeneity between the studies and the presence of cofounding factors such as platform-switching, screwed or cemented prosthesis, surgical technique with or without flap, etc, it has been established that a minimum of 2 mm thick initial crestal soft tissues is necessary to prevent marginal bone loss and to allow for the establishment of the biological space.

The reflection was also carried out in relation with the concept of platform switching. Most studies assessing the influence of the Platform-switching didn't take into account the initial thickness of the soft tissues.

Studies by Linkevicius have shown that soft tissue thickness is an important factor in peri-implant bone preservation. (7) A first study by Linkevicius (2009) showed that soft tissue thickness is a factor in peri-implant crestal bone stability, and that an initial vertical thickness of 2 mm is required for bone preservation. (90) A link was made with platform-switching : indeed, without this initial vertical thickness, platform-switching does not limit early marginal bone loss, which is due to the establishment of the biological width. He reconfirmed his results with his 2010 study, but this time with a larger sample. (91)

Likewise, Vandeweghe and De Bruyn (2012) have shown that platform-switching only has its full effect if required soft tissue thickness is present for the establishment of the biological space, otherwise early bone loss occur for the establishment of the biological width. (83)

More bone loss is associated with thin tissues biotypes. Increasing soft tissue thickness would be a possible solution to reach the required thickness threshold and thus prevent bone loss. Studies have shown that this solution works, and that crestal bone stability is maintained over time. There are different types of grafts such as autogenous graft from the palate, allogeneic graft (membrane), xenograft; but Porcine derived xenograft is recommended because a better bone augmentation can be expected than with autogenous, and it undergoes less shrinkage than allogeneic grafts. (70) (92) (78)

6. ABUTMENT HEIGHT

Abutment height has an impact on marginal bone loss, by influencing, among other things, the biological space reestablishment.

The selection of the abutment must be considered with a view to preventing bone loss. The quality and quantity (or thickness) of the gingival tissue will guide the practitioner in his choice.

Longer abutments are preferred to prevent marginal bone loss, since short abutments are associated with higher levels of bone loss. There are several explanations for this. One the one hand, with a short abutment, the distance between the bone and the interface crown-abutment is shorter. So, the bone is closer to the microgap that acts as a bacterial reservoir. An inflammatory reaction occurs, leading to bone loss.

On the other hand, short abutment (< 2mm) are associated with thin soft tissue biotype, that are the cause of bone loss due to biological width re-establishment.

According to Derks, short abutments impede a correct soft tissue sealing, provoking bone loss in response to bacterial invasion. But also, due to the shorter distance between the bone and the crown-abutment interface, especially if lower than 1.5mm, the prevalence of periimplantitis increases. Indeed, several factors act simultaneously. (71) (72)

In order to prevent bone loss, an optimal distance of 2mm from the crown to the bone crest was given by Galindo-Moreno. (93)

Moreover, an additional aspect of the importance of abutment height appeared with cemented prosthesis, compared to screw-retained prothesis : a short abutment associated with a cemented prosthesis with deep margins considerably increases the risk of bone loss due to the difficulty of removing cement remains.

CONCLUSION

Marginal bone loss around implants has a multifactorial etiology and can be explained by biological and mechanical factors. Of course, prevention includes diagnosis and treatment planning with the control of risk factors, a prior sanitation of the oral cavity, the therapeutic aspect, motivation for hygiene and professional maintenance. But there are some parameters over which the dentist has a certain flexibility which allows him to make choices in order to prevent or limit the risk of marginal bone loss around implants. These parameters are therefore part of a prevention protocol of marginal bone loss around implants.

- There is no consensus in the literature about an optimal implant length, but implant diameter appeared to be a more influent parameter : wider diameter implants have a bigger contact surface with the bone, reducing the stress for marginal bone and improving its distribution.

- For the positioning of the implant, It was commonly accepted that some rules must be respected in terms of horizontal distance: 3 mm for the inter-implant distance, and 1.5 mm for the tooth-implant distance. But it appears possible to reduce them, especially thanks to the platform-switching. However, there is no consensus about an optimal vertical positioning. Subcrestal implant position associated with platform-switching can present some advantages in terms of primary stability, emergence profile and esthetics.

- The selection of the type of connection has influence on the marginal bone loss, since the different systems behave differently. Internal connection, especially conical internal connection, allows a better loads distribution and a reduction of the risk of bacterial invasion into the bone. As part of a protocol to prevent marginal bone loss, it is also relevant to develop a treatment plan where the number of abutment disconnection-reconnection is limited, such as an immediate positioning and single abutment connection.

- Moreover it was demonstrated that Platform-switching allows a better bone preservation thanks to the inward reposition of the microgap, and to the better distribution of the forces.

- I should be remembered that a minimum of 2 mm of initial vertical soft tissue thickness is necessary to prevent marginal bone loss and to allow for the establishment of the biological space.

- Longer abutments are preferred to prevent marginal bone loss, since short abutments are associated with higher levels of bone loss

As part of a prevention protocol, it would be interesting to combine an implant with a sufficient diameter, an internal connection, platform-switching, a long abutment with a single abutment connection. Initial soft tissue thickening procedure may be necessary, for example with a xenograft.

More studies with a better homogeneity, would be needed to further improve protocols of prevention of marginal bone loss around implants.

RESPONSIBILITY

Dental implant treatment objective is to restore function, comfort, and esthetics with even better results compared to removable prosthesis, and with a certain reliability.

Implant treatment has the advantage, except in cases of total edentulousness, of allowing prosthetic restauration without adjacent teeth mutilation which are often healthy.

The development of marginal bone loss prevention protocols can improve the durability and the success rates of the implant treatment and therefore the quality of life of the patient. This review allows dentists to highlight certain parameters influencing marginal bone loss in order to facilitate the development of the treatment plan, with the aim of prevention

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ANNEXES

1. Buser D, Sennerby L, De Bruyn H. Modern implant dentistry based on osseointegration: 50 years of progress, current trends and open questions. Periodontol 2000. 2017;73(1):7–21.

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PERIODONTOLOGY 2000

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

DANIEL BUSER, LARS SENNERBY & HUGO DE BRUYN

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

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

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

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RESEARCH AND EDUCATION
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Osseointegration and its experimental background

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Osseointegration in clinical dentistry depends on an understanding of the healing and reparative capacities of hard and soft tissues. Its objective is a predictable tissue response to the placement of tooth root analogues. Such a response must be a highly differentiated one, and one that becomes organized according to functional demands. Since 1952, we have studied the concept of tissue-integrated prostheses at the Laboratory of Vital Microscopy at the University of Lund, and subsequently at the Laboratory for Experimental Biology at the University of Göteborg. Our collaborators in this research have included representatives from medical and dental faculties, various research institutes, and departments of technology. The basic aim has been to define limits for clinical implantation procedures that will allow bone and marrow tissues to heal fully and remain as such, rather than heal as a low differentiated scar tissue with unpredictable sequelae. The studies involved analyses of tissue injury and repair in diverse sites in different animals, with particular reference to microvascular structure and function. Special emphasis was placed on analyzing the disturbances caused in the intravascular rheology of blood by means of a series of different methodological approaches. The objective of this article is a brief review of the various investigations that have led to the clinical application of osseointegration.

CONCEPT DEVELOPMENT

The initial concept of osseointegration stemmed from vital microscopic studies of the bone marrow of the rabbit fibula, which was uncovered for visual inspection in a modified intravital microscope at high resolution in accordance with a very gentle surgical preparation technique. With special instrumentation, the marrow could be studied in transillumination in vivo, and in situ, after the covering bone was ground down to a thickness of only 10 to 20 μm. Circulation was maintained in this thin layer of bone and with very few signs of microvascular damage, which is the earliest and most sensitive indication of tissue injury. These intravascular studies of bone marrow circulation also revealed the intimate circulatory connection among marrow, bone, and joint tissue compartments. Subsequent studies of the regeneration of bone and marrow emphasized the close functional connection between marrow and bone in the repair of bone defects.

We, therefore, performed a series of in vivo studies on bone, marrow, and joint tissue with particular emphasis on tissue reaction to various kinds of injury: mechanical, thermal, chemical, and rheologic. We were also concerned with the various therapeutic possibilities to minimize the effect of such trauma. Aiming at a restitution ad integrum, we further sought to identify additional traumatic factors such as wound disinfectants and to explore the development of procedures that promote predictable healing of differentiated tissues.

We also performed long-term in vivo microscopic studies of bone and marrow response to implanted titanium chambers of a screw-shaped design. These studies in the early 1960s strongly suggested the possibility of osseointegration since the optical chambers could not be removed from the adjacent bone once they had healed in. We observed that the titanium chambers were inseparably incorporated within the bone tissue, which actually grew into very thin spaces in the titanium. Interdisciplinary clinical cooperation with plastic surgeons and otolaryngologists enabled us to study the repair of mandibular defects and replacement of ossicles by means of autologous bone grafts. Desired anatomic shapes of bone grafts were preformed in rabbits and dogs and subsequently applied clinically with long-term follow-up. In an extensive series, the repair of major mandibular and tibial defects in dogs was studied. Various procedures were used, with the most successful being the one based on the prior integration of titanium fixtures on both sides of the defect to be created later. When the fixtures had become safely incorporated within the bone, a defect

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Scand J Plast Reconstr Surg 3: 81–100, 1969

INTRA-OSSEOUS ANCHORAGE OF DENTAL PROSTHESES

I. *Experimental Studies*

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Abstract. An investigation of factors controlling healing and long term stability of intra-osseous titanium implants to restore masticatory function in dogs revealed that an integrity of the good anchorage of the implant requires: (1) Non-traumatic surgical preparation of soft and hard tissues and a mechanically and chemically clean implant. (2) Primary closure of the mucoperiosteal flap, to isolate the implant site from the oral cavity until a biological barrier has been reestablished. (3) Oral hygiene to prevent gingival inflammation. Provided these precautions are taken, it is possible to subject dental prostheses, connected to the implants, to unlimited masticatory load. With these precautions such implants were found to tolerate ordinary use in dogs for periods of more than 5 years without signs of tissue injury or other indications of rejection phenomena.

Macroscopic clinical investigation, stereomicroscopy, roentgenography and light microscopy of the implant site *in situ* and after removal from the body showed that the soft and hard tissues had accepted the implant and incorporated it without producing signs of tissue injury. In fact the bone appeared to grow into all the minute pits and impressions in the surface of the titanium implant, without any shielding layer of buffer tissue at all.

These findings indicate that dental prostheses can be successfully anchored intra-osseously in the dog suggesting that its possible clinical use in oral rehabilitation should be given unprejudiced consideration.

Attempts have long been made to devise a method for securing permanent anchorage of artificial dentures, total or partial, especially since retention of such dentures by conventional methods is difficult or sometimes even unacceptable. This is particularly apparent in cases where psychiatric and occupational factors make it difficult to use conventional removable dentures.

In some cases there is thus an obvious need for a permanently anchored artificial denture; this is also evident from the increasing number of models and methods of dental implants that have been tried in the last 10–15 years.

Though numerous types of implants have been tried, two main groups may be distinguished: a *subperiosteal* type and an *intra-osseous* type (Fig. 1). The former type consists of a more or less fine-meshed framework, which is inserted between the jawbone and its periosteum either as a single piece or in separate parts. From this framework or scaffolding abutments project into the oral cavity, where they serve as anchors for the artificial appliance.

At installation the bone in the area in question is exposed by raising a mucoperiosteal flap, after which an impression is made of the bone. The implant is shaped accordingly and, after a varying interval, it is inserted.

In the other main group, the intra-osseous group, various types of screws, posts or pins are anchored in the bone and projecting through the mucoperiosteum by an abutment for the appliance.

There are also methods which combine these two procedures, and one method consisting of implantation of magnets in the bone for retaining a magnetic appliance. The implants hitherto used consist mainly of stainless steel, chromium–cobalt–molybdenum alloys, tantalum or titanium.

Most investigations on humans comprise only a few cases, mostly running for a more or less

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Review Article

Current trends to measure implant stability

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Abstract Implant stability plays a critical role for successful osseointegration. Successful osseointegration is a prerequisite for functional dental implants. Continuous monitoring in an objective and qualitative manner is important to determine the status of implant stability. Implant stability is measured at two different stages: Primary and secondary. Primary stability comes from mechanical engagement with cortical bone. Secondary stability is developed from regeneration and remodeling of the bone and tissue around the implant after insertion and affected by the primary stability, bone formation and remodelling. The time of functional loading is dependent upon the implant stability. Historically the gold standard method to evaluate stability were microscopic or histologic analysis, radiographs, however due to invasiveness of these methods and related ethical issues various other methods have been proposed like cutting torque resistance, reverse torque analysis, model analysis etc. It is, therefore, of an utmost importance to be able to access implant stability at various time points and to project a long term prognosis for successful therapy. Therefore this review focuses on the currently available methods for evaluation of implant stability.

Key Words: Primary stability, resonance frequency analysis, secondary stability

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INTRODUCTION

Osseointegration is defined as a direct bone anchorage to an implant body which can provide a foundation to support prosthesis.[1,2] Implant stability is a requisite characteristic of osseointegration. Without it, long-term success cannot be achieved. Continuous monitoring in a quantitative and objective manner is important to determine the status of implant stability. Osseointegration is also a measure of implant stability which can occur in two stages: Primary and secondary.[3] Primary stability mostly occurs from mechanical attachment with cortical bone. Secondary stability offers biological stability through bone regeneration and remodeling.[4,5] Primary stability is affected by bone quality and quantity, surgical technique and implant geometry (length, diameter, surface characteristics). Secondary stability is affected by primary stability.[6]

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Objective measurement of implant stability is a valuable tool for achieving consistently good results that are influenced by:[7]

Good decisions about when to load

When a surgeon makes a decision about early loading, objective measurement of implant stability can be valuable. A specified degree of implant stability can serve as an inclusion criterion for immediate loading.

How to cite this article: Swami V, Vijayaraghavan V, Swami V. Current trends to measure implant stability. J Indian Prosthodont Soc 2016;16:124-30.

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Review Article

The dynamic interface: A review

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Abstract

The implant-to-tissue interface is an extremely dynamic region of interaction. Generally, a surgical procedure is performed on a patient to insert a foreign material into the bone, and the body is called on to "heal" the wound. The time schedule crucial for a healing process that is expected to result in *restitution ad integrum* must be determined with respect to the condition of the individual patient and tissue to be treated. There are various factors responsible for the formation of an adequate bone–implant interface. A comprehensive review of the response of bone to implant is described.

Key words: *Bone, implant, interface, osseointegration, risk factors, tissue*

INTRODUCTION

The term interface[1] is defined as a plane forming the common boundary between two parts of matter or space. It may represent a discrete boundary between the two materials or may consist of a region or zone of interactions between the two materials, i.e. the interface that exists between a dental implant and bone. The implant-to-tissue interface is an extremely dynamic region of interaction. The interface completely changes in character as it goes from its genesis (placement of the implant into the prepared bony site) to its maturity (healed condition). Relative movements (micromotion) between the implant and the bone at the time of placement are more likely to favor the development of a fibro-osseous interface. The healing phase of the interface is only the beginning of its dynamic nature. Generally, a surgical procedure is performed on a patient to insert a foreign material into bone, and the body is called on to "heal" the wound. A basic prerequisite for establishing true and lasting tissue integration of a non-biologic prosthesis with minimal risk of adverse local and general tissue reactions consists of a detailed understanding of the response behavior of highly differentiated hard and soft tissue to surgical preparation of the recipient site and installation of the prosthesis, as well as the long-term tissue adaptation to functional demands on the anchorage unit. The time schedule crucial for a healing process that is expected to result in *restitution ad integrum* (Latin term which means restoration to the original condition) must be determined with respect to the condition of the individual patient and the tissue to be treated.

HISTORICAL PERSPECTIVE

In 1952, Dr. Per Ingvar Branemark,[2] a Swedish anatomist, studied the functioning of the bone marrow and developed a technique known as *vital microscopy*. In this technique, a lens encased in titanium was introduced into the rabbit's tibia. After a month, this chamber was supposed to be retrieved, but to his

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The maintenance of crestal bone around dental implants

Author_Dr Mohammed A. Alshehri, Saudi Arabia

_Introduction

The longevity of dental implants is highly dependent on integration between implant components and oral tissues, including hard and soft tissues. Studies have shown that submerged titanium implants had 0.9 to 1.6 mm marginal bone loss from the first thread by the end of the first year in function, while only 0.05 to 0.13 mm bone loss occurred after the first year.[1–3]

The first report in the literature to quantify early crestal bone loss was a 15-year retrospective study that evaluated implants placed in edentulous jaws.[1] In this study, Adell *et al.* reported an average of 1.2 mm marginal bone loss from the first thread during healing and the first year after loading. In contrast with the bone loss during the first year, there was an average of only 0.1 mm bone lost annually thereafter.

Based on the findings on submerged implants, Albrektsson *et al.* and Smith and Zarb proposed criteria for implant success, including a vertical bone loss of less than 0.2 mm annually following the implant's first year of function.[4,5]

Non-submerged implants have also demonstrated early crestal bone loss, with greater bone loss in the maxilla than in the mandible, ranging from 0.6 to 1.1 mm, at the first year of function.[6–8]

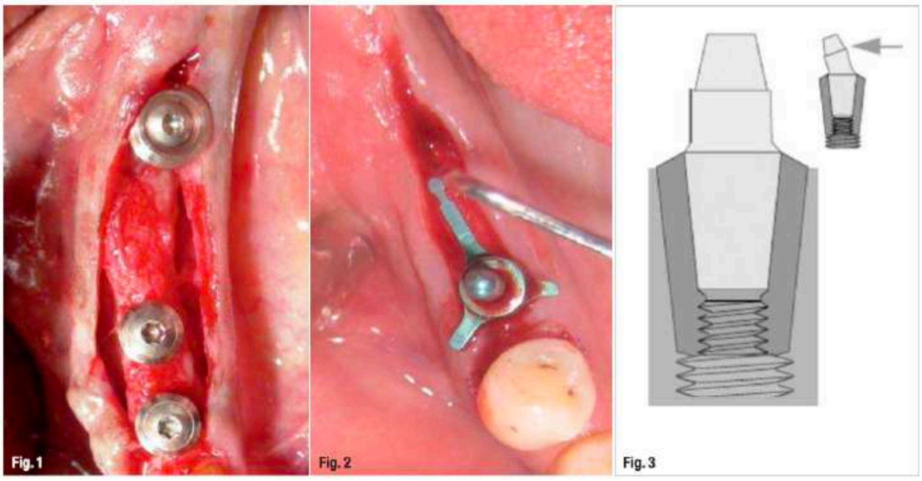

Fig. 1 Fig. 2 Fig. 3

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Influence of Soft Tissue Thickness on Peri-Implant Marginal Bone Loss: A Systematic Review and Meta-Analysis

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Background: Multiple variables have been shown to affect early marginal bone loss (MBL). Among them, the location of the microgap with respect to the alveolar bone crest, occlusion, and use of a polished collar have traditionally been investigated as major contributory factors for this early remodeling. Recently, soft tissue thickness has also been investigated as a possible factor influencing this phenomenon. Hence, this study aims to further evaluate the influence of soft tissue thickness on early MBL around dental implants.

Methods: Electronic and manual literature searches were performed by two independent reviewers in several databases, including Medline, EMBASE, and Cochrane Oral Health Group Trials Register, for articles up to May 2015 reporting soft tissue thickness at time of implant placement and MBL with ≥12-month follow-up. In addition, random effects meta-analyses of selected studies were applied to analyze the weighted mean difference (WMD) of MBL between groups of thick and thin peri-implant soft tissue. Metaregression was conducted to investigate any potential influences of confounding factors, i.e., platform switching design, cement-/screw-retained restoration, and flapped/flapless surgical techniques.

Results: Eight articles were included in the systematic review, and five were included in the quantitative synthesis and meta-analyzed to examine the influence of tissue thickness on early MBL. Meta-analysis for the comparison of MBL among selected studies showed a WMD of −0.80 mm (95% confidence interval −1.18 to −0.42 mm) ($P<0.0001$), favoring the thick tissue group. Metaregression of the selected studies failed to demonstrate an association among MBL and confounding factors.

Conclusion: The current study demonstrates that implants placed with an initially thicker peri-implant soft tissue have less radiographic MBL in the short term. *J Periodontol 2016;87:690-699.*

KEY WORDS

Alveolar bone loss; dental implant-abutment design; dental implants; endosseous dental implantation; evidence-based dentistry; review, systematic.

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Preservation of crestal marginal bone remains one of the most desired outcomes in implant dentistry.[1] Traditionally, marginal bone loss (MBL) <1.5 mm was defined as a reference point for successful implant treatment after 1 year of loading.[2] However, with the use of new surface technologies and new implant designs and the availability of new research on factors affecting bone remodeling,[3] this concept should be re-defined; having 1.5mm of MBL is no longer acceptable during the first year in function. In fact, a recent investigation has demonstrated that 96% of implants with MBL >2 mm during the first 18 months presented with ≥0.44 mm bone loss 6 months postloading.[4] This initial remodeling has traditionally been related to a variety of factors, including inadequate occlusion,[5] the presence of a microgap,[6] use of an implant with a smooth collar,[7] infection,[8] and more importantly, soft tissue thickness and its influence during re-establishment of the biologic width.[9]

Progressive MBL around the implant neck is a prelude to peri-implantitis development.[4] Hence, minimizing or preventing this initial bone remodeling is of paramount importance, starting at the time of implant placement. With this purpose in mind, many researchers have tested the efficacy of different methods, such as platform switching (PS),[10]

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The Influence of Initial Soft Tissue Thickness on Peri-Implant Bone Remodeling

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Hugo De Bruyn, DDS, MSc, PhD*‡

ABSTRACT

Aim: To elucidate the influence of initial soft tissue thickness on peri-implant bone remodeling. The research hypothesis was that implants installed in patients or at sites with thin mucosal tissues would show increased peri-implant bone loss.

Material and Methods: 79 edentulous patients were consecutively treated with two non-splinted implants supporting an overdenture in the mandible. During recall-visits, peri-implant health was determined by means of probing pocket depth and the modified plaque/bleeding index. Digital peri-apical radiographs were taken from individual implants. Bone level changes were measured from a reference point (lower border of the smooth implant collar) to the marginal bone-to-implant contact level. The linear mixed-effect model analysis was adopted to analyze the influence of clinical parameters and transmucosal abutment height on peri-implant bone loss.

Results: 67 patients attended the 1-year and 66 the 2-year recall-visit. Mean bone level changes were 0.89 mm (SD 0.62) and 0.90 mm (SD 0.66), plaque scores 0.82 (SD 0.94) and 0.87 (SD 0.92), bleeding scores 0.46 (SD 0.68) and 0.56 (SD 0.72) and PPD 1.65 mm (SD 0.60) and 1.78 mm (SD 0.59) after 1 year and 2 years respectively. The linear mixed-effect model revealed increasing bone level changes with decreasing abutment heights. Peri-implant bone level changes were significantly higher for implants with abutments of <2 mm (1.17 mm, $p < .01$; 1.23 mm, $p < .01$), 2 mm (0.86 mm, $p < .01$; 1.03 mm, $p < .01$) or 3 mm (0.38 mm, $p = .046$; 0.41 mm, $p = .044$) compared to ≥4 mm-abutments (bone level changes set to zero as reference value) both after 1 year and 2 years and bone level changes were significantly influenced by probing pocket depth ($p < .01$, $p < .01$), but not by plaque ($p = .31$, $p = .09$) and bleeding scores ($p = .30$, $p = .40$).

Conclusion: The present study suggests that implants with lower abutments, reflecting the initial gingival thickness, lose more peri-implant bone, possibly by a re-establishment of the biological width.

KEY WORDS: biologic width, dental implant, overdenture, peri-implant bone loss, soft tissue

INTRODUCTION

The dentogingival junction defines the soft tissue dimensions around teeth including the gingival sulcus, the junctional epithelium and supracrestal connective tissue. Gargiulo and colleagues found an average biological width, referring to the epithelial and connective tissue attachment of 2.04 mm around natural teeth in human skulls with corresponding average measures of 0.69 mm for the sulcus depth, 0.97 mm for the junctional epithelium and 1.07 for the connective tissue attachment. They further described a stable dimension in relation to the alveolar crest, but an individual variation was observed within patients and within sites of the same patient, especially in the epithelial component.[1] These findings were confirmed by Vacek and colleagues with the description of an average biological width of 1.91 mm in human cadaver jaws.[2] The term periodontal biotype was described by Seibert and Lindhe.[3] They described a thick-flat biotype with quadratic-looking teeth and a wide and voluminous zone of keratinized tissue and a thin-scalloped biotype with slender teeth and very narrow zones of keratinized tissue. De Rouck and colleagues found 1/3 of their sample corresponding to previously described thin-scalloped biotype and 2/3

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Short Communication

Dimension of the periimplant mucosa

Biological width revisited

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Berglundh T, Lindhe J: Dimension of the periimplant mucosa. Biological width revisited. J Clin Periodontol 1996; 23: 971–973. © Munksgaard, 1996.

Abstract. The objective of the present study was to determine the dimension of the mucosal-implant attachment at sites with insufficient width of the ridge mucosa. 5 beagle dogs were used. Extractions of all mandibular premolars were performed and 3 months later, 3 fixtures of the Brånemark System® were installed in each side. Following 3 months of healing, abutment connection was carried out. On the right or left side of the mandible, abutment connection was performed according to the Brånemark System® manual – (control side). On the contralateral side (test side), an incision not extending through the periosteum was made at the crest of the ridge. The soft tissue was dissected and a critical amount of connective tissue on the inside of the flap was excised. The periosteum was subsequently incised, abutment connection performed, and the trimmed flaps sutured. The sutures were removed after 10 days. After a 6-month period of plaque control, the animals were sacrificed, biopsies sampled and processed for light microscopy. The length of the junctional epithelium varied within a rather narrow range; 2.1 mm (control side) and 2.0 mm (test side). The height of the suprabony connective tissue in this model varied between 1.3±0.3 mm (test side) and 1.8±0.4 mm (control side). At sites where the ridge mucosa prior to abutment connection was made thin (≤2 mm), wound healing consistently included bone resorption. This implies that a certain minimum width of the periimplant mucosa may be required, and that bone resorption may take place to allow a stable soft tissue attachment to form.

Key words: periimplant mucosa; attachment; histometry; biological width

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In a series of studies from our laboratory the structure and function of the keratinized, non-mobile gingiva and the corresponding periimplant mucosa were examined in the beagle dog model (Berglundh et al. 1991, 1992, 1994, Ericsson et al. 1992). The 2 tissues were found to have many features in common. Thus, both soft tissues included a junctional epithelium that was about 2 mm in "apico-coronal" direction and was separated from the bone crest by a zone of connective tissue attachment >1 mm high. The fibers within the supraalveolar tissue at the tooth site originated from the acellular, extrinsic fiber cementum on the root surface, while the majority of the fibers at the implant sites occurred in an avascular compartment and were apparently anchored in the periosteum of the bone crest. In a recent experiment in the dog (Abrahamsson et al. 1996), it was observed that the mucosal barrier that formed following successful 1- and 2- stage implant installations had similar composition, i.e. it was comprised of one zone of junctional epithelium and one zone of connective tissue. Furthermore, it was detected that at sites where the mucosa of the edentulous ridge was thin, (i) angular bone defects occurred at the marginal border of the implants, and (ii) the dimension of the mucosal attachment to the implant was similar to that of sites with a thick mucosa. This feature of the implant – tissue interface was characteristic for both 1- and 2- stage implant systems. Abrahamsson et al. (1996) suggested that a certain width of the periimplant mucosa is required to enable a proper epithelial-connective tissue attachment, and if this soft tissue dimension is not satisfied, "bone resorption will occur to ensure" the establishment of attachment with a appropriate "biological width". The objective of the present study was to further test this hypothesis.

Material and Methods

5 beagle dogs, about 1 year old, were used. Extractions of all mandibular pre-

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Dimensions and Relations of the Dentogingival Junction in Humans

by ANTHONY W. GARGIULO, D.D.S., M.S., FRANK M. WENTZ, D.D.S., PH.D., AND BALINT ORBAN, M.D., D.D.S.*

IN 1921, Gottlieb's discovery of the epithelial attachment of the gingiva opened new horizons which served as the basis for a better understanding of the biology of the dental supporting tissues in health and disease. Three years later his pupils, Orban and Kohler (1924), undertook the task of measuring the epithelial attachment as well as the surrounding tissue relations during the four phases of passive eruption of the tooth. Gottlieb and Orban's descriptions of the epithelial attachment unveiled the exact morphology of this epithelial structure, and clarified the relation of this structure to the enamel of the tooth.

In recent years the prevailing concept of the epithelial attachment was challenged by Waerbaug.[3] He returned to the old concept of a potential space extending from the gingival margin to the cementoenamel junction. Waerhaug's altered convictions were based upon several observations. These are: (1) he was able to insert a thin steel blade into this space without pressure. From histologic sections, he claimed that there was no difference between the epithelium of the intact areas and in the area where the blade was inserted. (2) In addition he claimed that after a gingival flap had been pulled away from the enamel surface and the flap repositioned, no difference could be seen between the operated and the non-operated areas. Repetition of these procedures by Orban[4] have shown Waerhaug's findings could not be verified under similar experiments. Gottlieb's discovery was in the least reconfirmed; however Waerhaug's challenge was not without benefit. The so-called strength of adherence of the epithelial attachment, and the organic nature of the attachment had to be reconsidered. The author's are now inclined to subscribe to Weski's[5] idea; mainly that the epithelium after enamel maturation, produces a cementing substance that attaches the epithelium to the enamel surface and later to the surface of the cementum. It now seems impossible that Gottlieb's original idea of a union between ameloblast and the forming and maturing enamel rods could survive the final calcification of the enamel matrix.

Discussions with Sicher (1959)[6] lead to the reconsideration of the mode of attachment and the formulation of a physiologic division of labor of the supporting tissues at the "dento-gingival junction." This established the concept of the dentogingival junction as a functional unit composed of two parts: (1) the connective tissue fibrous attachment of the gingiva and (2) the epithelial attachment. The two separate components share a division of function.

The biologic protection of the dentogingival junction is the function of the epithelial attachment. The epithelium attaches to the circumference of the tooth as a broad band the "attached epithelial cuff." The epithelial attachment to the tooth is not firmly attached in spite of the fact that it is stronger than the individual cohesiveness of the epithelial cells. The firmness of the gingival attachment to the tooth is derived by the fibrous connective tissue bound to the cementum, alveolar bone and gingiva.

Because of the dynamic alterations in the component parts of the dentogingival junction it is important to know their positions in all phases of eruption under normal conditions. The importance of this relation is enhanced when one considers the imbalance of these components in periodontal disease. Thus, these dimensions can serve as a base line for future studies involving the pathologic status of the dentogingival junction and serve as "the physiologic dentogingival junction."

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*Dr. Orban died June 1, 1960.

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CLINICAL ORAL IMPLANTS RESEARCH

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Morphogenesis of peri-implant mucosa revisited: an experimental study in humans

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Key words: biologic width, dental implants, histology, human, morphometry, soft tissue, titanium

Abstract
Aim: To apply a novel human model to evaluate the morphogenesis of the mucosal attachment to implants.
Material and methods: Twenty one patients receiving implant-supported single-tooth replacement were enrolled in this study. After implant installation, a custom-designed experimental abutment was connected to the implant. Soft tissue biopsies representing 2, 4, 8 or 12 weeks of healing were collected by the use of a circular cutting device and prepared for histological analysis.
Results: The soft tissue biopsies were retrieved, preserved and processed with a technique that was safe and reproducible. The results from the histological analysis in regards to dimensional and qualitative changes in the mucosa over time were consistent with those reported from animal experiments. At 8 weeks, the soft tissue dimension was about 3.6 mm and included a barrier epithelium of 1.9 mm and a connective tissue portion of 1.7 mm. Similar dimensions were found at 12 weeks.
Conclusion: It is suggested that the new human model provides advantages in terms of cost-effectiveness in research as well as from ethical aspects and should be considered as an alternative to pre-clinical *in vivo* studies in animals.

Introduction

The establishment and maintenance of an efficient soft tissue seal around a dental implant are hallmarks for implant success. The formation of such a soft tissue barrier is the result of a wound-healing process, and results from animal experiments, that is, pre-clinical *in vivo* research, have revealed that the established mucosal attachment to the implant is comprised of one 1.5- to 2-mm-high epithelial portion and one 1- to 1.5-mm-high connective tissue portion (Berglundh et al. 1991; Buser et al. 1992; Abrahamsson et al. 1996; Berglundh & Lindhe 1996; Cochran et al. 1997). Similar to the osseointegration process, the build-up of the connective tissue elements and the functioning epithelial barrier in the mucosal interface to the implant takes several weeks. Thus, Berglundh et al. (2007) in an experimental study in Labrador dogs reported that the formation of a barrier epithelium commenced at 1–2 weeks and was completed at 6–8 weeks of healing. It was also reported that collagen fibers in the connective tissue portion became organized at 4–6 weeks of healing. Experimental studies have also been used to determine differences in soft tissue healing around different implant system (De Sanctis et al. 2010) and implants with different materials (Welander et al. 2008) and to evaluate the influence of the surgical protocol, that is, immediate implant installation (Vignoletti et al. 2009).

In a consensus report on pre-clinical *in vivo* research in implant dentistry (Berglundh & Stavropoulos 2012), it was stated that such research is performed to evaluate proof-of-principle concepts, such as biological mechanisms, pathological conditions, possible adverse reactions to candidate materials or devices prior to clinical testing. The report also underlined that the knowledge derived from such analyses should be optimally utilized and promote the 3R principle (Replacement, Reduction, Refinement) in the planning and evaluation of experiments. While experimental models in animals in

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20

Bone Quality Assessment for Dental Implants

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1. Introduction

Dental implants have become a predictable treatment option for restoring missing teeth. The purpose of tooth replacement with implants is to restore adequate function and esthetics without affecting adjacent hard and/or soft tissue structures. The use of dental implants in oral rehabilitation has currently been increasing since clinical studies with dental implant treatment have revealed successful outcomes (Turkyilmaz et al., 2008a). The successful outcome of any implant procedure depends on a series of patient-related and procedure-dependent parameters, including general health conditions, biocompatability of the implant material, the feature of the implant surface, the surgical procedure, and the quality and quantity of the local bone. (Turkyilmaz et al., 2007)

Successfully providing dental implants to patients who have lost teeth and frequently the surrounding bone relies on the careful gathering of clinical and radiological information, on interdisciplinary communication and on detailed planning. One of the most important factors in determining implant success is proper treatment planning. In the past, periapical radiographs along with panoramic images were used as the sole determinants of implant diagnosis and treatment planning. With the advancement of radiographic technology, Computed tomography (CT), as well as cone-beam computed tomography (CBCT) is increasingly considered essential for optimal implant placement, especially in the case of complex reconstructions (Benson & Shetty, 2009; Chan et al., 2010; Resnik et al., 2008).

2. Radiologic examination

The objectives of diagnostic imaging depend on a number of factors, including the amount and type of information required and the period of the treatment rendered. The desicion to image the patient is based on the patient's clinical needs. After a desicion has been made to obtain images, the imaging modality is used that yields the necessary diagnostic information related to the patient's clinical needs and results in the least radiologic risk (Resnik et al., 2008).

The ideal imaging technique for dental implant care should have several essential characteristics, including the ability to visualize the implant site in the mesiodistal, bucco-lingual and superioinferior dimensions; the ability to allow reliable, accurate measurements; a capacity to evaluate trabecular bone density and cortical thickness; reasonable access and cost to the patient and minimal radiation risk (Benson & Shetty, 2009). Diagnostic imaging is an integral part of dental implant therapy for preoperative planning, intraoperative assessment, and postoperative assessment by use of a variety of imaging techniques.

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CLINICAL ORAL IMPLANTS RESEARCH

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Ambiguity in bone tissue characteristics as presented in studies on dental implant planning and placement: a systematic review

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Key words: bone density, dental implant, systematic literature review

Abstract

Objectives: To survey definitions of bone tissue characteristics and methods of assessing them in studies of dental implant planning and placement.

Material and methodology: Three databases were searched using specified indexing terms. Three reviewers selected from the titles and retrieved abstracts in accordance with inclusion and exclusion criteria. Descriptions of bone tissue characteristics (bone quality, density and quantity) used before or during dental implant placement were searched for and categorized.

Results: The search yielded 488 titles. One hundred and fort-nine publications were selected and read in full text. One hundred and eight were considered relevant. There were many different definitions and classification systems for bone tissue characteristics and examination protocols. Approximately two-third of the included publications reported the Lekholm & Zarb classification system for bone quality and quantity. However, only four studies implemented the Lekholm & Zarb system as originally proposed. A few publications described bone quality in accordance with the Misch or Trisi and Rao classifications systems. Assessment methods were often described only briefly (or not at all in one-fifth of the publications). Only one study presented the diagnostic accuracy of the assessment method, while only two presented observer performance.

Conclusion: The differing definitions and classification systems applied to dental implant planning and placement make it impossible to compare the results of various studies, particularly with respect to whether bone quality or quantity affect treatment outcomes. A consistent classification system for bone tissue characteristics is needed, as well as an appropriate description of bone tissue assessment methods, their diagnostic accuracy and observer performance.

The justification for assessing jawbone tissue in endosseous dental implant treatment is twofold: (1) as a diagnostic tool to assess whether the jawbone tissue is sufficient for implant treatment; (2) as a prognostic tool to predict the probability of success or failure, as the bone tissue characteristics of quality, quantity and density are considered important with regard to treatment outcomes (Friberg et al. 1991). However, it is not evident from the literature what bone quality, bone quantity or bone density represent. It is even difficult to find definitions of these terms in studies whose main objective was to evaluate bone tissue characteristics and treatment outcomes (Engquist et al. 1988; Jaffin & Berman 1991; Jemt 1993; Friberg et al. 1995, 1999; Jemt & Lekholm 1995; Razavi et al. 1995; Truhlar et al. 1997a, 1997b; Trisi & Rao 1999; Bahat 2000; O'Sullivan et al. 2000; Choel et al. 2003; Locante 2004; Herrmann et al. 2005).

A classification system for jaw anatomy (jaw shape and quality) frequently referred to in publications on endosseous dental implant treatment was proposed by Lekholm & Zarb (1985). The system is presented as drawings of the jaws accompanied by text, and assessment methods to classify the bone tissue are recommended. Bone quality is broken down into four groups according to the proportion and structure of compact and trabecular bone tissue, and the quantity of jawbone is broken down into five groups, based on residual jaw shape following tooth extraction. Other classifications of bone tissue have also been used in studies of dental implants (Misch 1990b; Trisi & Rao 1999). Differing classification systems for bone tissue characteristics may lead to confusion and interfere with attempts to compare the results of various studies. Furthermore, the evidence for the efficacy of clinical methods to assess jawbone

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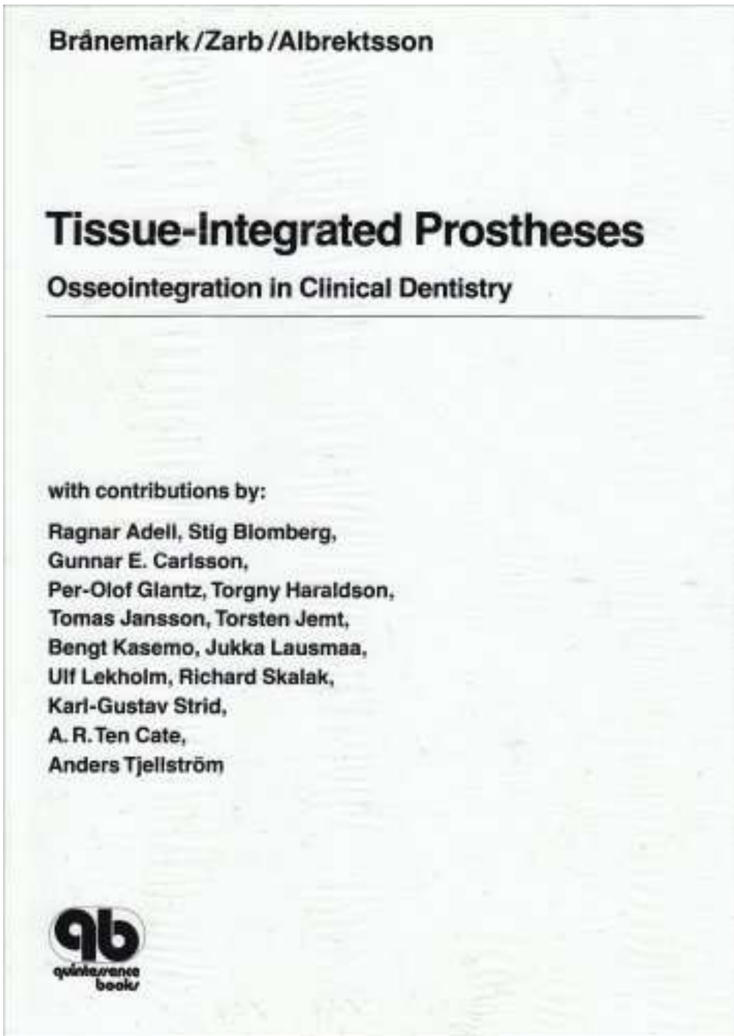

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Influence of bone parameters on peri-implant bone strain distribution in the posterior mandible

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Abstract

Objectives: The success rate of dental implants depends on the type of bone at the implant site. The purpose of the present study was to investigate the effects of the bone parameters at the implant-placement site on peri-implant bone strain distributions.

Study Design: The morphologies and bone densities of seventy-five potential implant sites in the posterior mandible were measured using computed tomography (CT). Based on the CT data, we defined bone parameters (low and high in terms of cancellous-bone density and crestal-cortical bone density, and thin and thick in terms of crestal-cortical bone thickness), and we constructed finite-element models simulating the various bone types. A buccolingual oblique load of 200 N was applied to the top of the abutment. The von Mises equivalent (EQV) strains in the crestal-cortical bone and in the cancellous bone around the implant were calculated.

Results: Cancellous-bone density greatly affected the maximum EQV strain regardless of the density and thickness of the crestal cortical-bone. The maximum EQV strains in the crestal cortical-bone and the cancellous bone in the low-density cancellous-bone models (of 150 Hounsfield units (HU) were 1.56 to 2.62-fold and 3.49 to 5.31-fold higher than those in the high-density cancellous-bone models (of 850 HU), respectively. The crestal cortical-bone density affected the maximum EQV strains in the crestal cortical-bone and in the cancellous bone in the low-density cancellous-bone models. The crestal cortical-bone thickness affected the maximum EQV strains in the cancellous bone and in the crestal cortical-bone in the low-density cancellous-bone models.

Conclusions: Our results confirm the importance of bone types for the peri-implant bone strain distribution. Cancellous-bone density may be a critical factor for peri-implant bone strain.

Key words: *Dental implant, bone density, finite-element analysis.*

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Relationship Between Long-Term Marginal Bone Loss and Bone Quality, Implant Width, and Surface

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Blas Noguerol, MD, PhD[4]/Antonio Magán-Fernández, MSc[1]/Francisco Mesa, MD, PhD[5]

Purpose: *Short- or long-term implant survival and success are related to peri-implant marginal bone loss (MBL), among other key factors. The purpose of this study was to analyze the role of clinical and implant-related variables in MBL over a long-term follow-up.* ***Materials and Methods:*** *A retrospective study of 558 implants in 172 patients was conducted, analyzing the relationship between MBL and clinical, implant-related, and prosthetic design–related variables. MBL was measured on digital radiographs with specific software, using implant threads as reference.* ***Results:*** *Linear mixed analysis revealed the following significant effects: a lower mean MBL for type IV bone (0.047 mm/year, 95% CI [–0.019, 0.119]) than for type III bone (0.086 mm/year, 95% CI [0.038, 0.138]), type II bone (0.112 mm/year, 95% CI [0.070, 0.167]), or type I bone (0.138 mm/year, 95% CI [0.052, 0.23]); an increased MBL of 0.033 mm/year for each increment of 1 mm in diameter (95% CI [0.002, 0.065]); a lower mean MBL in smooth implants (0.103 mm/year, 95% CI [0.090, 0.117]) vs rough implants (0.122 mm/year, 95% CI [0.102, 0.142]). The mean MBL was > 0 mm/year for all prostheses except for fixed complete dental prostheses.* ***Conclusion:*** *Within the limits of a retrospective follow-up study, a lower mean peri-implant MBL was associated with type IV bone, a smaller diameter, a smooth surface, and a fixed complete dental prosthesis.* Int J Oral Maxillofac Implants 2016;31:398–405. doi: 10.11607/jomi.4245

Keywords: *alveolar bone loss, bone tissue, dental implants, implant-supported dental prosthesis*

Once osseointegration has been achieved, short- or long-term implant survival and success are related to peri-implant marginal bone loss (MBL), among other key factors.[1] An MBL of up to 2 mm at 1 year after implant loading has become accepted as clinically "normal."[2] It was reported that 97% of implants with an MBL > 0.45 mm at 6 months postloading show a rapid and progressive MBL up to 2 mm at 1 year.[3] However, recent short-term[4] and long-term[5] studies have demonstrated an absence of pre-implant MBL, attributed to the development of novel implant surfaces and geometries.

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Short-term MBL appears to be influenced by multiple factors. Thus, Albrektsson et al considered osseointegration as a foreign-body reaction, with MBL being an imbalance in this reaction.[6] MBL has also been described as a biologic response to surgical trauma, overdrilling, and/or excessive heat[7] or to removal of the periosteum, which would account for approximately 1 mm of crestal bone loss.[8] Other authors have reported that MBL results from the establishment of the biologic width after prosthesis placement.[9,10] Galindo-Moreno et al observed that MBL was virtually absent after the surgical phase, increased after prosthetic loading, and was again stabilized at 6 months postloading.[3]

Other factors that have been proposed to influence long-term MBL include: IL1 gene polymorphisms (alleles 1 and 2 of the IL1A gene and alleles 1 and 2 of the IL1B gene)[11]; the presence of pathogenic microflora[12]; tobacco consumption[13]; implant-related characteristics, such as the switching platform[14]; macroarchitecture[15,16]; connection type[17]; implant diameter and surface[18]; and the prosthetic design.[19] Authors of the most widely used classification of bone quality, based on the bone density and distribution of cortical-medullary bone,[20] reported that the best response is obtained in type II bone and the worst in type IV bone. A more rapid osseointegration may be possible using implants with a rough versus smooth surface,[21] but this roughness may then have a negative

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Keywords: Dental implants; Implantation; Bone; Patient; Resorption; X-ray analysis; Peri-implant mucositis; Peri-implantitis

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Research Article

Marginal bone resorption at dental implant – RTG analysis

Abstract

Dental implants are modern solutions, they compensate the lost tooth or teeth in the maxilla or mandible. Their target is to improve the mastication, esthetics and phonation. They are made of metal, metal alloys or non-metallic materials. An important factor for successful implantation is biocompactibility. Bone resorption is destruction of bone tissue, and the loss of bone tissue is conducted by osteoclasts and mononuclear cells. In this final paper are described the peri-implant diseases exactly the peri-implant mucositis and peri-implantitis. This diseases are complication of ossteointegrated dental implants, and they make changes of the soft and bone tissue around the implant. They bring marginal bone resorption, around the dental implant, and they do destruction of the bone tissue. RTG analysis were made, with intention to see how much the marginal bone resorption is around the dental implants.

Introduction

Dental implantology is an area of dentistry that involves the insertion of dental implants in order to compensate for the lost tooth and improve the function of mastication, phonation and aesthetics [1]. This paper presents 12 patients who have been implanted 23 dental implants. Osteointegrated dental implants, after a period of 4 to 12 months, are characterized by changes in the alveolar bone. Certain factors lead to resorption of the alveolar bone, especially in the marginal part of the alveolar bone. One of the factors is the infectious agents i.e. the presence of pathogens on the site where the implant will be placed, their presence and around the abutment itself. Furthermore, the impact of traumatic injuries, occlusal trauma in the patient, excessive strain on the dental implant are also one of the factors that lead to marginal bone resorption [2].

Bone resorption is the destruction of bone tissue, whereby bone tissue loss occurs and is carried out by osteoclasts and mononuclear cells. Osteoclasts are responsible for the demineralization of the bone, while mononuclear cells play a major role in the process of degradation of the organic matrix. Bone resorption is the most critical factor in the loss of attachment process. The height and density of the alveolar bone is maintained by means of an equilibrium between the apposition and bone resorption, which is regulated by systemic and local influences. When we have bone resorption, which exceeds the formation, bone height and density are reduced.

The resorption of the alveolar bone can be of a vertical or horizontal type. The vertical type of bone resorption, localized marginally, around the osteointegrated dental implant is characterized by the presence of defects that are placed under a slant angle in relation to the longitudinal axis of the implant. While at horizonal loss of the alveolar bone, we have a bone that is reduced in height, but the bone edges are perpendicular to the tooth surface. The tissue healing process around the dental implant is similar to the physiological recovery of bone tissue. Studies on titanium implants in terms of their recovery are divided into three phases: osteoconductive, osteoarthritic and osteophilic [3].

The success of surgery, aesthetically and functionally depends on the amount of bone tissue and gingival tissue. The amount of alveolar bone loss in the first year affects sulcus. Increasing the depth of sulcus affects the longevity of the dental implant [4]. Radiographic analysis has shown that the shape of the micronut is very important in minimizing the loss of marginal alveolar bone during the stress-free phase and functional load. Such a surface on the microwave is recommended, around the neck of the implant acts preventively for the loss of the marginal alveolar bone and helps the early biomechanical adaptation of the load [5,6].

RTG - analyzes in front of the dental implants

Before the lining of dental implants, we had a thorough planning phase, in which we determined how many dental implants would be placed, their position and length. In planning, rhg analyzes enabled us to find out more data on the anatomical structures of the maxilla and mandible. When

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Parameters Associated with Marginal Bone Loss around Implant after Prosthetic Loading

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This study evaluated retrospectively the association among occlusal, periodontal and implant-prosthetic parameters and marginal bone loss (MBL) around implants and survival rate at 5.7 ±3.2 years of follow-up after prosthetic loading. Eighty-two patients received 164 external hexagon implants. After the standard healing period (3 to 6 months), the implants were restored with single-tooth or up to three splinted crowns. All patients were followed according to a strict maintenance program with regular recalls and clinically evaluated by a calibrated examiner. The MBL measurements taken from standardized radiographs made at permanent crown placement (baseline) and after the last evaluation were calculated considering occlusal, periodontal and implant-prosthetic parameters. Veneer fractures and abutment loosening were not considered failure. Two implants failed during the follow-up period, resulting in a survival rate of 98.8%. Cox regression analyses showed MBL associated with non-working side contacts (p=0.047), inadequate anterior guidance (p=0.001), lateral group guidance involving teeth and implants (p=0.015), periimplant plaque index (p=0.035), prosthetic design (p=0.030) and retention (p=0.006). Inadequate occlusal pattern guide, presence of visible plaque, and cemented and splinted implant-supported restoration were associated with greater MBL around the implant.

Key Words: implant survival, dental implant, observational studies, bone remodeling, occlusal guidance.

Introduction

Despite the excellent survival rates of dental implants, long-term studies have shown 1.5 to 2 mm of bone loss around the implant neck during the first year after functional loading (1,2) and an annual rate of marginal bone loss (MBL) around 0.2 mm, after the first year (3). Among other factors, this acceptable bone loss is most likely due to occlusal forces directed on the bone, which responds mechanically to this situation, remodeling it naturally (4). However, when the MBL reaches greater levels than those commonly observed in the first and subsequent years, it is possible that mechanical or biological risk factors had caused this loss, which may culminate in gradual or total loss of osseointegration (5).

A multifactorial background is linked to the onset and progression of marginal bone loss and later complications due to periodontal and implant-prosthetic risk factors such as implant location, prosthetic design and retention (3,4). Excessive surgical trauma together with an impaired healing ability, bacterial infection and biomechanical overload are among the most common causes of early implant losses (5). Progressive chronic peri-implant infection and overload together with the host characteristics are considered as major etiological factors causing late failures (5). It seems that infection alone cannot cause progressive bone resorption, but overloading associated with marginal peri-implant infection could certainly result in MBL and implant failure (6,7). The occlusion of implant-supported prostheses has been assessed but poorly studied in longitudinal clinical studies. Thus, this issue represents a gap in the knowledge of the longevity of the implant-prosthesis assembly (8,9). Although several aspects concerning implant survival rate and peri-implant bone loss have been reported, (1-11) there is still lack of clinical investigations in humans considering the role of unsuitable occlusal factors on the establishment and maintenance of oral implant osseointegration (12-14), together with implant-prosthetic and periodontal parameters.

This study evaluated retrospectively the association among occlusal, periodontal and implant-prosthetic parameters and MBL around implants and survival rates at 5.7±3.2 years of follow-up after prosthetic loading. The tested hypothesis was that the MBL is influenced by the evaluated parameters.

Material and Methods

Patient Selection

This cross-sectional observational study was approved by the Local Research Ethics Committee (protocol n° 01/2013) and followed the STROBE guidelines for reporting observational trials (15). Included patients were treated by properly trained clinicians at the Graduate Program in Dentistry from August 2004 to December 2013, received external hexagon implants (Neodent, Curitiba, PR, Brazil) following a single protocol (16) and a 3-6 month period was allowed before prosthetic loading. The inclusion criteria for

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The Long-Term Efficacy of Currently Used Dental Implants: A Review and Proposed Criteria of Success

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Criteria for the evaluation of dental implant success are proposed. These criteria are applied in an assessment of the long-term efficacy of currently used dental implants including the subperiosteal implant, the vitreous carbon implant, the blade-vent implant, the single-crystal sapphire implant, the Tübingen implant, the TCP-implant, the TPS-screw, the ITI hollow-cylinder implant, the IMZ dental implant, the Core-Vent titanium alloy implant, the transosteal mandibular staple bone plate, and the Brånemark osseointegrated titanium implant. An attempt has been made to standardize the basis for comments on each type of implant.

Dentists and dental specialists employ considerable clinical skills in an effort to cope with the consequences of partial and/or complete edentulism. These consequences are related mainly to partial or total deficits in one or both jaws' complement of periodontal ligaments. As a result, clinical ingenuity has led to many treatment successes, with prostheses supported by varying degrees of residual periodontium and/or alveolar bone. The notion of an analogue for a periodontal ligament attachment with predictable long-term success, has of necessity intrigued clinical researchers for several decades. Regrettably, the many proposed implant prescriptions to fulfill this objective did not survive scientific scrutiny, and the ideal implant (like the ideal dental cement) went on being frequently described, but never encountered. As a result clinical educators on both sides of the Atlantic were prone to regard the prescriptions on use of implants as "human experimentation without informed consent," a departure from the *Primum Non Nocere* commitment of the health professional. In 1978, an NIH-sponsored Consensus Development Conference[1] sought an update of the status of dental implants. This was a brave effort indeed, but one that fell somewhat short of what was really needed. With the obvious advantage of hindsight, several reasons can be advanced for the state-of-the-art, rather than the state-of-the-science report, which the conference produced:

1. A failure to address comprehensively the research literature on the subject. As a result, a significant body of already published European research was overlooked.
2. A failure to go beyond a retrospective rationalization of implant systems in limited, albeit scientifically untested, use.

Consequently, the consensus statement proposal of minimal criteria for implant success was sadly reminiscent of the early five-year cure rate criteria for cancer therapy—a reflection of the half-way state of biotechnology in the dental implant field as perceived on the North American continent.

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DOI 10.1007/s11033-014-3133-6

Meta-analysis of the association between common interleukin-1 polymorphisms and dental implant failure

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Abstract Interleukin-1 (IL) plays a pivotal role in immune–inflammatory response that maintains periodontal homeostasis. A number of epidemiological studies have been conducted to investigate the associations between common polymorphisms of *IL-1* (*IL-1A*, *IL-1B*) genes and risk of peri-implant disease, but the findings remain inconclusive. Thirteen studies evaluating the association between IL-1 polymorphisms and risk for peri-implant diseases (implant failure/loss, peri-implantitis) were included. Fixed model or random-effects models were applied to calculate overall and ethnicity-specific summary odds ratios (ORs) and corresponding 95 % confidence intervals (CIs) as risk estimates for *IL-1* polymorphisms individually or in combination. Heterogeneity and publication bias were evaluated by Q-test, I^2 statistic, Begg's funnel plot and Egger's test accordingly. The composite genotype of *IL-1A* (−889) and *IL-1B* (+3954) was associated with increased risk of implant failure/loss (OR 1.76, 95 % CI 1.21–2.57) and peri-implantitis (OR 2.34, 95 % CI 1.03–5.33). The significance was borderline in European descents (implant failure/loss: OR 1.48, 95 % CI 0.99–2.22; peri-implantitis: OR 1.65, 95 % CI 1.00–2.73). T allele of *IL-1B* (−511) was associated with increased risk of implant failure/loss (OR 1.28, 95 % CI 1.01–1.62), while the association was not significant in European descents (OR 1.12, 95 % CI 0.85–1.48). These findings support a potential role of *IL-1* polymorphisms, particularly the composite genotype of *IL-1A* (−889) and *IL-1B* (+3954), in peri-implant disease susceptibility. More studies with large sample size are needed to validate the associations.

Keywords IL-1 polymorphism · Genotype · Peri-implant disease · Peri-implantitis · Implant failure

Abbreviations

IL-1	Interleukin-1
CI	Confidence interval
HWE	Hardy–Weinberg equilibrium
OR	Odds ratio

Jian Liao and Chao Li contributed equally to this work.

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Introduction

Use of dental implant has become popular since Branemark and his colleagues introduced the dental titanium implants in 1982. This trend is expected to continue at a rapid rate over the next decades. Dental implants are now the most chosen option for oral rehabilitation in edentulous and partially dentate patients because of its high predictability and success rate [1]. Nevertheless, failures do occur despite adequate surgical and medical treatment, with reported global failure rates of 1.9–3.6 % [2–4].

Osseointegration, referring to the process of direct anchorage of the implant surface to the surrounding host bone, is a prerequisite and an alternative term for clinical

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Proinflammatory Gene Expression at Chronic Periodontitis and Peri-Implantitis Sites in Patients With or Without Type 2 Diabetes

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Background: Diabetes and periodontal diseases are often associated. Both have highly inflammatory components, but the role played by distinct phlogistic mediators in their pathogenesis is not fully understood and remains controversial. The purpose of this study is to evaluate whether type 2 diabetes alters the expression of inflammatory mediators in sites with chronic periodontitis (CP) or peri-implantitis (P-IM).

Methods: The expression of tumor necrosis factor (TNF)-α, interleukin (IL)-6 and -8, and monocyte chemotactic protein (MCP)-1 plus key CC chemokine receptors (CCR1 through 5) and CXC chemokine receptors (CXCR1 through 3) was quantified by real-time polymerase chain reaction (PCR) in gingival or peri-implant biopsies from 135 patients with well-controlled or poorly controlled diabetes and periodontal disease, 65 patients with periodontal disease but otherwise healthy, and 90 systematically and periodontally healthy subjects. Western blots were performed.

Results: Relative to controls, in patients without diabetes and patients with well-controlled diabetes, TNF-α, CCR5, and CXCR3 expression was exclusively higher in sites with P-IM ($P<0.01$), whereas IL-6 and -8 were overexpressed in sites with CP and, even more, in sites with P-IM ($P<0.01$). In patients with poor glycemic control, TNF-α, CCR5, and CXCR3 mRNAs were increased in sites with CP ($P<0.01$). A statistically significant higher IL-6 and -8 expression from patients without diabetes and patients with well-controlled diabetes was observed compared to patients with poorly controlled diabetes. Regardless of metabolic/glycemic status, MCP-1 and CCR2 and 4 were markedly higher in both of the oral pathologies examined ($P<0.01$). At the protein levels, Western blot experiments confirmed the real-time PCR results.

Conclusions: These findings showed that: 1) in subjects without diabetes and patients with well-controlled diabetes, TNF-α, CCR5, and CXCR3 may constitute distinctive biomarkers of P-IM; 2) poor glycemic control abolished the differences between CP and P-IM regarding the expression of these mediators; and 3) type 2 diabetes affected the expression of TNF-α, IL-6 and -8, CCR5, and CXCR3. *J Periodontol 2010;81:99-108.*

KEY WORDS

Chronic periodontitis; cytokines; diabetes mellitus; receptors, chemokine.

Diabetes mellitus (DM) is a systemic disease with several major complications affecting the quality and length of life. Periodontal disease has been considered another diabetic complication, in addition to cardiovascular disease, nephropathy, retinopathy, neuropathy and peripheral vascular diseases.[1,2] Southerland et al.[3] suggested that periodontal disease and diabetes share a common pathogenesis involving an increased inflammatory response at the local and systemic level. Patients with periodontal diseases often have elevated serum levels of proinflammatory cytokines, whereas patients with diabetes have hyperinflammatory immune cells that can exacerbate the elevated production of proinflammatory cytokines. This exacerbation has the potential to increase insulin resistance and makes it more difficult for the patient to control diabetes.[4] An increasing number of studies reported that alterations in inflammatory cytokine levels may be

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Original Article

The effects of diabetes mellitus on peri-implant marginal bone loss in the posterior maxilla

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Abstract

Aim: The aim of this retrospective study was to evaluate the effects of Diabetes Mellitus on peri-implant marginal alveolar bone loss in sinus lifted well-controlled diabetic patients at long term.
Materials and Methods: Thirty eight patients with 77 dental implants were included the study. The study consists of 2 groups; control group (C) and diabetes mellitus group (DM). The dental implants were placed after open window maxillary sinus lifting surgery at maxillary posterior region. After conventional loading process patients were followed periodically for bone loss and clinical parameters. The peri-implant marginal bone loss was assessed at minimum 3 years after functional loading. Standardized panoramic radiographs were obtained at the baseline and maintenance which were used for evaluating the marginal bone loss and clinical and anatomical crown to implant ratio. The Student-t test and Mann Whitney-U test were used to analyse any significant differences between two groups ($p<0.05$). The Kruskal Wallis test was used for inter-group comparisons of parameters and Chi-square test, Fisher's Exact Chi-square test and Continuity (Yates) correction were used to compare qualitative data. Spearman's rho correlation analysis was used to examine the relationships between parameters with non-normal distribution.
Results: A total of 77 dental implants were followed up for at least 36 months. The mean follow-up was 43.47±10.30 months. 2 implants were failed in DM group. The mean marginal bone loss in DM and C group were 1.35±1.22 mm and 0.91±1 mm respectively. There was no statistically significance in terms of marginal bone loss between the two groups ($p>0.05$).
Conclusion: Within the limitations of this study, it was shown that long-term follow-up results of dental implants in well-controlled diabetic patients were similar to those of healthy individuals and DM did not increase the peri-implant marginal bone loss.

Keywords: Crown to implant ratio; diabetes mellitus; marginal bone loss; sinus lifting.

INTRODUCTION

Dental implants have been successfully applied over the past years for dental restoration in cases of partial or complete edentulism (1). When compared to dental prostheses, it was known that dental implants, which had become an alternative treatment to restore missing teeth, offer more satisfactory and superior results in terms of aesthetics, comfort and function (2).

Although dental implant procedures were a promising treatment modality, the efficacy of this treatment depends on successful osseointegration at the time of healing (3). Osseointegration could be defined as a direct functional and structural integration between the living bone and the implant surface, characterized by a direct formation of the bone matrix and osteoblasts on the implant surface, with no soft and fibrous tissue on the bone-implant junction surface (4,5).

Most experimental studies had shown that in diabetic patients, bone formation around dental implants may be deficient or delayed, and that the newly formed bone was immature and poorly regulated (6). Hyperglycemia caused a decrease in the level of osseointegration of the implant due to its negative effects on bone formation and remodeling (7). Soft tissues were also affected by microvascular complications of hyperglycemia, vascularization of the tissues was decreased, healing was delayed, and the wound became vulnerable to infection. In

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Effects of diabetes on the osseointegration of dental implants

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ABSTRACT

The increased prevalence of diabetes mellitus has become a public health problem. Hyperglycaemia entails a rise in the morbidity and mortality of these patients. Although a direct relationship with periodontal disease has already been shown, little is known about the results of dental implants in diabetics.

The present paper reviews the bibliography linking the effect of diabetes on the osseointegration of implants and the healing of soft tissue. In experimental models of diabetes, a reduced level of bone-implant contact has been shown, and this can be reversed by means of treatment with insulin. Compared with the general population, a higher failure rate is seen in diabetic patients. Most of these occur during the first year of functional loading, seemingly pointing to the microvascular complications of this condition as a possible causal factor. These complications also compromise the healing of soft tissues. It is necessary to take certain special considerations into account for the placement of implants in diabetic patient. A good control of plasma glycaemia, together with other measures, has been shown to improve the percentages of implant survival in these patients.

Key words: *Diabetes Mellitus, hyperglycaemia, osseointegration, implant.*

RESUMEN

El incremento en la prevalencia de la diabetes mellitus se ha convertido en un problema de salud pública. La hiperglucemia conlleva un aumento en la morbilidad y mortalidad de estos pacientes. Aunque ya se ha demostrado una relación directa con la enfermedad periodontal, poco se conoce sobre el resultado del implante dental en el sujeto diabético.

En el presente trabajo se revisa la bibliografía que relaciona el efecto de la diabetes sobre la oseointegración de los implantes y la cicatrización de los tejidos blandos. En modelos experimentales de diabetes se ha demostrado una reducción en los niveles de contacto hueso-implante, que puede ser revertida mediante tratamiento con insulina. En el paciente diabético, comparado con la población general, se observa un mayor índice de fracaso. La mayoría de ellos se producen durante el primer año de carga funcional, lo que parece señalar a las complicaciones microvasculares de la enfermedad como posible factor causal. Dichas complicaciones comprometen también la cicatrización de los tejidos blandos. Se hace necesario establecer unas consideraciones especiales para la colocación de implantes en el paciente diabético. El buen control de la glucemia plasmática, junto con otras medidas, ha demostrado mejorar los porcentajes de supervivencia de los implantes en estos pacientes.

Palabras clave: *Diabetes Mellitus, hiperglucemia, oseointegración, implante.*

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INFLUENCE OF DIABETES ON THE SURVIVAL RATE AND MARGINAL BONE LOSS OF DENTAL IMPLANTS: AN OVERVIEW OF SYSTEMATIC REVIEWS

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Abstract:	We aimed to conduct an analysis of the systematic reviews in literature about the implant survival rate (ISR) and marginal bone loss (MBL) in diabetic and non-diabetic patients. This work was registered in The International Prospective Register of Systematic Reviews (PROSPERO) (CRD42018095314) and was developed following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and the Cochrane Library Handbook. A search was performed on PUBMED, COCHRANE, SCOPUS, EMBASE, and LILACS. The PICO question was "Do the survival rates of dental implants and marginal bone loss differ between diabetic and non-diabetic patients?" A total of 130 articles were retrieved. After eliminating repetitions, 118 were reviewed. Finally, six systematic reviews were included, all the reviews indicated that there is no effect of diabetes on the ISR; however, a negative effect of the disease can be observed in MBL. Analysis of the quality of the studies was performed using the assessment of systematic reviews in dentistry (Glenny Scale) and Assessing the Methodological Quality of Systematic Reviews (AMSTAR 2). Glenny scale showed a moderate to high quality of the included studies. In contrast, AMSTAR 2 pointed out a critically low level for four studies, with no study fulfilling the criteria for high quality. It may be concluded that there is no effect of diabetes on the ISR; however, a negative effect of the disease can be observed on MBL.

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RESEARCH Open Access

Influence of antihypertensive medications on the clinical parameters of anodized dental implants: a retrospective cohort study

Keisuke Seki[1,2*], Akira Hasuike[1,3], Yoshihiro Iwano[4] and Yoshiyuki Hagiwara[1]

Abstract

Background: Hypertension is a chronic medical condition in which blood pressure in the arteries is elevated. Given the large proportion of dental implant patients using antihypertensive medications, it is crucial to evaluate the effects of these drugs on the clinical parameters of osseointegrated implants. The aim of the present retrospective cohort study was to evaluate the influence of antihypertensive medications on clinical peri-implant tissue parameters.

Methods: Thirty-five patients received a total of 77 anodized dental implants. Based on the history of the use of antihypertensive medications, the patients were divided into two groups: the group taking antihypertensive medications (AH group) and the group of healthy patients (H group). Implants were followed up clinically and radiologically, with a focus on the peri-implant soft tissue parameters probing pocket depth, bleeding on probing, modified plaque index, and marginal peri-implant bone level stability.

Results: None of the implants were lost, and no technical failures occurred. The mean follow-up duration was 7 years and 1 month. A significant difference was observed in the probing pocket depth 3.8 ± 1.3 mm in the AH group and 3.0 ± 0.7 mm in the H group. In the AH and H groups, 26.5% (9/34) and 4.7% (2/43) of the patients were diagnosed with peri-implantitis at the implant level, respectively.

Conclusions: Our findings suggest some correlations between antihypertensive medication use and clinical parameters in anodized peri-implant tissue.

Keywords: Dental implants, Antihypertensive medications, Peri-implantitis, Clinical study

Background

Dental implants are the best option for replacing missing teeth, which show sufficient longevity in most cases. Even though dental implants have a long-term success rate of more than 90%, some people experience complications as with any treatment modality. Technical and biological complications can occur in implant dentistry [1]. The biological complications related to dental implants include peri-implant mucositis and peri-implantitis. There is no definitive evidence regarding the etiology and clinical countermeasures for these two biological complications [2]. Various risk indicators have been discussed, and etiological similarities between periodontal and peri-implant tissues have been of interest to clinicians and researchers [3]. Both periodontitis and peri-implantitis are initiated by the accumulation of microbial biofilms on the hard surfaces of the teeth or dental implants [4, 5].

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SYSTEMATIC REVIEWS

Impact of osteoporosis in dental implants: A systematic review

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Abstract

AIM: To assess the failure and bone-to-implant contact rate of dental implants placed on osteoporotic subjects.

METHODS: Extensive examination strategies were created to classify studies for this systematic review. MEDLINE (*via* PubMed) and EMBASE database were examined for studies in English up to and including May 2014. The examination presented a combination of the MeSH words described as follow: "osteoporosis" or "osteopenia" or "estrogen deficiency" AND "implant" or "dental implant" or "osseointegration". Assessment of clinical and/or histological peri-implant conditions in osteoporosis subjects treated with titanium dental implants. The examination included a combination of the MeSH terms described as follow: "osteoporosis" or "osteopenia" or "estrogen deficiency" AND "implant" or "dental implant" or "osseointegration".

RESULTS: Of 943 potentially eligible articles, 12 were included in the study. A total of 133 subjects with osteoporosis, 73 subjects diagnosed with osteopenia and 708 healthy subjects were assessed in this systematic review. In these subjects were installed 367, 205, 2981 dental implants in osteoporotic, osteopenic and healthy subjects, respectively. The failure rate of dental implant was 10.9% in osteoporotic subjects, 8.29% in osteopenic and 11.43% in healthy ones. Bone-to-implant contact obtained from retrieved implants ranged between 49.96% to 47.84%, for osteoporosis and non-osteoporotic subjects.

CONCLUSION: Osteoporotic subjects presented higher rates of implant loss, however, there is a lower evidence to strengthen or refute the hypothesis that osteoporosis may have detrimental effects on bone healing. Consequently, final conclusions regarding the effect of osteoporosis in dental implant therapy cannot be made at this time. There are no randomized clinical trial accessible for evaluation and the retrospective

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Dental Implants in Patients with Osteoporosis – A Review

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ABSTRACT

Osteoporosis is a systemic skeletal disease affecting the bone strength which deteriorates the bone mass, strength and affects the micro-architecture of the bone thus increasing the bone turn over and bone fragility. Osteoporosis also affects the jaw bones and Bisphosphonates are the first line of therapy. Hence, Osteoporosis is considered as a questionable condition for dental implant placement. However literature states that patients with osteoporosis do not appear to be at a significant risk of implant failure. Patients with Osteoporosis are not a contraindication for dental implants. This paper presents a review on Dental implants in patients with Osteoporosis.

Keywords: Dental Implants, Bone density, Osteoporosis, Implant stability.

INTRODUCTION

Dental implants have become a common and frequent treatment option for tooth replacement. Assessment of patients' medical condition is essential before treatment planning. Patients may present various systemic conditions as a challenge to dentists. Osteoporosis is a systemic skeletal disease affecting the bone strength. Around 300 million people are affected with Osteoporosis worldwide[1]. The condition is more common in women, especially post-menopause. The occurrence of Osteoporosis increases with age. Osteoporosis deteriorates the bone mass, strength and affects the micro-architecture of the bone thus increasing the bone turn over and bone fragility. The success of dental implants largely depends on Osseointegration. Factors that interfere with Osseointegration act as a potential threat to the implant prognosis. Osteoporosis also affects the jaw bones and bisphosphonates are the first line of therapy[2]. Hence, Osteoporosis is considered as a questionable condition for dental implant placement. With more number of patients receiving oral bisphosphonates, it is quiet normal to expect few of them requiring dental implants. This paper presents a review on Dental implants in patients with Osteoporosis.

Osseointegration of dental implants

The direct structural and functional relationship between ordered living bone and the surface of a load bearing implant is termed as osseointegration. Ordered living bone is an environment of constant remodeling. This dynamic process represents the balance between bone resorption and formation around the dental implant[3]. A sequence of events occurs in the osteotomy site

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Implant rehabilitation in patients irradiated for head and neck cancer: role of Intensity-Moduled Radiotherapy (IMRT) in planning the insertion site

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Summary

Purpose: currently, head and neck irradiation is not considered an absolute contraindication for implant placement (1), especially due to the transition from conventional to conformal radiotherapy. However, there is a difference in the success rate of implant placement between irradiated and non-irradiated bones (5). Successful osseointegration is mainly affected by the total dose of radiation (6). The main purpose of this study was to minimize problems related to radiation dose by evaluating in advance the most suitable site for implant insertion on the basis of the mean absorbed dose. Additional aims were: to estimate the appropriate timing for implant insertion in irradiated bones, to analyze the difference in stability between maxilla and mandible, and to evaluate the success of implants with wrinkled microgeometry and increased layer of TiO_2.

Materials and methods: five patients who had been irradiated for head and neck cancer using intensity-modulated radiotherapy (IMRT) were recruited for our study. Surgical procedures were performed following a pre-surgical evaluation of the correct insertion position of implant fixtures. The latter was based on a scrutiny of dose-volume histograms (DVH) developed by a team of experts in medical physics and radiotherapists after dentists had contoured the volumes of interest. Student's *t* test and Pearson's correlation test were used for comparison and correlation between the variables considered.

Results: the percentage of osseointegration was 100%, which supports the usefulness of the adopted technique. A statistically significant difference in stability and crestal bone resorption emerged in the comparison between maxilla and mandible, but not between times of insertion. Moreover, there was a significant correlation between radiation dose and ISQ values: an increase in radiation dose corresponded to a decrease in primary stability. However, the correlation between ISQ values and implant length was not significant as well as that between primary stability and implant diameter.

Conclusions: implantology guided by assessment of absorbed irradiation dose in the site to be rehabilitated can lead both to an increase in implant survival into irradiated tissue bone, and to a reduction in the incidence of ORN. However, both a larger sample size and the development of long-term prospective studies are necessary to validate the described method.

Key words: implants rehabilitation, contouring, IMRT.

Introduction

Radiotherapy side effects, sometimes combined with post-surgical consequences, affect patient's social life by causing a considerable psychological discomfort and cause important complications in both oral rehabilitation and restoration of dental occlusion (1).
While the inability of many patients to tolerate conventional removable prostheses has been widely documented, the use of dental implants often increases both patient's satisfaction and quality of life by allowing a reconstruction of tumor defects, a proper retention of removable prostheses and a reduction of the overload of vulnerable soft tissues (2,3).
Prior to 1986 (4), patients who had received head and neck radiation were usually excluded from implant reconstruction because of previous reports of hard and soft tissue damage (reduced vascularity, altered cellularity and tissue hypoxia), which would have theoretically interfered with successful osseointegration of titanium endosseous implants.
Today, head and neck irradiation is not considered anymore an absolute contraindication for implant placement (1), although a difference in success rate of implant placement between irradiated and non-irradiated bones can still be observed (5).
Successful osseointegration is mainly affected by total dose of radiation (6): while doses lower than 45 Gy are not associated with implant failure, doses in the 50-60 Gy range are usually not a contraindication for implantology

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Viability of dental implants in head and neck irradiated patients: A systematic review

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Running title: Dental implants in irradiated head and neck

Key words: Dental implant, osseointegration, radiotherapy, endosseous implant, radiation therapy

Summary

Based on the reviewed studies, the interval time between radiotherapy and implant placement as well as the radiation doses are not associated with significant implant failure rates. The placement of osseointegrated dental implants in irradiated bone is viable, and head and neck radiotherapy should not be considered as a contraindication for dental rehabilitation with implants.

Abstract

Background: This systematic review aimed to evaluate the safety of dental implants placed in irradiated bone and to discuss their viability when placed post-radiotherapy.

Methods: A systematic review was performed to answer the questions: "Are dental implants in irradiated bone viable?" and "What are the main factors that influence the loss of implants in irradiated patients?".

Results: The search strategy resulted in 8 publications. A total of 331 patients received 1237 implants, with an overall failure rate of 9.53%. The osseointegration success rates ranged between 62.5% and 100%. The optimal time interval between irradiation and dental implantation varied from 6 to 15 months.

Conclusions: The interval time between radiotherapy and implant placement and the radiation doses are not associated with significant implant failure rates. The placement of implants in irradiated bone is viable, and head and neck rasdiotherapy should not be considered as a contraindication for dental rehabilitation with implants.

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Osseointegration in Irradiated Cancer Patients: An Analysis With Respect to Implant Failures

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Purpose: This study retrospectively evaluated implant survival of 631 osseointegrated implants installed in irradiated cancer patients over a 25-year period.

Patients and Methods: The files of 107 patients followed since 1979 were evaluated. Factors influencing implant survival as oncologic treatment, radiotherapy protocols, patient and implant related elements were analyzed.

Results: Compared with a control group of non-irradiated patients, implant failures were higher after previous radiotherapy. High implant failures were seen after high dose radiotherapy and a long time after irradiation. All craniofacial regions were affected, but the highest implant failures were seen in frontal bone, zygoma, mandible, and nasal maxilla. Lowest implant failures were seen in oral maxilla. The use of long fixtures, fixed retention, and adjuvant hyperbaric oxygen therapy decreased implant failures. Noncontributing factors to implant survival were gender, age, smoking habits, tumor type and size, surgical oncologic treatment, and osseointegration (OI) surgery experience.

Conclusion: Survival after cancer therapy is so high, and outcome from OI therapy so favorable that OI in the irradiated patient can be recommended. However, the OI clinician should be aware of the risks and pitfalls of treating such patients.

J Oral Maxillofac Surg 63:579-585, 2005

Previous radiotherapy was originally considered a contraindication for installation of osseointegrated implants (OI) in cancer patients.[1] Nevertheless, this has been tried in many countries with variable results. In the literature, there is an intense discussion concerning the outcome of OI in cancer patients.[2-10] There seems to be a disagreement whether implant failures or other complications are more common after previous irradiation. There is no general consensus when the ideal time is to rehabilitate cancer patients with OI implants, how irradiation doses affect implant survival, if irradiation after implant installation is possible, whether chemotherapy affects OI, or if hyperbaric oxygen therapy (HBO) is necessary. A number of questions arise concerning what other factors might affect implant survival in the irradiated tissues.

Beginning in 1979, we have used the OI concept for rehabilitation of cancer patients, and in 1981 we operated on the first patient that had been irradiated. Since that time we have gathered experience from more than 100 irradiated cancer patients and more than 1,100 non-irradiated patients (350 of which were cancer patients) treated according to the osseointegration principle. Some clues to the questions above can be related to long-term follow-up of irradiated cancer patients. Because of the Swedish health care system, we have been able to follow each patient from the beginning of treatment. The present investigation was undertaken in an attempt to answer the above questions how OI implants perform in the irradiated tissues.

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Patients and Methods

The amount of data gathered during these 25 years required a database to be able to handle it all. Such a database was created using the Microsoft Excel system (Microsoft, Redmond, CA). Approval for the

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Dental Implant Placement in Patients on Bisphosphonate Therapy: a Systematic Review

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ABSTRACT

Objectives: The review aims to study dental implant placement purposefulness for patients who have been treated or are on treatment with bisphosphonate medication.
Material and Methods: Structured search strategy was applied on electronic databases: MEDLINE, PubMed, PubMed Central and ResearchGate. Scientific publications in English between 2006 and 2017 were identified in accordance with inclusion, exclusion criteria. Publication screening, data extraction, and quality assessment were performed. Outcome measures included implant failure or implant-related osteonecrosis of the jaw.
Results: In total, 32 literature sources were reviewed, and 9 of the most relevant articles that are suitable to the criteria were selected. Heterogeneity between the studies was found and no meta-analysis could be done. Five studies analysed intraoral bisphosphonate medication in relation with implant placement, three studies investigated intravenous bisphosphonate medication in relation with implant placement and one study evaluated both types of medication given in relation with implant placement. Patients with intraoral therapy appeared to have a better implant survival (5 implants failed out of 423) rate at 98.8% vs. patients treated intravenously (6 implants failed out of 68) at 91%; the control group compared with intraoral bisphosphonate group appeared with 97% success implant survival rate (27 implants failed out of 842), showing no significant difference in terms of success in implant placement.
Conclusions: Patients treated with intravenous bisphosphonates seemed to have a higher chance of developing implant-related osteonecrosis of the jaw. The intraorally treated patient group appeared to have more successful results. Implant placement in patients treated intraorally could be considered safe with precautions.

Keywords: bisphosphonate-associated osteonecrosis of the jaw; bisphosphonate osteonecrosis; dental implants; oral surgery.

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Bisphosphonate treatment and dental implants: A systematic review

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Abstract

Background: To analyze articles that studied patients submitted to diphosphonates therapy and who received dental implants before, during or after bisphosphonate (BP) treatment, compared to healthy patients, analyzing the increase of failure and loss of implants or bisphosphonate related osteonecrosis of the jaw (BRONJ) incidence.
Material and Methods: The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement was used in this study. The clinical question in "PICO" format was: In patients under bisphosphonate therapy, do dental implants placement, compared to healthy patients, increase the failure and loss of implants or bisphosphonate related osteonecrosis of the jaw incidence? PubMed/MEDLINE was searched for articles published up until April 15, 2015 using a combination of MeSH terms and their Entry terms.
Results: The search resulted in 375 articles. After selection according to the eligibility criteria, 15 studies fulfilled were included (eight retrospective, one prospective and six case series), with a total of 1339 patients analyzed, 3748 implants placed, 152 loss of implants and 78 cases of BRONJ.
Conclusions: Due to the lack of randomized clinical trials looking at this theme, further studies with longer follow-up are needed to elucidate the remaining questions. Thus, it is wise to be careful when planning dental implant surgery in patients undergoing bisphosphonate therapy because of the risk of developing BRONJ as well as occurring failure of implant. Moreover, complete systemic condition of the patient must be also taking into considering when such procedures are performed.

Key words: *Bisphosphonates, diphosphonates, dental implants, osteonecrosis.*

34. Kasat V, Ladda R. Smoking and dental implants. J Int Soc Prev Community Dent. 2012;2(2):38.

Review Article

Smoking and dental implants

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Abstract

Smoking is a prevalent behaviour in the population. The aim of this review is to bring to light the effects of smoking on dental implants. These facts will assist dental professionals when implants are planned in tobacco users. A search of "PubMed" was made with the key words "dental implant," "nicotine," "smoking," "tobacco," and "osseointegration." Also, publications on tobacco control by the Government of India were considered. For review, only those articles published from 1988 onward in English language were selected. Smoking has its influence on general as well as oral health of an individual. Tobacco negatively affects the outcome of almost all therapeutic procedures performed in the oral cavity. The failure rate of implant osseointegration is considerably higher among smokers, and maintenance of oral hygiene around the implants and the risk of peri-implantitis are adversely affected by smoking. To increase implant survival in smokers, various protocols have been recommended. Although osseointegrated dental implants have become the state of the art for tooth replacement, they are not without limitations or complications. In this litigious era, it is extremely important that the practitioner clearly understands and is able and willing to convey the spectrum of possible complications and their frequency to the patients..

Key words: *Bone, dental implants, nicotine, osseointegration, smoking, titanium, tobacco*

INTRODUCTION

One of the most imperative developments in modern dentistry is the ability to replace missing teeth using titanium implants placed directly into the jaw. From one tooth to a whole arch or simply to stabilise a moving denture, implant dentistry can offer a successful alternative to many restorative problems. The major breakthrough in implant success which ultimately led to the very successful materials and techniques now being used was made in 1952 by a Swedish orthopedic surgeon named Per-Ingvar Branemark while investigating microscopic healing of bony defects in rabbit using specially designed microscope heads made up of titanium. These were placed firmly in holes drilled into the thigh bone. At the end of the experiment while attempting to retrieve the microscope heads, he found that they could not be removed and had actually integrated into the bone. He called this innovation as "osseointegration." Further studies convinced him that the titanium was biocompatible and could be used in humans.

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Smoking is a prevalent behaviour in the population all over the world. The aim of this review is to shed light on the effects of smoking with special emphasis on dental implants. For this, a search of "PubMed" was made with the key words "dental implant," "nicotine," "smoking," "tobacco," and "osseointegration." Also, publications on tobacco control by the Government of India were considered.

SMOKING AND HEALTH

4.83 million people worldwide died in 2000 as a result of their addiction to nicotine.[1] This number is sufficient to explain the harm being caused by tobacco. Tobacco appears to be as old as human civilization and was introduced into India by Portuguese traders during AD 1600. It spread like fire to such a great extent that today India is the second largest producer and consumer of tobacco in the world.[2] Nicotine increases

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Original Article

Evaluation of marginal bone loss around dental implants in cigarette smokers and nonsmokers. A comparative study

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Abstract

Background: The overall success of osteointegrated dental implants depends on various factors. The deleterious effects of smoking on wound healing after the tooth extraction and its association with poor quality of bone are well documented. Similar effects of tobacco use on the success of dental implants are expected. Cigarette smoke mainly contains nicotine that delays the bone healing and increases the rate of infections at the implant insertion site. **Aim:** The purpose of the present study was to evaluate and compare the marginal bone loss around dental implants in smokers and nonsmokers. **Materials and Methods:** The study was conducted on 500 individuals who received dental implants in maxillary or mandibular edentulous regions from 2010 to 2017. The sample was divided into two groups: Group I (smokers, $n = 280$) and Group II (nonsmokers, $n = 220$). Marginal bone loss was measured on mesial, distal, buccal, and lingual side of each implant using periapical radiographs 3 months after loading, 6 months after loading, and 12 months after loading. **Results:** The crestal bone loss around dental implants was significantly greater in smokers (Group I) as compared to nonsmokers (Group II) irrespective of the duration of loading ($P < 0.001$). Marginal bone loss did vary significantly by location in either groups. **Conclusion:** Smoking overall lowers the success rate of dental implants. Increased duration and frequency of smoking leads to a greater degree of marginal bone loss around dental implants.

Keywords: Dental implants, marginal bone loss, smoking

Introduction

The longterm success of dental implants depends mainly on the preservation of the bony support around the implant, which is usually evaluated with radiographic images. Osseointegration or osteointegration refers to a direct bone-to-metal interface without the interposition of nonbone tissue. This concept has been described by Branemark, as consisting of a highly differentiated tissue making a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant.[1] Through his initial observations on osseointegration, Branemark showed that titanium implants could become permanently incorporated within bone, that is, the living bone could become so fused with the titanium oxide layer of the implant that the two could not be separated without fracture.[2] Bone healing around implants involves a cascade of cellular and extracellular biological events that take place at the bone-implant interface until the implant surface appears finally

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CASE REPORT

Stress Related Peri-Implant Bone Loss

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Psychological stress has been reported to be associated with periodontal bone loss; however, this association has not been studied for peri-implant bone loss. Psychological stress may be a factor in peri-implant bone loss. Alone, stress may not be significant, but in tandem with other factors, certain types of psychological stress may aggravate or accelerate peri-implant bone loss. This association needs to be studied further.

Key Words: dental implant, osseous loss, recession, psychological stress

STRESS RELATED PERI-IMPLANT BONE LOSS

Psychological stress has been shown to be contributory to periodontal bone loss.[1] During World Wars I and II, a condition called trench mouth, also known as acute necrotizing ulcerative gingivitis, occurred that was caused by a combination of poor nutrition, poor oral hygiene, and the psychological stress of being in a war zone.[2] Trench warfare was common in World War I, and this oral condition was found in the soldiers who fought in these trenches. Additionally, the emotional stress of military service in wartime Viet Nam was found to be associated with severe periodontal bone loss.[3]

Psychological factors have been shown to be associated with the incidence and severity of periodontitis, but the mechanism of action is still unknown.[4]

One Swedish study of 298 dentate patients found that there was an association with those who exercised extreme exterior emotional psychological control and the risk for periodontitis. Additionally, investigators found an association between periodontitis risk and the loss of a spouse.[5] A stressful life event tests the ability of an individual to cope with and ameliorate the stressful situation. Those who can successfully cope may change the risk for progression or occurrence of periodontitis.

Financial strain and associated psychological stress may be expressed as psychological depression. Again, problem-solving and coping skills have been shown to be important in relieving the stress-associated risks for periodontitis in these patients.[6,7] Thus, inadequacy of these psychological coping skills may influence the onset and progression of periodontitis.

Although evidence from the past has been directed at periodontal conditions, stress-related bone loss around dental implants may also occur. Stress alone may not cause periodontal or peri-implant bone loss, but when other factors act in tandem, periodontal or peri-implant bone loss may occur. No reported research has been directed at the association between psychological stress and peri-implant bone loss.

CASE REPORT

A 67-year-old female patient sustained dental fractures and carious breakdown of multiple maxillary teeth. She had a medical history that included a diagnosis of and treatment for breast cancer and was in remission. She had never smoked. The

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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

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Original Article

Dentistry Section

Impact of Alcohol Dependency on Oral Health – A Cross-sectional Comparative Study

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ABSTRACT

Introduction: Alcoholism is a chronic and progressive psychiatric illness characterised by a loss of control over alcohol consumption. Consumption of alcohol inevitably affects the oral cavity, oral mucosa and teeth. Literature indicates that alcohol dependents may have increased risk of dental caries, probing pocket depth and mucosal lesions.

Aim: To assess the impact of alcohol dependency on oral health status among alcoholics in comparison with non alcoholics.

Materials and Methods: A total 76 alcoholic patients visiting Psychiatric Department were compared with matched non alcoholics. Subjects were categorised as alcohol dependents based on American Psychiatric Association Diagnostic and Statistical Manual of Mental Disorders (DSM-5) diagnostic criteria. Non alcoholic subjects were selected by controlling for potentially confounding variables such as for cigarette, smoking and age. Data was collected by interview and clinical examination. Oral health status of subjects was assessed using a modified WHO proforma and salivary pH and plaque pH were assessed. Chi-square test was used for assessing socio demographic details and Mann-whitney U test was used for prevalence of dental caries and periodontal diseases, Unpaired t-test was used for plaque and salivary pH.

Results: There was no statistically significant difference noted among alcoholic and nonalcoholic control group with respect to socio demographic details. Prevalence of dental caries was higher in alcohol dependent subjects with a mean DMFT of 5.92 compared to nonalcoholic subjects (4.51). Prevalence of periodontitis was higher (89%) in alcohol dependent subjects compared to controls (78.67%). Prevalence of mucosal lesions among alcohol dependent subjects was 31.6% which was higher than the controls (25%). Subjects who were categorised as alcoholics showed a lower plaque and salivary pH compared to non alcoholics.

Conclusion: Subjects categorised as alcohol dependent subjects had slightly lower mean plaque and salivary pH and a higher prevalence of dental caries, periodontitis and mucosal lesions compared with non alcoholic subjects

Keywords: Dental caries, Plaque pH, Probing depth, Salivary pH

INTRODUCTION

Alcoholism is a chronic and progressive psychiatric illness described as an unsanctioned, maladaptive, repeated pattern of alcohol ingestion, irrespective of its adverse physical, psychological and social consequences [1,2]. The World Health Organization (WHO) estimates that excessive alcohol consumption is the third largest life style risk factor in the developed world [2]. It is also evident that an excessive intake of alcohol can seriously damage health [3].

Alcohol is consumed by drinking. It may thus inevitably affect the oral cavity, oral mucosa, and teeth of the consumer. Oral sideeffects of alcohol depend on the nature and contents of the drink, its alcohol concentration, and the frequency and amount of consumption [4]. The psychological effects and the personality changes in the abuser may affect the patient-dentist relationship as they take a reduced interest in seeking and paying for dental care. The physiological effect of alcohol intoxication may lead to the inability to understand and accept advice given by health care workers that may result in noncompliance [5].

With respect to oral health, alcohol is among the most important risk factors for oral cancer [6,7]. Alcohol causes a change in the rate of penetration of substances from the oral environment across the mucosa and this alteration of mucosal permeability may have a role to play in carcinogenesis [1]. Evidence suggests that the increasing incidence of oral cancer, particularly in younger people, is associated with increased alcohol intake rather than tobacco use [8]. While increased alcohol consumption has also been associated with an increased risk of oral premalignant lesions, there is a paucity of data concerning the prevalence of oral mucosal lesions in persons with a history of alcohol abuse [1].

Alcoholic dependents might experience dry mouth at night, they consume higher levels of refined carbohydrate to satisfy their "munchies" and neglect both personal and professional oral health care, all of these might increase their risk of caries [5,9]. There is very limited information about the relationship between drinking and periodontitis. Only few studies examined the relationship between drinking and Probing Depth (PD) [10,11]. Thus aim of present study was to assess the impact of alcohol dependency on oral health status among alcoholics in comparison with non alcoholics. Objective of the study was to assess and compare dental caries prevalence, periodontal status, mucosal lesions and the salivary and plaque pH difference among alcohol dependents and non alcoholic subjects.

MATERIALS AND METHODS

A cross-sectional clinical comparative study was conducted among alcohol dependents and non alcohol subjects visiting Narayana Medical College, Nellore district, Andhra Pradesh, India, during the month of May 2015. The study was approved by Institutional Ethical Committee of Narayana Dental College.

Subjects categorized as alcohol dependents by investigator based on American Psychiatric Association Diagnostic and Statistical Manual of Mental Disorders (DSM-5) diagnostic criteria [12]. Subjects who were willing to participate in the study and who gave written consent and with minimum of 20 natural teeth were included in the study.

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Review Article

Clinical Management of Implant Prostheses in Patients with Bruxism

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There is general agreement that excessive stress to the bone-implant interface may result in implant overload and failure. Early failure of the implant due to excessive loading occurs shortly after uncovering the implant. Excess load on a final restoration after successful implant integration can result in physical failure of the implant structure. Many clinicians believe that overload of dental implants is a risk factor for vertical peri-implant bone loss and/or may be detrimental for the suprastructure in implant prostheses. It has been documented that occlusal parafunction, such as, bruxism (tooth grinding and clenching) affects the outcome of implant prostheses, but there is no evidence for a causal relation between the failures and overload of dental implants. In spite of this lack of evidence, often metal restorations are preferred instead of porcelain for patients in whom bruxism is presumed on the basis of tooth wear. The purpose of this paper is to discuss the importance of the occlusal scheme used in implant restorations for implant longevity and to suggest a clinical approach and occlusal materials for implant prostheses in order to prevent complications related to bruxism.

1. Introduction

The most important factor in implant longevity as a factor for clinically successful implant treatment is the formation of a direct interface between the implant and the bone, without intervening soft tissue, a process called "osseointegration". Osseointegrated dental implants represent an advance in modern odontology, which has become a great option for the rehabilitation of missing single teeth in partially or totally edentulous patients. Despite the very high success rates [1], complications associated with implant treatment may occur. Early loading failure may affect 2% to 6% of implants, and as many as 15% of restorations fail as a result of this problem [2, 3]. Excess load on a final restoration after successful implant integration can result in failure of the implant itself [4]. Therefore, it is important to clarify the risk factors for failure of implant prostheses in order to further improve the good success rate.

The consequences of overload of dental implants can be divided into two groups: biological and biomechanical complications [5]. Biological complications can be divided into early failures and late failures [6]. In case of early failures, osseointegration was insufficient: the implant is lost before the first prosthetic loading. Late biological failures are characterized by pathological bone loss after full osseointegration was obtained at an earlier stage [7]. Late biological implant failures are associated with overload. Some insight into bone physiology is needed for a proper understanding of these

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Repair of peri-implant bone loss after occlusal adjustment

A case report

Robert L. Merin, DDS, MS

ABSTRACT

Background. Peri-implantitis generally is attributed to a bacterial challenge, with occlusion being a modifying factor. The author presents a case of peri-implant marginal bone loss that was treated successfully with only occlusal adjustment.

Case Description. A 63-year-old female patient with a history of bruxism reported for a yearly periodontal examination 38 months after restoration of an implant in the tooth no. 30 position. A radiograph indicated that this implant had significant peri-implant bone loss. The evaluation showed very heavy occlusion on the implant restoration, and the author performed an occlusal adjustment. A radiograph obtained five months later showed significant repair of the lost alveolar bone.

Conclusions and Practical Implications. Patients with dental implants require periodic examination and maintenance therapy to prevent peri-implantitis. The examination should include a periodontal, prosthetic, radiographic and occlusal evaluation.

Key Words. Peri-implantitis; peri-implant bone loss; occlusion and dental implants; bruxism and dental implants; occlusal overload and dental implants; occlusal adjustment and dental implants.

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The maintenance of healthy marginal soft tissue and bone around dental implants requires control of bacterial and mechanical factors.[1] Peri-implantitis is a significant risk for dental implants, with a reported incidence of 18.8 percent of patients and 9.6 percent of implants.[2] Peri-implantitis is characterized by progressive bone loss beyond physiological bone remodeling, bleeding or suppuration on probing (or both) and pocket depths greater than 4 millimeters.[1-3] Marginal peri-implantitis generally is regarded as a biofilm-mediated disease, and controversy exists regarding the relationship between occlusal overload and peri-implant disease.[1] Because of the difficulty in defining occlusal overload, clinical and experimental studies have produced conflicting results. The case of marginal peri-implant bone loss I describe in this article did not involve all the signs of peri-implantitis, because the patient had neither bleeding on probing nor pockets greater than 4 mm. I treated the bone loss only with occlusal adjustment, and repair was radiographically evident five months later. The purpose of this case report is to show that heavy occlusion can become a primary factor in marginal peri-implant bone loss around an osseointegrated implant.

CASE REPORT

I placed a dental implant (SLA, Straumann, Andover, Mass.) in the tooth no. 30 position in November 2009

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

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

IN BRIEF

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

PRACTICE

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

INTRODUCTION

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

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

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

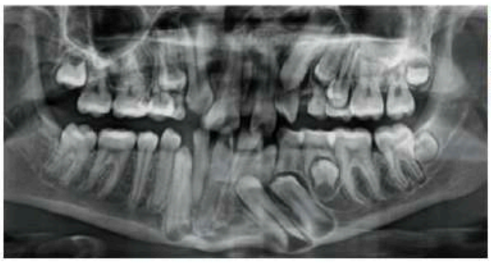

Fig. 1a This patient presented complaining of a crowded dentition and commonly managed plaque associated diseases

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

CASE SELECTION

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

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

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Review

Periodontally compromised vs. periodontally healthy patients and dental implants: A systematic review and meta-analysis

CrossMark

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ABSTRACT

Objectives: To test the null hypothesis of no difference in the implant failure rates, postoperative infection, and marginal bone loss for the insertion of dental implants in periodontally compromised patients (PCPs) compared to the insertion in periodontally healthy patients (PHPs), against the alternative hypothesis of a difference.

Methods: An electronic search without time or language restrictions was undertaken in March 2014. Eligibility criteria included clinical human studies, either randomized or not.

Results: 2768 studies were identified in the search strategy and 22 studies were included. The estimates of relative effect were expressed in risk ratio (RR) and mean difference (MD) in millimetres. All studies were judged to be at high risk of bias, none were randomized. A total of 10,927 dental implants were inserted in PCPs (587 failures; 5.37%), and 5881 implants in PHPs (226 failures; 3.84%). The difference between the patients significantly affected the implant failure rates (RR 1.78, 95% CI 1.50–2.11; $P < 0.00001$), also observed when only the controlled clinical trials were pooled (RR 1.97, 95% CI 1.38–2.80; $P = 0.0002$). There were significant effects of dental implants inserted in PCPs on the occurrence of postoperative infections (RR 3.24, 95% CI 1.69–6.21; $P = 0.0004$) and in marginal bone loss (MD 0.60, 95% CI 0.33–0.87; $P < 0.0001$) when compared to PHPs.

Conclusions: The present study suggests that an increased susceptibility for periodontitis may also translate to an increased susceptibility for implant loss, loss of supporting bone, and postoperative infection. The results should be interpreted with caution due to the presence of uncontrolled confounding factors in the included studies, none of them randomized.

Clinical Significance: There is some evidence that patients treated for periodontitis may experience more implant loss and complications around implants including higher bone loss and peri-implantitis than non-periodontitis patients. As the philosophies of treatment may alter over time, a periodic review of the different concepts is necessary to refine techniques and eliminate unnecessary procedures. This would form a basis for optimum treatment.

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Review Article

Significance of the width of keratinized mucosa on peri-implant health

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Abstract

In implant therapy, the adequate state of peri-implant tissue health and soft-tissue aesthetics is the essential criterion of restorative success. The need for keratinized mucosa for the maintenance of peri-implant health and soft-tissue integration remains a debated issue. The aim of this paper is to provide a narrative review of the current literature concerning the significance of keratinized mucosa with respect to the clinical parameters of monitoring oral hygiene practice and tissue status. The published studies revealed that there were conflicting results with regard to the influence of keratinized mucosa on plaque score and soft-tissue inflammation. Most studies showed that the amount of soft-tissue recession was significantly increased at implant sites with narrow keratinized mucosa, but the amount of keratinized mucosa had little effect on deepening of peri-implant pockets. The evidence related to the effect of keratinized mucosa on the changes of attachment or bone levels is limited, and conclusions could not be drawn at present. Further, this review found that a band of keratinized mucosa was not absolutely necessary for the maintenance of peri-implant tissue, whereas lack of adequate keratinized mucosa around the implant might impede proper oral hygiene performance and compromise the aesthetic results. In conclusion, because there is a wide variety of clinical features in patients pursuing implant therapy, individual consideration of treatment strategies for the patient with minimal keratinized mucosa is recommended.

Keywords: clinical parameters; dental implants; keratinized mucosa; peri-implant soft tissue

1. Introduction

The peri-implant keratinized mucosa is firmly bound to the underlying bone and constitutes a functional barrier between the oral environment and underlying dental implants. However, after teeth are extracted, the resorption of surrounding bone and keratinized gingiva occurs, which may result in deficiency of keratinized mucosa during subsequent implant placement.

The need for keratinized mucosa around dental implants has been widely discussed. During the early development of endosseous dental implants, the establishment of a dense connective tissue around the implant collar for long-term implant stability was repeatedly addressed.[1–3] Nevertheless, a number of subsequent studies showed that implants had a high survival rate irrespective of the presence or absence of keratinized mucosa.[4–6] Nowadays, in addition to achieving high implant survival following implant therapy, maintenance of functionally loaded implants in an adequate status of health and aesthetics had become a prerequisite for long-term success of implant restoration. The need for keratinized tissue around the dental implant to maintain health and tissue stability is therefore becoming of increasing concern.

In the beginning years of implant dentistry, few comparative studies investigated the relationship between the width of keratinized mucosa and the health of peri-implant tissues. In

Conflicts of interest: The authors declare that there are no conflicts of interest related to the subject matter or materials discussed in this article.

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The Influence of Initial Hard and Soft Tissue Dimensions on Initial Crestal Bone Loss of Immediately Loaded Dental Implants

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Sara Östman, DDS[2]
Hugo De Bruyn, DDS, MSc, PhD[3]
Pär-Olov Östman, DDS, PhD[4]

The aim of this case-control study was to evaluate the influence of soft tissue thickness at implant placement (thin [< 3 mm] vs thick [≥ 3 mm]) and bone volume (abundant vs limited) on initial crestal bone remodeling of immediate postextraction and delayed (healed site) implants in immediate loading situations. A total of 67 patients with 133 implants could be evaluated, of which 77 were placed immediately after extraction and 56 in healed ridges. If sufficient bone volume is present and primary stability is achieved, immediate loading of the implant yields good clinical and radiographic outcomes, yet implants placed in healed ridges with thin soft tissues are more prone to initial crestal bone loss.
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Traditionally, dental implants have been placed in healed ridges and loaded after 3 to 6 months. However, as implant treatment has become more predictable, faster treatment strategies have developed. Immediate placement after extraction and immediate loading have been shown to be viable treatment options if some prerequisites are fulfilled.[1,2] One of the major requirements for immediate loading is primary stability, which is linked to the insertion torque at implant placement. The latter can be measured from the drill torque during implant insertion or the ISQ values, which reflect on the micromobility of the implant.[3] In a comparative study by Ottoni et al,[4] 23 patients each received two single implants, of which one was loaded after a healing period and one was immediately loaded. Of the 23 immediately loaded implants, 10 failed. However, 9 of those were placed with a seating torque of < 20 Ncm, indicating a poor primary implant stability. If primary stability is achieved, however, survival rates of immediately loaded implants are comparable with conventionally loaded ones.[5]

Crestal bone preservation remains an important concern in implant dentistry. Initial crestal bone remodeling happens during the first year after implant placement, reaching a steady state and leading to stable crestal bone levels over the

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2017 WORLD WORKSHOP

JOURNAL OF Periodontology

The etiology of hard- and soft-tissue deficiencies at dental implants: A narrative review

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

Abstract

Objective: The objective of the present paper was to review factors and conditions that are associated with hard and soft-tissue deficiencies at implant sites.

Importance: Hard- and soft-tissue deficiencies at dental implants are common clinical findings. They can lead to complications and compromise implant survival and, hence, may require therapeutic interventions. It is, therefore, important to understand the etiology of hard and soft-tissue deficiencies. Based on this understanding, strategies should be developed to correct hard and soft-tissue deficiencies with the aim of improving clinical outcomes of implant therapy.

Findings: A large number of etiological factors have been identified that may lead to hard and soft-tissue deficiencies. These factors include: 1) systemic diseases and conditions of the patients; 2) systemic medications; 3) processes of tissue healing; 4) tissue turnover and tissue response to clinical interventions; 5) trauma to orofacial structures; 6) local diseases affecting the teeth, the periodontium, the bone and the mucosa; 7) biomechanical factors; 8) tissue morphology and tissue phenotype; and 9) iatrogenic factors. These factors may appear as an isolated cause of hard and soft-tissue defects or may appear in conjunction with other factors.

Conclusions: Hard- and soft-tissue deficiencies at implant sites may result from a multitude of factors. They encompass natural resorption processes following tooth extraction, trauma, infectious diseases such as periodontitis, peri-implantitis, endodontic infections, growth and development, expansion of the sinus floor, anatomical preconditions, mechanical overload, thin soft tissues, lack of keratinized mucosa, malpositioning of implants, migration of teeth, lifelong growth, and systemic diseases. When more than one factor leading to hard and/or soft-tissue deficiencies appear together, the severity of the resulting condition may increase. Efforts should be made to better identify the relative importance of these etiological factors, and to develop strategies to counteract their negative effects on our patient's wellbeing.

KEYWORDS
gingival thickness, implantology, osseointegration, osseous defects

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CONTINUING EDUCATION

Vertical and Horizontal Dimensions of Implant Dentistry: Numbers Every Dentist Should Know

Steven Kendrick, DDS; and David Wong, DDS

LEARNING OBJECTIVES

After reading this article, the reader should be able to:

- describe the minimum and ideal amount of vertical space required for both single and multiple cement- and screw-retained fixed restorations.
- describe the minimum and ideal amount of vertical space required for removable implant-retained prostheses.
- describe the horizontal distance necessary for implant spacing between natural teeth and implants as well as between implants.
- discuss the importance of arch form as it relates to anterior-posterior spread.

ABSTRACT

Implant dentistry has become routine treatment in a growing number of general practices. The profession has generally acknowledged that this discipline is restoratively driven, not surgically driven. Despite the widespread application of implant dentistry, the vertical and horizontal parameters of implant dentistry are still frequently addressed after the implants have integrated, which can be too late because it reduces the predictability for successful restoration. Thus, these vertical and horizontal parameters should be known and followed preoperatively, not pre-restoratively. This article will review the most common vertical and horizontal measurements that the general dentist placing and restoring implants should know, and illustrate how using these parameters will provide more reliable outcomes.

Before any treatment can occur, all patients should be evaluated for overall oral health during the initial examination regardless of the number of teeth present. If the patient is a candidate for implant therapy, a systematic series of steps should be taken to assess the possible treatment options available to the patient. The stress treatment theorem for implant dentistry as described by Misch[1] is a biomechanical model used to assess the patient for implant reconstruction. The evaluation criteria are listed below in descending order of importance:

- Prosthesis design
- Patient force factors
- Bone density in implant sites
- Key implant positions and number
- Implant size
- Available bone
- Implant design

By starting with prosthesis design, the prosthetic options and available space must be addressed first. The idea that implant dentistry is a prosthetically driven discipline, not a surgically driven one, is accepted in dentistry without argument. Yet more often than not, the restorative dentist either does not examine the available space or expects the specialist placing the implant to position the implant in the right place. Because this is not a predictable model under which to operate, it is certainly not in the best interest of the patient. These parameters must be addressed first.

The crown height space is a parameter that is often overlooked until after the implants have integrated and the patient is ready for restoration. If enough space is available, traditional implant prosthetics are completed in a very satisfactory way. However, if there is too little space, then the outcome is generally unacceptable for both the patient and the doctor. The patient may be displeased because he or she may have to undergo additional procedures or have to be fitted with a different type of prosthesis than originally planned. Both of these scenarios generally require more chair time and a greater cost. In this article, the vertical and horizontal parameters that must be followed to avoid these potential complications will be addressed as they pertain to prosthesis design.

CROWN HEIGHT SPACE: THE KEY VERTICAL PARAMETER

Crown height space is the distance from the occlusal plane to the crest of the alveolar ridge[2] (Figure 1). The available crown height space will influence the type of prosthesis, material choices, and surgical technique that will be used. This important preoperative parameter will be discussed as it pertains to various types of restorations.

Fixed Restorations

The cement-retained implant prosthesis requires a minimum of 8 mm of crown height space.

The ideal space, however, for a cement-retained prosthesis is 9 mm to 10 mm in the posterior and 10 mm to 12 mm in a maxillary central. The crown height space for a cement-retained prosthesis has three main regions: the soft tissue, abutment, and occlusal material. The ideal vertical dimensions of each region are: 3 mm for the soft tissue;[3] 5 mm for the abutment height;[4] and 2 mm for the occlusal metal or porcelain (Figure 2).

Taking a more detailed look at these distances, the soft tissue, also known as the peri-implant biological width, is comprised

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Biomechanical implant treatment complications: a systematic review of clinical studies of implants with at least 1 year of functional loading

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PMID: 22848892

Abstract

Purpose: The aim of this article is to discuss the current literature available on the etiology and management of biomechanical complications of dental implant treatment.

Materials and methods: An electronic search of the PubMed database for English-language articles published before May 31, 2011, was performed based on a focus question: "How can biomechanical implant treatment complications be managed and identified?" The key words used were "dental implant," "etiology," "management," "excessive occlusal forces," "occlusal forces," "occlusion," "parafunctional habits," "biomechanical failure," "biomechanical complications," and "occlusal overloading." Clinical trials with a minimum of 10 implants followed for at least 1 year after functional loading were included.

Results: The initial electronic search identified 2,087 publications, most of which were eliminated, as they were animal studies, finite element analyses, bench-top studies, case reports, and literature reviews. After the titles, abstracts, and full text of 39 potentially eligible publications were reviewed, 15 studies were found to fulfill the inclusion criteria.

Conclusion: Occlusal overloading was thought to be the primary etiologic factor in biomechanical implant treatment complications, which commonly included marginal bone loss, fracture of resin/ceramic veneers and porcelain, retention device or denture base fracture of implant-supported overdentures, loosening or fracture of abutment screws, and even implant failure. Occlusal overloading was positively associated with parafunctional habits such as bruxism. An appreciation of the intricacy of implant occlusion would allow clinicians to take a more preventive approach when performing implant treatment planning, as avoidance of implant overloading helps to ensure the long-term stability of implant-supported prostheses.

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Does excessive occlusal load affect osseointegration? An experimental study in the dog

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Key words: bone loss, histology, marginal bone level, occlusal load, osseointegration, titanium implants

Abstract

Aim: The purpose of this study was to evaluate the effect of excessive occlusal load following placement of titanium implants in the presence of healthy peri-implant mucosal tissues.
Materials and methods: Mandibular bilateral recipient sites in six Labrador dogs were established by extracting premolars and molars. After 3 months, two TPS (titanium plasma sprayed) implants and two SLA (sandblasted, large grit, acid etched) implants were placed on each side of the mandible in each dog. Three implants were lost in the initial healing phase, leaving 45 implants for evaluation. Following 6 months of healing, gold crowns were placed on implants on the test side of the mandible. The crowns were in supra-occlusal contact with the opposing teeth in order to create excessive occlusal load. Implants on the control side were not loaded. Plaque control was performed throughout the experimental period. Clinical measurements and standardised radiographs were obtained at baseline and 1, 3 and 8 months after loading. At 8 months, the dogs were killed and histologic analyses were performed.
Results: At 8 months, all implants were osseointegrated. The mean probing depth was 2.5 ± 0.3 and 2.6 ± 0.3 mm at unloaded and loaded implants, respectively. Radiographically, the mean distance from the implant shoulder to the marginal bone level was 3.6 ± 0.4 mm in the control group and 3.7 ± 0.2 mm in the test group. Control and test groups were compared using paired non-parametric analyses. There were no statistically significant changes for any of the parameters from baseline to 8 months in the loaded and unloaded implants. Histologic evaluation showed a mean mineralised bone-to-implant contact of 73% in the control implants and 74% in the test implants, with no statistically significant difference between test and control implants.
Conclusion: In the presence of peri-implant mucosal health, a period of 8 months of excessive occlusal load on titanium implants did not result in loss of osseointegration or marginal bone loss when compared with non-loaded implants.

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doi: 10.1111/j.1600-0501.2004.01019.x

Osseointegration is a term defined as a direct bone deposition on implant surfaces at the light microscopic level (Brånemark et al. 1977). This functional unit, able to transmit occlusal forces to the alveolar bone, has also been described as 'functional ankylosis' (Schroeder et al. 1981). The 'direct structural and functional connections between ordered, living bone and the surface of a load-bearing implant' (Listgarten et al. 1991) is a more comprehensive way of characterising this unique bonding of a foreign body to living bone.

Following the preparation of an implant bed, osseointegration generally follows three stages: (1) incorporation by woven

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Influence of forces on peri-implant bone

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Key words: bone remodeling, bone resorption, dental implants, implant failure, mechanical stress, occlusal load.

Abstract: Occlusal forces affect an oral implant and the surrounding bone. According to bone physiology theories, bones carrying mechanical loads adapt their strength to the load applied on it by bone modeling/remodeling. This also applies to bone surrounding an oral implant. The response to an increased mechanical stress below a certain threshold will be a strengthening of the bone by increasing the bone density or apposition of bone. On the other hand, fatigue micro-damage resulting in bone resorption may be the result of mechanical stress beyond this threshold. In the present paper literature dealing with the relationship between forces on oral implants and the surrounding bone is reviewed. Randomized controlled as well as prospective cohorts studies were not found. Although the results are conflicting, animal experimental studies have shown that occlusal load might result in marginal bone loss around oral implants or complete loss of osseointegration. In clinical studies an association between the loading conditions and marginal bone loss around oral implants or complete loss of osseointegration has been stated, but a causative relationship has not been shown.

Occlusal forces affect the bone surrounding an oral implant. Mechanical stress can have both positive and negative consequences for bone tissue (Frost 2004) and, thereby, also for maintaining osseointegration of an oral implant.

After the first year of function, loss of marginal bone is small around most oral implants (Brånemark et al. 1977; Adell et al. 1981, 1986; Quirynen et al. 1991, 1992b; Isidor et al. 1999; Manz 2000), although a considerable loss can be observed at some implants (Brånemark et al. 1977; Adell et al. 1981; Cox & Zarb 1987; Block & Kent 1990; Malmqvist & Sennerby 1990; Naert et al. 1992; Quirynen et al. 1992a; Isidor et al. 1999; Carlsson et al. 2000; Fransson et al. 2005). Furthermore, it has been stated that the occlusal forces on an oral implant can result in loss of the marginal bone or complete loss of osseointegration even after a long time of service (Adell et al. 1981; Jemt et al. 1989; Naert et al. 2001a, 2001b).

An association between oral microbiota (plaque accumulation), peri-implant mucositis, loss of marginal bone (peri-implantitis), and subsequently loss of implants has also been described (for a review see Quirynen et al. 2002). With the exception of the consequences of mechanical load, peri-implantitis as well as other biologic factors causing loss of ossointegration (Esposito et al. 1998a, 1998b) will not be discussed in this paper.

It is difficult clinically to quantify the magnitude and direction of naturally occurring occlusal forces. Clinical indices concerning these and their impact on

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Histological features of peri-implant bone subjected to overload

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ABSTRACT

Purpose: The aim of this review has been to investigate the histological findings of bone structure surrounding implants subjected to excessive load.
Materials and methods: Clinical and pre-clinical histological studies that observed overloaded intraoral implants were included.
Results: All included studies ($n = 15$) were conducted on animals. Most of them failed to find pathological alteration in the microstructure of bone surrounding overloaded implants. Overload and infection alone may induce bone loss, but related lesions have different and peculiar features.
Conclusions: The different histological features observed around implants subjected to overload or to ligature-induced peri-implantitis may indicate a specific pathogenetic mechanism for overload or infection-induced loss of osseointegration. The clinical significance of these findings should be confirmed in human studies.

Contents

1. Introduction

Loading the bone tissue during physiologic masticatory function regulates the remodeling of peri-implant tissue (Greenstein et al., 2013). When the applied force has the potential to cause permanent deformation or damage to the structure or its support, overloading occurs (Laney et al., 2007).

In implant dentistry, the effect of occlusal overloading on the loss of osseointegration is still a controversial issue. Some recent reviews were designed to examine the role of excessive and adverse masticatory load in peri-implant bone loss (Naert et al., 2012; Chambrone et al., 2010; Chang et al., 2013). These studies did not resolve this issue since the available data in the literature were too limited. Therefore, the question of whether the occlusal overloading by itself is able to induce peri-implant bone loss and

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51. Zurdo J, Romão C, Wennström JL. Survival and complication rates of implant-supported fixed partial dentures with cantilevers: A systematic review. Clin Oral Implants Res. 2009;20(SUPPL. 4):59–66.

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Survival and complication rates of implant-supported fixed partial dentures with cantilevers: a systematic review

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Key words: cantilever extensions, complications, fixed partial dental prosthesis, implant-supported, survival, systematic review

Abstract

Objective: The objective of the present systematic review was to analyze the potential effect of incorporation of cantilever extensions on the survival rate of implant-supported fixed partial dental prostheses (FPDPs) and the incidence of technical and biological complications, as reported in longitudinal studies with at least 5 years of follow-up.

Methods: A MEDLINE search was conducted up to and including November 2008 for longitudinal studies with a mean follow-up period of at least 5 years. Two reviewers performed screening and data abstraction independently. Prosthesis-based data on survival/failure rate, technical complications (prosthesis-related problems, implant loss) and biological complications (marginal bone loss) were analyzed.

Results: The search provided 103 titles with abstract. Full-text analysis was performed of 12 articles, out of which three were finally included. Two of the studies had a prospective or retrospective case–control design, whereas the third was a prospective cohort study. The 5-year survival rate of cantilever FPDPs varied between 89.9% and 92.7% (weighted mean 91.9%), with implant fracture as the main cause for failures. The corresponding survival rate for FPDPs without cantilever extensions was 96.3–96.2% (weighted mean 95.8%).

Technical complications related to the supra-constructions in the three included studies were reported to occur at a frequency of 13–26% (weighted mean 20.3%) for cantilever FPDPs compared with 0–12% (9.7%) for non-cantilever FPDPs. The most common complications were minor porcelain fractures and bridge-screw loosening.

For cantilever FPDPs, the 5-year event-free survival rate varied between 66.7% and 79.2% (weighted mean 71.7%) and between 83.1% and 96.3% (weighted mean 85.9%) for non-cantilever FPDPs.

No statistically significant differences were reported with regard to peri-implant bone-level change between the two prosthetic groups, either at the prosthesis or at the implant level.

Conclusion: Data on implant-supported FPDPs with cantilever extensions are limited and therefore survival and complication rates should be interpreted with caution. The incorporation of cantilevers into implant-borne prostheses may be associated with a higher incidence of minor technical complications.

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The selection of prosthetic options to replace missing teeth should be based on scientific evidence. The incorporation of cantilever extensions into implant-borne reconstructions may be considered as an option in situations where local conditions of the residual edentulous ridge preclude the possibility to place an implant. However, it has been claimed that cantilever extensions increase the risk of bending

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2017 WORLD WORKSHOP

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Peri-implantitis

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

Abstract

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

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

Conclusions:

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

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

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

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

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

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

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

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Clin Oral Impl Res 1998: 9: 73–79

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Soft tissue response to plaque formation at different implant systems. A comparative study in the dog

Abrahamsson I, Berglundh T, Lindhe J. Soft tissue response to plaque formation at different implant systems. A comparative study in the dog. Clin Oral Impl Res 1998: 9: 73–79. © Munksgaard 1998.

The aim of the present experiment was to study the location and composition of plaque associated lesions in the mucosa adjacent to implant systems that differed with respect to both geometry and dimension. At day 0 extraction of the mandibular premolars were performed. After a healing period of 3 months, fixtures of the Astra Tech Implants, Dental System®, the Brånemark System® and the ITI Dental Implant System® were installed. In each mandibular quadrant 1 fixture of each implant system was installed in a randomized order. A period of plaque control was initiated. Following another 3 months of healing, abutment connection was performed in the 2-stage systems (the Astra Tech Implants, Dental System® and the Brånemark System®). After 1 month, the plaque control measures were abandoned and plaque formation was allowed for 5 months. The animals were killed and biopsies representing each implant region obtained. The tissue samples were prepared for light microscopy and exposed to histometric and morphometric measurements. The present study demonstrated that plaque formation resulted in the establishment of an ICT lateral to a pocket epithelium. The lesion was found to be similar regarding extension and composition in the peri-implant mucosa of the 3 implant systems tested. The vertical extension of the ICT was in all systems within 91–99% of the vertical dimension of the junctional epithelium. The marginal bone level, measured from the abutment/fixture (PS) border, did not differ between the three systems.

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Key words: peri-implant mucosa – plaque accumulation – mucositis – ICT – histometry – morphometry – dogs

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The structure of the mucosa around osseointegrated implants was studied in experiments using the canine model (e.g., Berglundh et al. 1991; Buser et al. 1992; Cochran et al. 1997). It was observed that the healthy peri-implant mucosa formed a barrier towards implants – made of commercially pure titanium – that was comprised of 2 zones; 1 zone including a junctional epithelium and 1 zone comprised of a collagen rich but cell poor connective tissue. Abrahamsson et al. (1996) used the beagle dog model to study the soft tissue barrier at 3 different implant systems, namely the Astra Tech Implants, Dental System®, the Brånemark System® and the ITI Dental Implant System®. The 3 systems are all made of c.p. titanium but differ with respect to design (geometry and surface) and installation technique (1-stage and 2-stage systems). The authors reported that the mucosal barrier which developed at the 3 systems was similar, i.e., included 1 junctional epithelium about 1.5–2 mm long, and 1 connective tissue portion above the bone crest that was about 1–2 mm high. It was concluded that proper mucosal healing, including the establishment of an adequate barrier to the abutment, consistently occurred provided the installation procedure resulted in implant stability.

Berglundh et al. (1992) and Ericsson et al. (1992) demonstrated that the gingiva and the peri-implant mucosa adjacent an implant *ad modum* Brånemark responded to microbial plaque build up by the establishment of an inflammatory cell infiltrate located lateral to the junctional epithelium. It was suggested

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REVIEW

WILEY

The influence of implant-abutment connection to peri-implant bone loss: A systematic review and meta-analysis

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Abstract

Purpose: Different implant-abutment connections are available and it has been claimed they could have an effect on marginal bone loss. The aim of this review is to establish if implant connection configuration influences peri-implant bone loss (PBL) after functional loading.

Methods: A specific question was formulated according to the Population, Intervention, Control, and Outcome (PICO): Does the type of implant-abutment connection (external, internal, or conical) have an influence on peri-implant bone loss? A PubMed/MEDLINE electronic search was conducted to identify English language publications published in international journals during the last decade (from 2006 to 2016). The search was conducted by using the Medical Subject Headings (MeSH) keywords "dental implants OR dental abutment AND external connection OR internal connection OR conical connection OR Morse Taper." Selected studies were randomized clinical trials and prospective studies; in vitro studies, case reports and retrospective studies were excluded. Titles and abstracts and, in the second phase, full texts, were evaluated autonomously and in duplicate by two reviewers.

Results: A total of 1649 articles were found, but only 14 studies met the pre-established inclusion criteria and were considered suitable for meta-analytic analysis. The network meta-analysis (NMA) suggested a significant difference between the external and the conical connections; this was less evident for the internal and conical ones. Platform-switching (PS) seemed to positively affect bone levels, non-regarding the implant-connection it was applied to.

Conclusions: Within the limitations of this systematic review, it can be concluded that crestal bone levels are better maintained in the short-medium term when internal kinds of interface are adopted. In particular, conical connections seem to be more advantageous, showing lower peri-implant bone loss, but further studies are necessary to investigate the efficacy of implant-abutment connection on stability of crestal bone levels.

KEYWORDS
bone levels, dental implant, implant-abutment connection, peri-implant bone loss, systematic review

1 | INTRODUCTION

Replacement of missing teeth by means of dental implants insertion has become through the years a viable option both for partially and completely edentulous patients.[1,2] However, implant-prosthetic treatment is not free of possible complications and limitations. Long-term survival and success rates can be affected by crestal bone resorption, which is influenced by biological aspects such as biological width estabilishment,[3] implant-abutment interface colonization,[4,5] peri-implantitis,[6,7] or biomechanical and prosthetic factors that can lead to overloading.[8]

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Platform Switching: A New Concept in Implant Dentistry for Controlling Postrestorative Crestal Bone Levels

*Richard J. Lazzara, DDS, MScD**
*Stephan S. Porter, DDS, MSD, MS**

Histologic and radiographic observations suggest that a biologic dimension of hard and soft tissues exists around dental implants and extends apically from the implant-abutment interface. Radiographic evidence of the development of the biologic dimension can be demonstrated by the vertical repositioning of crestal bone and the subsequent soft tissue attachment to the implant that occurs when an implant is uncovered and exposed to the oral environment and matching-diameter restorative components are attached. Historically, two-piece dental implant systems have been restored with prosthetic components that locate the interface between the implant and the attached component element at the outer edge of the implant platform. In 1991, Implant Innovations introduced wide-diameter implants with matching wide-diameter platforms. When introduced, however, matching-diameter prosthetic components were not available, and many of the early 5.0- and 6.0-mm-wide implants received "standard"-diameter (4.1-mm) healing abutments and were restored with "standard"-diameter (4.1-mm) prosthetic components. Long-term radiographic follow-up of these "platform-switched" restored wide-diameter dental implants has demonstrated a smaller than expected vertical change in the crestal bone height around these implants than is typically observed around implants restored conventionally with prosthetic components of matching diameters. This radiographic observation suggests that the resulting postrestorative biologic process resulting in the loss of crestal bone height is altered when the outer edge of the implant-abutment interface is horizontally repositioned inwardly and away from the outer edge of the implant platform. This article introduces the concept of platform switching and provides a foundation for future development of the biologic understanding of the observed radiographic findings and clinical rationale for this technique. (Int J Periodontics Restorative Dent 2006;26:9–17.)

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Comparison of Marginal Bone Loss Between Implants with Internal and External Connections: A Systematic Review

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Enric Jané-Salas, MD, DDS, PhD[2]/José López-López, MD, DDS, PhD[3]

Purpose: *The objective of this systematic review was to compare the loss of marginal bone between implants with internal and external connections by analyzing results reported in studies published after 2010.* ***Materials and Methods:*** *A literature search in MEDLINE with the keywords "dental implant connections, external internal implant connection, bone loss implant designs, internal and external connection implant studies in humans" was conducted. Clinical trials on human beings, comparing both connections and published in English, from 2010 to 2016 were selected. Their methodologic quality was assessed using the Jadad scale.* ***Results:*** *From the initial search, 415 articles were obtained; 32 were chosen as potentially relevant based on their titles and abstracts. Among them, only 10 finally met the inclusion criteria. A total of 1,523 patients with 3,965 implants were analyzed. Six out of 10 studies observed that internal connections showed significantly less bone loss compared with external connections. The remaining four articles did not find statistically significant differences between the two connections.* ***Conclusion:*** *According to this systematic review and considering its limitation due to the degree of heterogeneity between the included studies, both internal and external connections present high survival rates. To assess whether marginal bone loss differs significantly between the two connections, more homogenous clinical studies are needed with identical implant characteristics, larger samples, and longer follow-up periods. Studies included in this review and characterized by long-term follow-ups showed that the external connection is a reliable connection on a long-term basis.* INT J ORAL MAXILLOFAC IMPLANTS 2018;33:580–589. doi: 10.11607/jomi.6190

Keywords: *bone loss, external connection, implant design, internal connection*

Implant dentistry has undergone major development and expansion since the 1960s, when Brånemark introduced the concept of osseointegration.[1] The use of implants to replace missing teeth and restore function has presented a high success rate and long-term survival. For this reason, rehabilitation with implants has become standard and well accepted by patients, who increasingly demand treatments offering greater comfort and esthetics.[2,3] Implant-based treatments must fulfill a range of physiologic, functional, and esthetic criteria before they can be considered successful. These criteria include osseointegration stability and duration, absence of pathologic processes, and esthetics that satisfy patient expectations.[4]

There are diverse types of implants and corresponding systems that connect the implant to the prosthesis. They fall into two main groups:

- External connection: It can have the shape of a hexagon or an octagon, among others, located on the implant platform. This design was developed to facilitate the placement of components such as abutments and impression copings providing an anti-rotation capacity of the elements.[5] The weakness of this system is attributed to the limited height of the hexagon; when subjected to high

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THE JOURNAL OF PROSTHETIC DENTISTRY

SYSTEMATIC REVIEW

Marginal bone loss around dental implants with and without microthreads in the neck: A systematic review and meta-analysis

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ABSTRACT

Statement of problem. Whether microthreads in the crestal portion can reduce the amount of marginal bone loss (MBL) around implants has not yet been determined.

Purpose. The purpose of this systematic review was to investigate the marginal bone loss around dental implants with and without microthreads in the neck.

Material and methods. This review was based on the PRISMA guidelines. An electronic search with no restrictions on language was performed from inception to August 19, 2015, in PubMed, Cochrane Central Register of Controlled Trials, EMBASE, Web of Sciences, and AMED (Ovid) databases. A manual search was also performed. Randomized clinical trials (RCTs) that compared the MBL between implants with and without microthreads in the neck were included. Qualitative synthesis and meta-analysis were performed. MBL was measured by using the mean difference (MD). Review Manager v5.3 software was used for meta-analysis (α=.05).

Results. Five articles were included in the qualitative synthesis, and 3 articles were included in the meta-analysis. Four studies found that a microthread design can significantly reduce MBL under functional loading, whereas 1 study found no significant difference. The homogeneity test of meta-analysis confirmed acceptable heterogeneity among the 3 studies (I^2=0.49). A random-effects model was used. The result shows that MBL around implants with microthread design can be reduced significantly (P=.030; MD: −0.09; CI: −0.18 to −0.01).

Conclusions. Meta-analysis showed that microthread design in the implant neck can reduce the amount of MBL; however, RCTs included in the review were few and the difference was small. In clinical practice, an implant with a roughened surface and microthreaded neck could be selected to maintain bone level. (J Prosthet Dent 2016;■:■-■)

According to clinical studies,[1,2] the long-term survival of dental implants has exceeded 96%. Patients are concerned about the long-term function and esthetics of implants, so failures must be limited. Different factors relate to implant failures. Iatrogenic conditions (surgical technique, contamination, and occlusal trauma), poor bone quality and quantity, suboptimal implant choice, periimplantitis, and poor oral hygiene maintenance (heavy smoking) can cause early or late failures.[3,4] The implant design, including macrodesign and microdesign, is a fundamental factor in implant primary stability and stress distribution.[5]

More than 100 implant systems in different designs have been marketed.[6-8] Manufacturers have claimed that microthreads in the crestal portion can reduce marginal bone loss (MBL) around implants. Clinical studies have shown that rough surfaced implants with microthreads at the neck can maintain the marginal bone level during the healing period and cause significantly less MBL under long-term functional loading.[9-15] Microthreads location is important in reducing MBL, and implants with microthreads placed at the implant top have less bone loss than those in

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Influence of Different Implant Geometry in Clinical Longevity and Maintenance of Marginal Bone: A Systematic Review

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Keywords
Cylindrical implant; dental implants; implant geometry; marginal bone loss; tapered implant.

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Abstract

Purpose: To assess, through a systematic review, the influence of different implant geometries on clinical longevity and maintenance of marginal bone tissue.
Methods: An electronic search was conducted in MEDLINE, Scopus, and Web of Science databases, limited to studies written in English from 1996 to 2017 using specific search strategies. Only randomized controlled trials (RCTs) that compared dental implants and their geometries were included. Two reviewers independently selected studies, extracted data, and assessed the risk of bias of included studies.
Results: From the 4006 references identified by the search, 24 were considered eligible for full-text analysis, after which 10 studies were included in this review. A similar behavior of marginal bone loss between tapered and cylindrical geometries was observed; however, implants that had micro-threads in the neck presented a slight decrease of marginal bone loss compared to implants with straight or smooth neck. Success and survival rates were high, with cylindrical implants presenting higher success and survival rates than tapered ones.
Conclusions: Implant geometry seems to have little influence on marginal bone loss (MBL) and survival and success rates after 1 year of implant placement; however, the evidence in this systematic review was classified as very low due to limitations such as study design, sample size, and publication bias. Thus, more well-designed RCTs should be conducted to provide evidence regarding the influence of implant geometry on MBL and survival and success rates after 1 year of implant placement.

The use of dental implants to replace missing teeth is a consolidated technique with high survival and success rates observed through long-term follow-up studies.[1-3] To achieve such successful results, some aspects that could influence osseointegration should be considered, such as obtainment of primary stability during implant insertion and caution with surgical steps to avoid bone overheating during implant drilling osteotomy.[4]

Although dental implants show high survival rates, complications occasionally lead to marginal bone loss that could result in implant failure. Evidence shows that the most common factors contributing to implant failure are biological complications of infectious nature, such as mucositis and peri-implantitis, and mechanical complications due to high stress concentration that can result in irreversible biological and structural damage to the implant or prosthetic components.[5-7]

To facilitate obtaining adequate stability and adequate stress distribution, a large number of implant geometries were designed for different bone types and clinical situations.[8,9] At present, the most common implant geometries can be classified as cylindrical, tapered, and hybrid (cylindrical body with tapered geometry in the implant apex region). Also, it has been argued that alterations in microdesign, which can be made by mechanical and chemical additive or subtractive processes (e.g., ion deposition or acid-etching) or by biological coating (e.g., growth factors), can affect primary stability, bone/implant contact, and stress distribution to the surrounding tissues.[10-12] However, each commercial brand presents its unique specifications in regard to implant geometry and screw thread and profile.

It has been suggested that 1300+ dental implants are available, with variations in shape, thread design, material, surface, and prosthetic connection.[13] This high number of dental implants commercially available could be interpreted as a concern, since only a few implant designs are supported by high level scientific research.[13,14] Likewise, there is still no data supporting the indication of one implant geometry over another in relation to marginal bone loss (MBL). Thus, the aim of this study was to assess, through a systematic review, the influence of different

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Dental Implant Thread Design and the Consequences on Long-Term Marginal Bone Loss

Zeev Ormianer, DMD,* Shlomo Matalon, DMD,* Jonathan Block, DMD,† and Jerry Kohen, DMD‡

Aim: *The aim of this study was to present the implant macrostructure effect on marginal bone loss using 3 dental implant thread designs with differences in thread pitch, lead, and helix angle. All implants used were sourced from the same company and had the same microstructured surface.*

Materials and Methods: *This is a nonrandomized, retrospective, double-blind study. Data were collected by an independent Tel Aviv University group from a general practitioner's private practice patient records. In total, 1361 implants met the inclusion criteria representing the 3 types of implants macrostructure.*

Results: *Overall survival rate was 96.3% with 50 implants failing (3.7%) out of a total of 1361 implants. Survival rates for the 3 groups were: group A 96.6%, group B 95.9%, and in group C 100%. Average bone loss for groups A, B, and C were 2.02 (±1.70) mm, 2.10 (±1.73) mm, and 1.90 (±1.40) mm, respectively. Pairwise comparisons revealed that less bone loss occurred in group A compared with group B (P = 0.036).*

Conclusion: *Favorable long-term bone loss results were found in implants with a larger pitch, deeper apical threads, and a narrower implant core. One-piece V-thread design implants demonstrated 100% survival rate. (Implant Dent 2016;25:471–477)*

Key Words: implant thread design, bone loss, V-thread, double thread

There are a variety of dental implant thread designs commercially available. While having an influence on insertion torque and primary stability, thread design also can enhance initial contact, dissipate load forces, and increase surface area at the bone-implant interface.[1–3] Implant geometry may also have an impact on marginal bone loss. There are 4 main geometric thread parameters: pitch, lead, shape, and depth[4] (Fig. 1).

Of the different implant thread design variables, pitch has the most significant influence on surface area.[5] The importance of the thread pitch has been highlighted in an *in vivo* animal study showing improved anchorage of implants with a narrow pitch.[6]

Thread lead influences the amount of revolutions required to insert an implant in reverse proportion.[5] As the thread lead grows, the thread helix angle grows accordingly, resulting in a potential effect on the forces transmitted to the bone.[7]

Thread shape is important in providing long-term function under occlusal load.[5] Different thread shapes have shown different properties in animal studies.[8] The direction of forces arising from occlusal load in a restored implant is influenced by the apical face angle of the thread.[1] Research using finite element analysis (FEA) to evaluate design parameters of osseointegrated dental implants concluded that the square thread design has a beneficial shape for occlusal loading compared with other thread designs.[7]

Profound thread depth increases functional surface area. This is advantageous in soft bone. A shallow thread is more easily inserted, which is advantageous for denser bone.[5,9] Implant design can have progressive threads with higher thread depth in the apical area that gradually decreases coronally. The purpose is to increase the load transfer to the more flexible cancellous bone and decrease load transfer to the crestal cortical bone. This may contribute to less cortical bone resorption.[10] However, little is known on how these macrostructure dental implant features reduce or enhance bone loss.

There are numerous articles using FEA methods to assess the effect of thread design on stress and strain distribution in models of implants embedded in bone[11–15] showing that different thread designs perform variably.

Clinical studies have assessed crestal bone loss around dental implants as a gauge for clinical performance and

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CLINICAL ORAL IMPLANTS RESEARCH

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A systematic review on marginal bone loss around short dental implants (<10 mm) for implant-supported fixed prostheses

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Key words: dental implants, review and evidence-based dentistry, alveolar bone loss, longitudinal studies

Abstract

Purpose: This systematic review aimed to evaluate the effect of implant length on peri-implant marginal bone loss (MBL) and its associated influencing factors.

Material and methods: An electronic search of the PubMed and MEDLINE databases for relevant studies published in English from November 2006 to July 2012 was performed by one examiner (AM). Selected studies were randomized clinical trials, human experimental clinical trials or prospective studies (e.g., cohort as well as case series) with a clear aim of investigating marginal bone loss of short dental implants (<10 mm) supporting fixed prostheses. A random-effect meta-regression model was used to determine the relationship between the effect size mean MBL and the covariate "implant length." Additionally, a subgroup analysis, by means of a random-effect one-way ANOVA model, comparing mean MBL values at different levels of each factor ("type of connection" and "type of prostheses") was also performed.

Results: The meta-regression of mean MBL on the moderator "implant length" was found to be insignificant ($P = 0.633$). Therefore, it could not be concluded that implant length had an effect on peri-implant MBL. In addition, standardized differences in mean MBL on the subgroups short (<10 mm) and standard (≥10 mm) implants, as determined by the meta-analysis (random-effect model), were found to be statistically insignificant ($P = 0.222$).

Conclusions: Within limitations of the present systematic review, it could be concluded that short dental implants (<10 mm) had similar peri-implant MBL as standard implants (≥10 mm) for implant-supported fixed prostheses.

Short dental implants have slowly gained popularity among clinicians because of their ability to provide a successful restoration while avoiding vital structures and the morbidity of advanced bone grafting techniques. There is still no consensus regarding the length to be considered short or standard implant. Some uses 7 mm as the cut-off length (Hagi et al. 2004), and others use 8 mm (Renouard & Nisand 2006) or 10 mm (Monje et al. 2013a). Several meta-analyses have also determined the factors that influence the long-term success of short dental implants (Romeo et al. 2006; Pommer et al. 2011; Sun et al. 2011; Telleman et al. 2011b; Annibali et al. 2012; Monje et al. 2013a, 2013). For instance, short dental implants were less predictable if they were of machined surfaces or if they were placed in areas of poorer bone quality, for example the maxilla (Sun et al. 2011). Despite these limitations, short dental implants, regardless of their diameters (Monje et al. 2013b), have been shown to enjoy similar long-term survival rates as standard (≥10 mm) implants (Pommer et al. 2011; Sun et al. 2011; Telleman et al. 2011b; Monje et al. 2013a). However, if failures do occur, short implants generally fail 2.5 years earlier compared to standard implants (Monje et al. 2013a). It seems plausible that marginal bone loss (MBL) affects long-term survival of short implants as they present with less bone contact surface to maintain osseointegration. As such, MBL around short implants is more crucial than standard implants (≥10 mm).

Factors such as implant–abutment connection (Penarrocha-Diago et al. 2012), implant

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REVIEW ARTICLE

The influence of the connection, length and diameter of an implant on bone biomechanics

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Abstract

Background. Regardless of the multiple options of connections, diameters and heights for dental implants, the clinician should know the biomechanical behavior of the bone to plan the treatment according to the biological and anatomical conditions of each patient, without risk to the long-term treatment success. ***Review.*** The following review attempts to summarize the relevant literature to establish guidelines for clinicians based on the scientific evidence regarding the influence by the implant's connection, diameter and length on the bone biomechanics. ***Conclusions.*** The length, diameter and connection of each implant have a degree of influence in bone biomechanics. Despite the influence of different implant connections, diameters and lengths on peri-implant bone stress and strain, these characteristics should remain within the physiological limits to avoid a pathological overload, bone resorption and consequent risk to the long-term success of implant-prosthetic treatment.

Key Words: *biomechanics, bone, dental implants, implant connection*

Introduction

In the last decades, major technological and scientific advances have occurred in dental implantology. The esthetic requirements of clinicians and high patient expectations continue to increase, as do advances in implant design and clinical techniques [1].

Many types of implants are available, which have different external designs, surfaces, platforms, connections, diameters and lengths [2]. This extensive range of options should be analyzed biomechanically by the clinician, according to the biological and anatomical conditions of each patient. The clinical success of rehabilitation by implant prostheses is predominantly related to the way that mechanical stresses are transferred from the implant to the surrounding bone without generating tensions that could endanger the longevity of the implants and prostheses [3,4].

The following review attempts to summarize the relevant literature to establish guidelines for clinicians based on scientific evidence regarding the factors that influence the biomechanical behavior of implant prosthesis. The objective of this review was to focus on studies that report the influence of the connection, diameter and length on an implant on bone biomechanics.

Biomechanics in implantology

The term *biomechanics* is related to the application of mechanical engineering to solve biological problems [5]. This field is primarily important in dentistry because the teeth, temporomandibular joint, maxilla and mandible undergo biomechanical activities during chewing and functioning [5].

The prognosis and long-term success of dental implant treatment are greatly influenced by the biomechanical environment in which they are exposed [6], in combination with the physical and geometric properties of each implant component [7]; the clinician's poor knowledge of biomechanical concepts is related to the failure of implant restorations [8]. Clinicians should know that the process and

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Effect of Interimplant Distance (2 and 3 mm) on the Height of Interimplant Bone Crest: A Histomorphometric Evaluation

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Background: Implants restored according to a platform-switching concept (implant abutment interface with a reduced diameter relative to the implant platform diameter) present less crestal bone loss than implants restored with a standard protocol. When implants are placed adjacent to one another, this bone loss may combine through overlapping, thereby causing loss of the interproximal height of bone and papilla. The present study compares the effects of two interimplant distances (2 and 3 mm) on bone maintenance when bone-level implants with platform-switching are used.

Methods: This study evaluates marginal bone level preservation and soft tissue quality around a bone-level implant after 2 months of healing in minipig mandibles. The primary objective is to evaluate histologically and histomorphometrically the affect that an implant design with a horizontally displaced implant–abutment junction has on the height of the crest of bone, between adjacent implants separated by two different distances.

Results: Results show that the interproximal bone loss measured from the edge of the implant platform to the bone crest was not different for interimplant distances of 2 or 3 mm. The horizontal position of the bone relative to the microgap on platform level (horizontal component of crestal bone loss) was 0.31 ± 0.3 mm for the 2-mm interimplant distance and 0.57 ± 0.51 mm above the platform 8 weeks after implantation for the 3-mm interimplant distance.

Conclusions: This study shows that interimplant bone levels can be maintained at similar levels for 2- and 3-mm distances. The horizontally displaced implant–abutment junction provided for a more coronal position of the first point of bone–implant contact. The study reveals a smaller horizontal component at the crest of bone than has been reported for non-horizontally displaced implant–abutment junctions. *J Periodontol 2011;82:1749-1756.*

KEY WORDS

Alveolar bone loss; dental abutments; dental implants; dental papilla; histology; prosthesis design.

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The long-term survival of dental implants has been well proven in both the maxilla and mandible.[1-3] Peri-implant bone level has often been used to ascertain the success of dental implants.[4] An average of 1.2 mm marginal bone loss from the first thread at the end of the first year in function and subsequently 0.1 in following years has been reported.[5] Peri-implant bone remodeling occurs after the implant is open to the oral environment.[4] The criteria for implant success have allowed 0.2 mm of vertical bone loss annually.[5,6] This survival rate is well established for implants whether the implant platform is placed at the crest, subcrestally, or supracrestally.[7-10] The level of implant platform placement is often dictated by clinical requirements because it was shown that positioning the implant platform subcrestally is associated with greater crestal bone loss.[11,12]

The proximity of implant–abutment junction and the rough–smooth border can also modify the degree of bone loss. Mechanical load also has been shown to maintain the interproximal soft tissue at a higher level.[13]

In esthetic areas it may be necessary to place the implant platform more apically to produce the desired gingival masking and emergence profile.[14,15] This level of placement may compromise the long-term esthetic results, however, if crestal bone loss occurs around the implant. This

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Crestal Bone Changes on Platform-Switched Implants and Adjacent Teeth When the Tooth-Implant Distance is Less Than 1.5 mm

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Because of the peri-implant bone resorption that occurs when a non–platform switched implant is exposed to the oral environment, it has been recommended to maintain 1.5 mm between the tooth and implant to preserve the bone adjacent to the teeth. Several studies have documented that platform-switched implants have less peri-implant bone resorption than matched implants. This retrospective radiographic analysis studied 70 platform-switched implants placed less than 1.5 mm from an adjacent tooth and with prostheses loaded for a minimum of 6 months. The mean distance between the implant and tooth was 0.99 mm (range, 0.20 to 1.49 mm); the mean horizontal and vertical bone resorption was 0.36 and 0.43 mm, respectively. The mean bone peak reduction was 0.37 mm. The results confirm that the use of platform-switched implants reduces bone resorption after two-piece implants have been uncovered and that it is possible to place this type of implant 1 mm from teeth while maintaining the bone level adjacent to them (the bone peak). (Int J Periodontics Restorative Dent 2012;32:149–155.)

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Over the past 30 years, replacing teeth with dental implants has become a viable solution. Better understanding of the osseointegration process makes implant rehabilitation no longer just a vehicle to restore lost masticatory and phonetic function, but now esthetics as well.[1]

Some authors have recommended to leave 1.5 mm between the tooth and implant to maintain the bone adjacent to the teeth and to obtain good esthetic results.[2–5] This distance comes from the peri-implant bone loss that occurs when implants are exposed to the oral environment: 1.5 to 2.5 mm in the vertical and 1.5 mm in the horizontal dimension.[2–4,6,7] This fact makes it impossible to place an implant of 4-mm diameter in a mesiodistal space of less than 7 mm without causing potential bone loss on the adjacent teeth.

The platform switching concept was developed in an attempt to reduce the effects of peri-implant bone resorption.[8,9] This concept proposes the creation of a discrepancy between the diameter of the implant platform and the diameter

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materials

MDPI

Review

Bone Loss in Implants Placed at Subcrestal and Crestal Level: A Systematic Review and Meta-Analysis

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Abstract: Background: To assess differences in marginal bone loss in implants placed at subcrestal versus crestal level. Methods: An electronic and a manual research of articles written in English from Jaunary 2010 to January 2018 was performed by two independent reviewers. Clinical trials comparing bone loss for implants placed at crestal and subcrestal level were included. Pooled estimates from comparable studies were analyzed using a continuous random-effects model meta-analysis with the objective of assessing differences in crestal bone loss between the two vertical positions. Results: 16 studies were included; 10 studies did not encounter statistically significant differences between the two groups with respect to bone loss. Three articles found greater bone loss in subcrestal implants; while 3 found more bone loss in crestal implants. A meta-analysis for randomized control trial (RCT) studies reported an average and non-statistically different crestal bone loss of 0.028 mm. Conclusions: A high survival rate and a comparable bone loss was obtained both for crestal and subcrestal implants' placement. Quantitative analysis considering a homogenous sample confirms that both vertical positions are equally valid in terms of perimplant bone loss. However, with respect to soft tissue; in presence of a thin tissue; a subcrestal placement of the implant should be preferred as it may reduce the probability for the implant to become exposed in the future and thus avoid the risk of suffering from peri-implant pathologies.

Keywords: systematic review; subcrestal; crestal; bone loss; implants; meta-analysis

1. Introduction

Dental implants have become the preferred choice for the replacement of missing teeth. The five-year success rate of dental implants has increased from 93.5% to 97.1% within the past decade, with a higher survival and a lower complication rate [1]. Patients increasingly require treatments that offer more aesthetics and comfort, making implantology a demanding field, where, obtaining osseointegration or meeting the success criteria of implants highlighted by Buser et al. in the 1990s [2], such as lack of pain and infection, absence of radiolucency and mobility and possibility of restoration, is no longer considered a sufficient condition.

Research in the area of implantology has been evolving substantively. Scientists begin to devote their attention to physical and chemical properties of the implants; on creating different types of surfaces and degrees of roughness [3,4] with the objective of reducing the healing time to achieve secondary stability [4,5]. Furthermore, researchers have also focused, among others aspects, on finding

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ORIGINAL ARTICLE

Marginal bone loss around dental implants with various types of implant-abutment connection in the same patient

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Abstract

Introduction. One of the criteria of implant therapy success is marginal bone loss. The objective of the study was to assess the correlation between peri-implant marginal bone loss and implant-abutment connection systems used in the same patient, as well as other specific characteristics of implant treatment. The initial research hypothesis assumed that there was no difference in marginal bone loss around implants with different implant-abutment connection systems placed in the same patient.

Materials and method. Marginal bone loss was assessed around implants with two different types of implant-abutment connection: with conical (Type I) and with internal hexagonal (Type II) in the same patient. The study included 28 patients aged 37–66 years.

Results. Marginal bone loss around Type I implants was 0.112 mm/month before loading with prosthetic restorations, and 0.010 mm/month after loading, while for Type II implants it reached, respectively, 0.123 mm/month and 0.030 mm/month. Marginal bone loss after loading with prosthetic restorations was 11 times lower for Type I implants and 4 times lower for Type II implants. Evaluation of marginal bone loss in the studied patient groups was made on the basis of orthopantomographic radiographs.

Conclusions. Implants with conical implant-abutment connection are significantly more favourable to osseointegration than those with internal hexagonal connection. As marginal bone loss is faster before loading implants with prosthetic restorations than after loading, it is advisable to consider early loading if the necessary clinical conditions are met.

Key words

dental implants, abutment type, marginal bone loss, humans

INTRODUCTION

Knowledge of factors that affect implant survival and successful treatment at its every stage may significantly contribute to the achievement of therapeutic success. Papaspyridakos et al. [1] proposed a list of factors that lead to the complete success of implant treatment. Therapeutic success is defined as the correct function of the whole complex composed of implants, prosthetic restorations and the surrounding hard (bone) and soft (mucosa and gum) tissues. The particular criteria of maximum success include: implant immobility, absence of pain, and bone loss below 1.5 mm (observed on radiographs). It is also suggested that the success of implant treatment is guaranteed if the therapy follows the principles of bone stability and healthy soft tissues [1].

OBJECTIVE

The main objective of the study was to assess the correlation between peri-implant marginal bone loss and implant-abutment connection systems used in the same patient, as well as other specific characteristics of implant treatment. The initial research hypothesis assumed that there was no difference in marginal bone loss around implants with different implant-abutment connection systems used in one patient.

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MATERIALS AND METHOD

Study population. The study involved 28 patients (11 male and 17 females) treated with dental implants, aged 37–66 years (mean age: 55.8). The maximum observation time from implantation was 46 months. The patients were treated at the Non-Public Health Centre Dent-Plast in Białystok, Poland.

Characteristic of the studied implant systems. The patients were restored with two types of implants with different implant-abutment connection. Type I were implants with Morse taper connection (DENTSPLY Friadent ANKYLOS®), Type II included implants with internal hexagonal connection (MIS Seven®, Alpha-Bio SPI and DFI®, Adin Tuareg RP®, AB 12®, DENTSPLY Friadent Xive®). The patients received 91 Type I implants (Ankylos®) and 149 Type II implants (MIS Seven®: 36, Alpha-Bio SP and DFI®: 73, Adin Tuareg RP®: 14, DENTSPLY Friadent Xive®: 8).

Characteristic of the implant treatment. The total number of implants in the study was 240, including 91 Type I and 149 Type II implants. At least one implant of each type was

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Abutment Disconnection/Reconnection Affects Peri-implant Marginal Bone Levels: A Meta-Analysis

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Purpose: *Preclinical and clinical studies have shown that marginal bone loss can be secondary to repeated disconnection and reconnection of abutments that affect the peri-implant mucosal seal. The aim of this systematic review and meta-analysis was to evaluate the impact of abutment disconnections/reconnections on peri-implant marginal bone level changes.* ***Materials and Methods:*** *To address this question, two reviewers independently performed an electronic search of three major databases up to October 2015 complemented by manual searches. Eligible articles were selected on the basis of prespecified inclusion and exclusion criteria after a two-phase search strategy and assessed for risk of bias. A random-effects meta-analysis was performed for marginal bone loss.* ***Results:*** *The authors initially identified 392 titles and abstracts. After evaluation, seven controlled clinical studies were included. Qualitative assessment of the articles revealed a trend toward protective marginal bone level preservation for implants with final abutment placement (FAP) at the time of implant placement compared with implants for which there were multiple abutment placements (MAP). The FAP group exhibited a marginal bone level change ranging from 0.08 to 0.34 mm, whereas the MAP group exhibited a marginal bone level change ranging from 0.09 to 0.55 mm. Meta-analysis of the seven studies reporting on 396 implants showed significantly greater bone loss in cases of multiple abutment disconnections/reconnections. The weighted mean difference in marginal bone loss was 0.19 mm (95% confidence interval, 0.06–0.32 mm), favoring bone preservation in the FAP group.* ***Conclusion:*** *Within the limitations of this meta-analysis, abutment disconnection and reconnection significantly affected peri-implant marginal bone levels. These findings pave the way for revisiting current restorative protocols at the restorative treatment planning stage to prevent incipient marginal bone loss.*
Int J Oral Maxillofac Implants 2017;32:575–581. doi: 10.11607/jomi.5367

Keywords: *bone loss, dental abutments, dental implants, follow-up studies, osseointegration, titanium*

The establishment and maintenance of a soft tissue seal around dental implants is essential for implant success. The average dimensions of the peri-implant soft tissues are well established: an average of 2 mm of long barrier epithelium and 1 to 1.5 mm of connective tissue integration zones.[1–4]

Any factor that disturbs the connective tissue interaction area has the potential to influence peri-implant bone levels.[1] Dental implant therapy protocols often involve repeated removal and replacement of healing abutments and/or provisional restorations before delivery of a final prosthesis. Several studies have assessed whether a series of abutment disconnections/reconnections can affect the mucosal barrier and result in marginal bone loss; the outcomes have been conflicting.[5–8] Initially, Abrahamson et al[5] reported a more apically positioned connective tissue zone on implants (external hex configuration) subsequent to a series of five abutment disconnections/reconnections. In a later study,[6] the same group used implants with an internal conical connection and reported that a single abutment disconnection/reconnection did not influence the amount of bone resorption or the quality or dimensions of the transmucosal attachment. In a more

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Luigi Canullo, Isabella Bignozzi, Roberto Cocchetto, Maria Paola Cristalli, Giuliano Iannello

Immediate positioning of a definitive abutment versus repeated abutment replacements in post-extractive implants: 3-year follow-up of a randomised multicentre clinical trial

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Key words *bone preservation, definitive abutment, dental implant, immediate loading, platform switching*

Purpose: The aim of this randomised clinical trial was to evaluate the influence of restoration on marginal bone loss (MBL) using immediately definitive abutments (one abutment–one time concept) versus provisional abutments later replaced by definitive abutments.
Materials and methods: In three private clinics, 32 patients with 32 hopeless maxillary premolars were selected for post-extractive implant-supported immediate restoration and randomised to provisional abutment (PA) and definitive abutment (DA) groups, 16 sites in each group. After tooth extraction, 7 patients had to be excluded for buccal wall fracture at tooth extraction or lack of sufficient primary implant stability (< 35 Ncm). The remaining 25 patients (10 PA, 15 DA) received a post-extractive wide-diameter implant. Immediately after insertion, the PA group were immediately restored using a platform-switched provisional titanium abutment. In the DA group, definitive platform-switched titanium abutments were tightened. In both groups, provisional crowns were adapted, avoiding occlusal contacts. All implants were definitively restored after 3 months. In the PA group, a traditional impression technique with coping transfer was adopted, dis/reconnecting abutments several times; in the DA group, metal prefabricated copings were used and final restorations were seated, avoiding abutment disconnection. Digital standardised periapical radiographs using a customised film holder were recorded at baseline (T_0 = implant insertion), final restoration (T_1 = 3 months later), and at 18-month (T_2) and 3-year (T_3) follow-ups. The MBL was evaluated with a computerised measuring technique and digital subtraction radiography (DSR) software was used to evaluate radiographic density.
Results: At the 3-year follow-up a success rate of 100% in both groups was reported. In the PA group, peri-implant bone resorption was 0.36 mm at T_1, 0.43 mm at T_2, and 0.55 mm at T_3. In the DA group, peri-implant bone resorption was 0.35 mm at T_1, 0.33 mm at T_2, and 0.34 mm at T_3. Statistically significant lower bone losses were found at T_2 (0.1 mm) and T_3 (0.2 mm) for the DA group. At T_3, significantly higher DSR values around implant necks were recorded in the DA group (72 ± 5.0) when compared with the PA group (52 ± 9.5).
Conclusions: The current trial suggests that the 'one abutment–one time' concept might be a possible additional strategy in post-extraction immediately restored platform-switched single implants to further minimise peri-implant crestal bone resorption, although a 0.2 mm difference may not have any clinical effect. Additional clinical trials with larger groups of patients should be performed to better investigate this hypothesis.

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ORIGINAL RESEARCH

CLINICAL ORAL IMPLANTS RESEARCH WILEY

Influence of abutment disconnection on peri-implant marginal bone loss: A randomized clinical trial

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Abstract

Objectives: To evaluate the influence of abutment disconnections and reconnections on peri-implant marginal bone loss.

Material and methods: Twenty-four participants received single-unit implants and were randomly assigned into one of the two groups: the definitive abutment group (DEF), in which the definitive abutments were connected at the same time as the implant was inserted; and as a control, the healing abutment group (HEA), in which the healing abutments were disconnected and reconnected three times, at 8, 10, and 12 weeks after surgery. Peri-implant marginal bone level was measured through radiographic follow-up performed immediately after the surgery (baseline), at 8 weeks and after 6, 12, and 24 months. Implant stability and peri-implant health were assessed by resonance frequency analysis and peri-implant probing, respectively.

Results: At the end of 2 years, the mean bone level was −0.18 ± 0.12 mm for the DEF group and −0.13 ± 0.13 mm for the HEA group, resulting in a cumulative bone loss of −0.61 ± 0.10 mm and −0.81 ± 0.15 mm, respectively, with no statistical difference between groups. Bone level changes showed statistically significant differences only between 0 and 2 months (DEF: −0.70 ± 0.12 mm; HEA: −0.36 ± 0.10 mm) and between 2 and 6 months (DEF: −0.11 ± 0.11 mm; HEA: −0.65 ± 0.14 mm). No differences were observed between the groups for implant stability, probing depth, and bleeding on probing.

Conclusion: Immediate connection of the prosthetic abutments did not reduce bone loss in comparison with three disconnections of the healing abutments.

KEYWORDS

abutment, dental implants, disconnection, peri-implant bone loss

1 | INTRODUCTION

Previously, the criteria for successful osseointegrated implants proposed in the 1980s included an expected peri-implant marginal bone loss of about 1 mm in the first year of function as a result of unavoidable bone injury during surgery (Albrektsson, Zarb, Worthington, & Eriksson, 1986). The initial bone loss could be considered acceptable since the bone level stabilized after the first year and this would therefore not jeopardize the long-term function of implants (Albrektsson, Chrcanovic, Ostman, & Sennerby, 2017; Albrektsson et al., 1986). However, the expansion of dental implant indications to partially edentulous patients led to the establishment of additional

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Meta Analysis
Dental Implants

Platform-switching implants and bone preservation: a systematic review and meta-analysis

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J. F. Santiago Junior, V. E. de Souza Batista, F. R. Verri, H. M. Honório, C. C. de Mello, D. A. dF. Almeida, E. P. Pellizzer: Platform-switching implants and bone preservation: a systematic review and meta-analysis. Int. J. Oral Maxillofac. Surg. 2015; xxx: xxx–xxx.

Abstract. The aim of this study was to perform a systematic review and meta-analysis to evaluate the possible benefits of platform-switching (PSW) implants when compared to regular platform (RP) implants in the categories of bone preservation and longevity. This systematic review and meta-analysis was performed in accordance with the PRISMA statement, PICO question, and Jadad scale. The relative risk (RR) of failure and the mean difference for marginal bone loss were calculated considering a confidence interval (CI) of 95%. Heterogeneity and subgroup analyses were performed, and funnel plots drawn. Twenty-five studies (17 randomized controlled trials (RCTs) and eight prospective studies) involving 1098 patients and 2310 implants were analysed. The meta-analysis revealed a significant reduction in crestal bone loss for PSW implants compared with RP implants (−0.41 mm, 95% CI −0.52 to −0.29, $P < 0.00001$). However, there was no statistically significant difference in implant failure (RR 1.10, 95% CI 0.6–2.02, $P = 0.75$). A reduction in bone loss with PSW implants was observed for the following subgroups: RCTs only, implants in the maxilla, and implants in the mandible. PSW implants presented lower bone resorption compared with RP implants. RCTs should be done to explain the possible biases.

Keywords: dental implants; alveolar bone loss; dental implant platform switching; meta-analysis; review.

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The introduction of larger-diameter implants during a period when compatible prosthetic components were not accessible allowed for standard prosthetic components (4.1 mm) to be used with large-diameter implants (5 mm and 6 mm). This concept became known as 'platform switching'.[1] The first clinical case studies[2–4] and retrospective studies[1,5] on platform switching indicated a lower rate of bone loss around these dental implants when compared with implants that received prosthetic abutments of the same diameter platform (Fig. 1).

Several theories have emerged to explain the lower bone loss with this platform-switching treatment modality.[1,6–9] It has been suggested that positioning the implant/abutment interface away from the bone crest allows the biological width to be determined horizontally, enabling the creation of an additional horizontal surface area for the attachment of soft tissue.[7] The peri-implant microbiota is another relevant factor, since the design of these implants can increase the distance between the inflammatory cell infiltrate

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Crestal Bone Stability around Implants with Horizontally Matching Connection after Soft Tissue Thickening: A Prospective Clinical Trial

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ABSTRACT

Background: It has been shown that thin mucosal tissues may be an important factor in crestal bone loss etiology. Thus, it is possible that mucosal tissue thickening with allogenic membrane might reduce crestal bone loss.

Purpose: The purpose of this study was to evaluate how implants with traditional connection maintain crestal bone level after soft tissue thickening with allogenic membrane.

Materials and Methods: One hundred three patients received 103 internal hex implants of 4.6 mm diameter with regular connection. According to gingiva thickness, patients were assigned into A (thin tissues, $n = 34$), B (thin, thickened with allogenic membrane, $n = 35$), and C group (thick tissues, $n = 34$). Groups A and C had one-stage approach, and in group B, implants were placed in two stages. Radiographic examination was performed after implant placement, 2 months after healing, after restoration, and after 1-year follow-up. Crestal bone loss was calculated medially and distally. Significance was set to 0.05.

Results: After 1-year follow-up, implants in group A had 1.65 ± 0.08-mm bone loss mesially and 1.81 ± 0.06 mm distally. Group B had 0.31 ± 0.05 mm mesially and 0.34 ± 0.05 mm distally. C group implants experienced bone loss of 0.44 ± 0.06 mm mesially and 0.47 ± 0.07 mm distally. Differences between A and B, and A and C were significant ($p = .000$) both mesially and distally, whereas differences between B and C were not significant mesially ($p = .166$) and distally ($p = .255$).

Conclusions: It can be concluded that thin mucosal tissues may cause early crestal bone loss, but their thickening with allogenic membrane may significantly reduce bone resorption. Implants in naturally thick soft tissues experienced minor bone remodeling.

KEY WORDS: allogenic membrane, biological width, crestal bone loss, thickening of mucosal tissues, thin mucosal tissues

INTRODUCTION

Stable crestal bone remains one of the most wanted features of successful implant treatment. Many methods have been proposed to maintain crestal bone stability around implants, like platform switching[1–3] or laser-modified implant surface,[4,5] yet the most effective one is still to be established. Implants have improved dramatically since introduction of crestal bone resorption definition in 1986 by Albrektsson and colleagues[6]; however, despite all efforts, we still observe this "crater-like" bone loss pattern. Numerous factors are suggested as reasons for bone loss – polished implant collar,[7] overload,[8] microgap,[9–11] etc. Among them is initial mucosal tissue thickness, which as a factor for crestal bone loss was brought up by Berglundh and Lindhe.[12] It was proposed that if tissue thickness is 2 mm or less, formation of biological width around implants will involve bone loss. Later, this concept was confirmed clinically by study of

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SYSTEMATIC REVIEW

Influence of abutment height on peri-implant marginal bone loss: A systematic review and meta-analysis

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ABSTRACT

Statement of problem. Whether abutment height can influence peri-implant marginal bone loss has not yet been determined.

Purpose. The purpose of this systematic review and meta-analysis was to investigate the early and late marginal bone loss around implants with long and short abutment height.

Material and methods. Electronic (PubMed, EMBASE, and Cochrane) and hand literature searches were performed to identify articles published up to May 2018. A random-effects model was used to analyze the weighted mean difference of marginal bone loss between the long and short groups. Potential confounding factors, including implant/abutment connection, healing, and cement- or screw-retained restoration type, were investigated using meta-regression.

Results. Fourteen studies fulfilled the inclusion criteria, and 8 were further included in the meta-analysis. Around bone-level implants with a long abutment, marginal bone loss can be reduced significantly in both the early (−0.52 mm; 95% confidence interval [CI]: −0.79 to −0.24; P=.001) and late (−0.53 mm; 95% CI: −1.03 to −0.02; P=.041) period. Among tissue-level implants, however, and compared with the short-abutment group, more bone loss was found during the early stage in the long abutment (weighted mean difference: 0.28 mm; 95% CI: 0.03 to 0.54; P=.031). Meta-regression failed to find any association between confounding factors and early bone loss around bone-level implants.

Conclusions. Within the limitation of this systematic review and meta-analysis, abutment height can influence early bone loss around bone-level implants. However, the evidence is insufficient to determine its impact on late bone loss around bone-level implants and early and late bone loss around tissue-level implants. (J Prosthet Dent 2018;■:■-■)

Marginal bone loss has been one of the criteria to define implant success.[1] Early bone loss, considered to be mainly physiological,[2] happens rapidly during the early healing phase from implant installation to 1 year after loading.[3] Progressive bone loss is often regarded as the first step before peri-implantitis, which may be triggered by early bone loss.[4]

Peri-implant marginal bone loss can be influenced by surgical trauma,[5] implant position,[6] occlusal overload,[7] implant-abutment connection type,[8] plaque accumulation,[9] and biologic width reformation.[10] Similar to natural teeth, supracrestal tissue attachment exists around dental implants, providing a biologic seal against the invasion of bacterial pathogens and the ingress of food debris into the implant-tissue interface.[11] Abutment height has been reported to impact peri-implant marginal bone loss.[12,13] Theoretically, the selection of abutment height could influence the space for biologic width re-establishment, the width of the gap between the abutment/crown and bone, and the location of the subgingival crown margin. Some studies[12-19]

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Minimum Abutment Height to Eliminate Bone Loss: Influence of Implant Neck Design and Platform Switching

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Purpose: *This retrospective study quantitatively analyzed the minimum prosthetic abutment height to eliminate bone loss after 4.7-mm-diameter implant placement in maxillary bone and how grafting techniques can affect the marginal bone loss in implants placed in maxillary areas.* ***Materials and Methods:*** *Two different implant types with a similar neck design were singularly placed in two groups of patients: the test group, with platform-switched implants, and the control group, with conventional (non–platform-switched) implants. Patients requiring bone augmentation underwent unilateral sinus augmentation using a transcrestal technique with mineralized xenograft. Radiographs were taken immediately after implant placement, after delivery of the prosthetic restoration, and after 12 months of loading.* ***Results:*** *The average mesial and distal marginal bone loss of the control group (25 patients) was significantly more than twice that of the test group (26 patients), while their average abutment height was similar. Linear regression analysis highlighted a statistically significant inverse relationship between marginal bone loss and abutment height in both groups; however, the intercept of the regression line, both mesially and distally, was 50% lower for the test group than for the control group. The marginal bone loss was annulled with an abutment height of 2.5 mm for the test group and 3.0 mm for the control group. No statistically significant differences were found regarding marginal bone loss of implants placed in native maxillary bone compared with those placed in the grafted areas.* ***Conclusion:*** *The results suggest that the shorter the abutment height, the greater the marginal bone loss in cement-retained prostheses. Abutment height showed a greater influence in platform-switched than in non–platform-switched implants on the limitation of marginal bone loss.* Int J Oral Maxillofac Implants 2018;33:405–411. doi: 10.11607/jomi.5604

Keywords: *abutment height, crestal sinus floor augmentation, dental implants, marginal bone loss, platform switching*

The amount of marginal bone loss occurring around implant necks has been used for many years as a criterion for defining long-term implant success.[1] The etiology of marginal bone loss is not well understood, even if several theories have been proposed to explain it.[2] An adaptive change of crestal bone level after implant placement and subsequent prosthetic restoration was first described by Adell et al.[3] Subsequently, some authors attributed early bone loss to mechanical stresses transferred from the coronal part of the implant to the alveolar crest[4] or, around cement-retained prostheses, to 'foreign-body reaction' stimulated by the presence of cement in soft tissues.[5] Other studies, however, suggested that crestal bone loss may be related to the presence of a microgap at the implant-abutment interface.[6] Irrespective of the implant system used, this internal space of approximately 10 microns would invariably be colonized by bacteria,[7] causing inflammatory cell infiltration around the implant-abutment microgap, as histologically demonstrated in a dog model.[8]

A subsequent report suggested that bone resorption would be reduced as a consequence of increased distance between the bone crest and the area of inflammation produced by bacteria in the implant-abutment microgap.[9] Consequently, a narrow abutment and the resulting mismatch with the implant neck (ie, the platform-switching concept) could reduce the vertical component of biologic width and generate a greater

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Article

Comparative Analysis of Peri-Implant Bone Loss in Extra-Short, Short, and Conventional Implants. A 3-Year Retrospective Study

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Abstract: Objective: To evaluate the influence of implant length on marginal bone loss, comparing implants of 4 mm, 6 mm, and >8 mm, supporting two splinted crowns after 36-month functional loading. Materials and Methods: this retrospective clinical trial evaluated the peri-implant behavior of splinted crowns (two per case) on pairs of implants of the same length placed in the posterior maxilla (molar area). Implants were divided into three groups according to length (Group 1: extra-short 4 mm; Group 2: short 6 mm; Group 3: conventional length >8 mm). Marginal bone loss was analyzed using standardized periapical radiographs at the time of loading and 36 months later. Results: 24 patients (19 women and 5 men) were divided into three groups, eight rehabilitations per group, in the position of the maxillary first and second molars. The 48 Straumann® Standard Plus (Regular Neck (RN)/Wide Neck (WN)) implants were examined after 36 months of functional loading. Statistical analysis found no significant differences in bone loss between the three groups ($p = 0.421$). No implant suffered biological complications or implant loss. Long implants were associated with less radiographic bone loss. Conclusions: extra-short (4 mm); short (6 mm); and conventional length (>8 mm) implants in the posterior maxilla present similar peri-implant bone loss and 100% survival rates in rehabilitation, by means of two splinted crowns after 36 months of functional loading. Implants placed in posterior positions present better bone loss results than implants placed in anterior positions, regardless of the interproximal area where bone loss is measured. Conventional length (>8 mm) implants show better behavior in terms of distal bone loss than short (6 mm) and extra-short (4 mm) implants.

Keywords: short dental implants; marginal bone loss; tissue-level; peri-implantitis; implant-supported prostheses

1. Introduction

Physiological resorption of bone volume begins to develop as soon as teeth are lost from the mandible or the maxilla. This is due to the fact that formation and preservation of the alveolar processes depend on the presence of the teeth. In particular, the maxilla undergoes centripetal resorption from vestibular to palatine, while resorption in the mandible is centrifugal from lingual to vestibular [1,2]. Nevertheless, whether in the mandible or the maxilla, more or less resorption will occur, depending on the number of teeth lost and the time passed since tooth loss [3].

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The Effect of the Distance From the Contact Point to the Crest of Bone on the Presence or Absence of the Interproximal Dental Papilla

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THIS STUDY WAS DESIGNED to determine whether the distance from the base of the contact area to the crest of bone could be correlated with the presence or absence of the interproximal papilla in humans. A total of 288 sites in 30 patients were examined. If a space was visible apical to the contact point, then the papilla was deemed missing; if tissue filled the embrasure space, the papilla was considered to be present. The results showed that when the measurement from the contact point to the crest of bone was 5 mm or less, the papilla was present almost 100% of the time. When the distance was 6 mm, the papilla was present 56% of the time, and when the distance was 7 mm or more, the papilla was present 27% of the time or less. *J Periodontol 1992; 63:995–996.*

Key Words: Papilla, interproximal; gingiva/anatomy and histology.

The presence or absence of the interproximal papilla is of great concern to periodontists, restorative dentists, and to patients. The loss of the papilla can lead to cosmetic deformities, phonetic problems, and lateral food impaction.

If the papilla reforms after surgical treatment, there will be increased pocket depth which could create difficulties with oral hygiene. Additionally, if the papilla reforms the interproximal col, which is non-keratinized and more permeable to bacterial by-products, will also be present.

Since Cohen first described the col in 1959 as buccal and lingual peaks of keratinized tissue with a non-keratinized or parakeratinized interproximal area,[1] very little has been done to determine when the interproximal papilla with its col is present.

In 1961 Kohl and Zander stripped the interproximal tissue on monkeys to determine if the papilla and col would reform.[2] They found that the papilla reformed by the end of the eighth postsurgical week. In 1963 Matherson and Zander[3] also studied the interproximal papilla and the shape of the col. Their study showed that the col took the shape of the contact area of the adjacent teeth and not the underlying bone. In addition, Stahl[4] showed that use of interproximal stimulation can modify the degree of keratinization of the col area.

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All of these studies were designed to determine the shape of the col if it were present, or the degree of keratinization of the col. However, none determined when the papilla would, or would not, be present. The purpose of this study was to determine whether the distance between the contact point and the crest of bone correlated with the presence or absence of the interproximal papilla in humans.

MATERIALS AND METHODS

A total of 288 interproximal sites, 99 anterior interproximal, 99 pre-molar interproximal, and 90 molar sites, in 30 patients were randomly selected for examination. All contact points were closed, and a standardized periodontal probe with Williams markings was used for measurements.

To reduce any edema and inflammation that might be present, all patients underwent thorough scaling and root planing 2 to 8 weeks before the measurements were recorded.

The presence or absence of the interproximal papilla was determined visually prior to probing. If there was no space visible apical to the contact point, the papilla was deemed to be present.

At the time of surgery, the patient was anesthetized and the probe was inserted vertically on the facial aspect of the contact point until the crest of bone was sounded. All measurements were rounded off to the nearest millimeter.

Additionally, the depths of the pocket of the teeth adjacent to the test sites were probed, and were found to be 4 mm or greater in a majority of the sites.

To verify these sounded measurements, 38 of the 288

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The Effect of Inter-Implant Distance on the Height of Inter-Implant Bone Crest*

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Background: The biologic width around implants has been well documented in the literature. Once an implant is uncovered, vertical bone loss of 1.5 to 2 mm is evidenced apical to the newly established implant-abutment interface. The purpose of this study was to evaluate the lateral dimension of the bone loss at the implant-abutment interface and to determine if this lateral dimension has an effect on the height of the crest of bone between adjacent implants separated by different distances.

Methods: Radiographic measurements were taken in 36 patients who had 2 adjacent implants present. Lateral bone loss was measured from the crest of bone to the implant surface. In addition, the crestal bone loss was also measured from a line drawn between the tops of the adjacent implants. The data were divided into 2 groups, based on the inter-implant distance at the implant shoulder.

Results: The results demonstrated that the lateral bone loss was 1.34 mm from the mesial implant shoulder and 1.40 mm from the distal implant shoulder between the adjacent implants. In addition, the crestal bone loss for implants with a greater than 3 mm distance between them was 0.45 mm, while the implants that had a distance of 3 mm or less between them had a crestal bone loss of 1.04 mm.

Conclusions: This study demonstrates that there is a lateral component to the bone loss around implants in addition to the more commonly discussed vertical component. The clinical significance of this phenomenon is that the increased crestal bone loss would result in an increase in the distance between the base of the contact point of the adjacent crowns and the crest of bone. This could determine whether the papilla was present or absent between 2 implants as has previously been reported between 2 teeth. Selective utilization of implants with a smaller diameter at the implant-abutment interface may be beneficial when multiple implants are to be placed in the esthetic zone so that a minimum of 3 mm of bone can be retained between them at the implant-abutment level. *J Periodontol 2000;71:546-549.*

KEY WORDS

Dental implants; dental implantation; bone loss; alveolar bone; papilla.

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The existence of the biologic width around teeth has been documented in the literature. It was a study by Gargiulo et al.[1] in 1961 that gave us a dimensional understanding of this physiologic attachment apparatus. The average distance from the base of the sulcus to the crest of the bone was found to be 2.04 mm. The epithelial attachment averaged 0.97 mm and the connective tissue attachment averaged 1.07 mm in length. Another cadaver study by Vacek et al.[2] in 1994 confirmed the consistency of these dimensions while showing the connective tissue attachment to average 0.77 mm and the epithelial attachment to average 1.14 mm.

The presence of a biologic width around implants has also been investigated. Multiple research groups have verified that a biologic width also exists around implants.[3-8] This is true for implants of all shapes after uncovering (stage 2) surgery. For 1-piece non-submerged implants[4,7,8] or 2-stage implants used with a single-stage non-submerged protocol, the biologic width will form at the time of implant placement. This phenomenon is not related to loading and it will occur whether the implant is unloaded or loaded.[7]

The biologic rationale is that the bone exposed to the oral cavity will always cover itself with periosteum and connective tissue. Additionally, connective tissue will always cover itself with epithelium. If a chronic irritant, such as bacteria, reaches the implant-abutment interface through screw-access channels,[9-12] or if the abutment is removed after initial healing,[6] the bone will resorb to create a distance from this chronically exposed or irritated area. Tarnow et al.[13] have previously histologically documented a similar bone response to subgingival crown preparations that violate the attachment apparatus on human teeth.

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Effect of the Vertical and Horizontal Distances Between Adjacent Implants and Between a Tooth and an Implant on the Incidence of Interproximal Papilla

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Background: The interproximal dental papilla is considered an essential component of the anterior and posterior regions of the maxilla and mandible. The absence of this structure has esthetic and phonetical consequences and lateral food impaction problems occur with the implant-supported prosthesis. The aims of the present study were to: 1) evaluate the effect of the vertical and horizontal distances between adjacent implants (group 1) and between a tooth and an implant (group 2) on the presence of the interproximal dental papilla; and 2) determine whether the interaction between the vertical and horizontal distances might be associated with the incidence of the papilla.

Methods: In 48 patients, 96 interproximal sites in group 1 and 80 in group 2 were examined. The distance from the base of the contact point to the bone crest (D1), the distance between tooth and implant or between two implants (D2), and the distance from the base of the contact point to the tip of the papilla (D3) were measured.

Results: In both groups, when D2 was 3, 3.5, or 4 mm, the papilla was present most of the time ($P<0.05$), and when D2 was 2 or 2.5 mm, the papilla was absent 100% of the time ($P<0.05$). Further, in group 2, when D1 was between 3 and 5 mm, the papilla was present most of the time ($P<0.05$). However, in Group 1, only when D1 was 3.0 mm was the papilla present most of the time ($P<0.05$). For both groups, analysis of the interaction between D1 and D2 showed that when D2 was ≤2.5 mm, the papilla was absent; otherwise, when D2 was ≥3 mm, there was an interaction between D1 and D2.

Conclusions: We conclude that the ideal distance from the base of the contact point to the bone crest between adjacent implants is 3 mm and, between a tooth and an implant, 3 mm to 5 mm. The ideal lateral spacing between implants and between tooth and implant is 3 mm to 4 mm. Further, there is an interaction between horizontal and vertical distances when the lateral spacing is greater than 3 mm. *J Periodontol 2004;75:1242-1246.*

KEY WORDS

Dental implants; dental papilla/anatomy and histology; dental prosthesis design; dental prosthesis, implant supported; gingiva/anatomy and histology.

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The application of osseointegration principles to single-tooth and partial edentulism has increased patients' esthetic demands. For dental implants in an esthetic zone, the criteria for success involve the establishment of a soft tissue contour with an intact interproximal papilla and a gingival outline that is harmonious with the gingival silhouette of the adjacent healthy dentition.[1]

The absence of the interproximal papilla can lead to cosmetic deformities, phonetic difficulty, and food impaction.[2] The contour of the interdental tissues, as well as the color and texture of the keratinized tissues, are essential factors in the esthetics of anterior implant-supported restorations.[3]

Different surgical and prosthetic management techniques of the soft tissue around implant restorations have been developed to achieve esthetic results.[4,5] However, the predictable regeneration of the interproximal papilla adjacent to dental implants remains a complex challenge and the peri-implant mucosal response is not clearly understood. Characterization of the components that affect the presence or absence of this papilla is thus of great importance.

Recently, Choquet et al.[1] reported a correlation between the distance from the base of the contact point to the bone crest and the presence or absence of the interproximal papilla. Their study showed that when the vertical distance is 3 mm, the papilla filled up the entire proximal space 80.0% of the time. The same group had previously

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REVIEW ARTICLE

WILEY CLINICAL ORAL IMPLANTS RESEARCH

A systematic review on the influence of the horizontal distance between two adjacent implants inserted in the anterior maxilla on the inter-implant mucosa fill

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Abstract

Objectives: To address the following focused question: "Does the horizontal distance between two adjacent implants inserted in the anterior maxilla affect the inter-implant mucosa fill?".

Material and Methods: A comprehensive literature screening was performed in MEDLINE and Cochrane databases from January 1, 2000 until July 1, 2017. Clinical human studies including ≥10 patients treated with at least two adjacent implant-supported crowns in the anterior maxilla with a minimum of 12 months of follow-up were searched. Studies reporting on inter-implant mucosa fill in relation to the radiographic horizontal distance between the two adjacent implants were included. The reporting of this systematic analysis adhered to the Preferred Reporting items for Systematic Review and Meta-analyses (PRISMA) statement.

Results: The initial search resulted in 208 publications. From 13 full-text articles reviewed, 4 were included in the final analysis. Depending on the reference points used, the horizontal inter-implant distance ranged between 2.01 and 4.0 mm. In 21 to 88.5% of the cases, inter-implant-mucosa filled more than half of the inter-implant space. When interpreting results of inter-implant mucosa fill, time of implant placement (immediate or delayed) and restoring (immediate or conventional) were taken into consideration. A tendency towards incomplete inter-implant mucosa fill at a distance of <3 mm was noted in the 3 included papers. One of the studies found this trend to be statistically significant (p = .008).

Conclusions: Based on the available evidence, it is not possible to define a precise threshold for the optimal horizontal distance between two adjacent implants.

KEYWORDS
aesthetics, dental implants, horizontal distance, interdental papilla, interproximal soft tissue, papillae

1 | INTRODUCTION

Nowadays, the aesthetic outcome following implant placement has become a key issue in the evaluation of the overall treatment success. A crucial factor is related to the presence and height of the interproximal papilla, which is commonly assessed employing different classification scores (Furhauser et al., 2005; Jemt, 1997).

A variety of factors might influence the presence or absence of the papilla. Next to a single implant, the development of the peri-implant papilla was shown to be predominantly related to the marginal

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REVIEW

WILEY

The effect of implant-abutment junction position on crestal bone loss: A systematic review and meta-analysis

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University of Michigan Periodontal Graduate Student Research Fund

Abstract

Purpose: To investigate the effect of the apico-coronal implant position on early and late crestal bone loss (CBL), in bone and tissue level implants.

Materials and methods: Electronic and manual literature searches were conducted for controlled clinical trials reporting on CBL before and after functional loading of implants. Random effects meta-analyses were applied to analyze the weighted mean difference (WMD) and meta-regression was conducted to investigate any potential influences of select confounding factors.

Results: Fourteen articles were included in the systematic review and 12 were included in the quantitative synthesis. For bone level implants, WMD comparing *early* CBL in equi and subcrestal placement was 0.15 mm ($P = .18$). For analyses of *late* CBL in bone level implants, equi and subcrestal placement revealed a 0.03 mm WMD ($P = .88$). Where in supra and subcrestal placement, WMD was 0.04 mm ($P = .86$). The comparison presented considerable heterogeneity between these two arms, where the P value for chi-square test presented as .006. Finally, for CBL between supra and equicrestal placement, WMD was −0.64 mm ($P < .0001$), favoring the supracrestal group. For tissue level implants, WM of early and late CBL in implants placed equi-crestally was 0.68 ± 0.12 mm and 0.69 ± 0.54 mm, respectively, where for implants placed sub-crestally, the WM of CBL was 1.72 ± 0.15 mm and 2.26 ± 0.63 mm, respectively.

Conclusion: Within the limitations of this study, it is recommended to place tissue level implants equicrestally, and bone level implants subcrestally.

KEYWORDS
bone remodeling, clinical study, dental implant, review, systematic

1 | INTRODUCTION

The root causes of crestal bone loss (CBL) around dental implants is a topic that is often challenged, and although the literature is dwelled with articles debating the topic, a verdict is yet to be reached.[1,2] This is particularly true since the exact reasons behind CBL and the determinant factors upon which its magnitude fluctuates is still uncertain.[2–4] It is known beforehand that if CBL is controlled, good esthetic outcomes can be sustained,[5] and the likelihood of metal showing can be decreased.[6,7] Crestal bone stability is usually considered a sign of implant success,[8] presence of CBL in early stages is considered an indication of further bone loss progression,[9] and CBL is often considered the first step preceding peri-implantitis.[10] Previously, studies investigating CBL could not differentiate early bone loss following surgical implant placement from bone remodeling resulting from biologic width formation after implant exposure to the oral cavity, apart from a disease process leading to peri-implantitis.[11,12] All stated forms of CBL were regarded as a single entity, a part of the "physiologic/inevitable" CBL after implant placement.[13] Such differentiation is indispensable, for if we wish to control the initial physiologic response exhibited in CBL, we must know what caused it first-hand.[2]

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Review article

Comparison of external and internal implant-abutment connections for implant supported prostheses. A systematic review and meta-analysis

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ARTICLE INFO

Keywords:
External connection
Internal connection
Bone loss
Complication
Implant survival
Systematic review

ABSTRACT

Objective: The systematic review and meta-analysis aimed to answer the PICO question: "Do patients that received external connection implants show similar marginal bone loss, implant survival and complication rates as internal connection implants?".

Data: Meta-analyses of marginal bone loss, survival rates of implants and complications rates were performed for the included studies. Study eligibility criteria included (1) randomized controlled trials (RCTs) and/or prospective, (2) studies with at least 10 patients, (3) direct comparison between connection types and (4) publications in English language. The Cochrane risk of bias tool was used to assess the quality and risk of bias in RCTs, while Newcastle-Ottawa scale was used for non-RCTs.

Source: A comprehensive search strategy was designed to identify published studies on PubMed/MEDLINE, Scopus, and The Cochrane Library databases up to October 2017.

Study selection: The search identified 661 references. Eleven studies (seven RCTs and four prospective studies) were included, with a total of 530 patients (mean age, 53.93 years), who had received a total of 1089 implants (461 external-connection and 628 internal-connection implants). The internal-connection implants exhibited lower marginal bone loss than external-connection implants ($P < 0.00001$; Mean Difference (MD): 0.44 mm; 95% Confidence interval (CI): 0.26–0.63 mm). No significant difference was observed in implant survival ($P = 0.65$; Risk Ratio (RR): 0.83; 95% CI: 0.38–1.84), and complication rates ($P = 0.43$; RR: 1.15; 95% CI: 0.81–1.65).

Conclusion: Internal connections had lower marginal bone loss when compared to external connections. However, the implant-abutment connection had no influence on the implant's survival and complication rates. Based on the GRADE approach the evidence was classified as very low to moderate due to the study design, inconsistency, and publication bias. Thus, future research is highly encouraged.

Clinical significance: Internal connection implants should be preferred over external connection implants, especially when different risk factors that may contribute to increased marginal bone loss are present.

1. Introduction

Dental implants are a favorable treatment modality for partially or totally edentulous patients [1]. The success of the prostheses along with bone level stability and soft tissue health maintenance around dental implants are critical components for long-term success of implant therapy [2]. According to Albrektsson et al. [3] success criteria established as acceptable comprised an average bone loss of 1.5 mm during the first year in function and of less than 0.2 mm annually in the subsequent years without clinical sign of peri-implant infection.

The implant-abutment connection design seems to be an important factor in modulating bone level changes in implant-supported reconstructions [4]. Marginal bone changes around implants with different connection types have been attributed to several etiological factors, such as biomechanical factors that increase the stress at marginal bone tissue and potentially contribute to alveolar bone resorption [5]. Moreover, biological factors such as peri-implant accumulation of inflammatory cells at the implant-abutment interface may contribute to

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Article

Influence of Implant Connection, Abutment Design and Screw Insertion Torque on Implant-Abutment Misfit

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Abstract: Background: An accurate fit at the implant-abutment interface is an important factor to avoid biological and mechanical complications. The aim of this study was to evaluate the marginal misfit at the implant-abutment interface on external and Morse taper connection, with straight and angulated abutments under different insertion torque loads. Materials and Methods: A total of 120 implants were used, 60 with external connection (EC) and 60 with Morse taper connection (IC). Straight (SA) ($n = 60$) and angulated abutments (AA) ($n = 60$) were randomly screwed to each connection at different torque levels ($n = 10$ each): 10, 20 and 30 Ncm. All specimens were subjected to thermal and cyclic loading and the misfit was measured by scanning electron microscopy. Data were analyzed with one-way ANOVA, t-test and Kruskal-Wallis test. Results: Significant differences ($p < 0.001$) were found between connections and abutments regardless of the torque applied. Morse taper connections with straight and angulated abutments showed the lowest misfit values (0.6 µm). Misfit values decreased as torque increased. Conclusions: The misfit was affected by the type of connection. The type of abutment did not influence the fit in the Morse taper connection. The higher the tightening torque applied the increase in the fit of the implant-abutment interface.

Keywords: external connection; internal connection; abutment; implant-abutment interface; misfit

1. Introduction

During the last decade, dental implants have been constantly evolving through development and research in order to improve the quality of patient care, allowing us to practice a comprehensive and global restorative dentistry, which means obtaining a complete integration between the hard and soft peri-implant tissues [1]. Osseointegration has been considered as a fundamental and priority factor related to the success of the implants [2,3]. However, biological complications can occur due to the bacteria penetration into the microgap at the implant-abutment interface [4,5].

Since the introduction of dental implants, several implant-abutment connection designs have been developed [6]. The first osseointegrated implants had an external hexagon design on the implant platform [7]. This type of connection has been associated with a certain amount of peri-implant bone loss, especially during the first year of performance [8,9]. Such bone loss may be due to chronic inflammation in the implant-abutment interface, the distribution of tensions in the marginal bone crest and the presence of micromovements in the implant-abutment interface. [1,10,11]. To overcome some of the design limitations and bone loss of the external hexagonal connection, internal connection with

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THE JOURNAL OF PROSTHETIC DENTISTRY

SYSTEMATIC REVIEW

Evaluation of marginal bone loss of dental implants with internal or external connections and its association with other variables: A systematic review

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Since their introduction in the 1960s and 1970s, osseointegrated dental implants have been used worldwide to rehabilitate patients with partial or complete edentulism.[1] The evaluation of bone stability is essential to ensure optimal long-term results of osseointegrated implants, because excessive bone loss can result in periimplantitis,[2] which can lead to eventual implant loss. Additionally, the loss of marginal bone height can change the surrounding soft tissue architecture, resulting in the loss of interdental papilla and causing esthetic and phonetic changes and food impaction.[3] Decreases in inflammatory reactions, load concentrations, and bacterial leakage at the implant-abutment interface are closely associated with marginal bone loss.[4,5]

ABSTRACT

Statement of problem. Different factors can influence marginal bone loss around dental implants, including the type of internal and external connection between the implant and the abutment. The evidence needed to evaluate these factors is unclear.

Purpose. The purpose of this systematic review was to evaluate marginal bone loss by radiographic analysis around dental implants with internal or external connections.

Material and methods. A systematic review was conducted following the criteria defined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Initially, a population, intervention, comparison, and outcome(s) (PICO) question was defined: does the connection type (internal or external) influence marginal bone loss in patients undergoing implantation? An electronic search of PubMed/MEDLINE and Scopus databases was performed for studies in English language published between January 2000 and December 2014 by 2 independent reviewers, who analyzed the marginal bone loss of dental implants with an internal and/or external connection.

Results. From an initial screening yield of 595 references and after considering inclusion and exclusion criteria, 17 articles were selected for this review. Among them, 10 studies compared groups of implants with internal and external connections; 1 study evaluated external connections; and 6 studies analyzed internal connections. A total of 2708 implants were placed in 864 patients. Regarding the connection type, 2347 implants had internal connections, and 361 implants had external connections. Most studies showed lower marginal bone loss values for internal connection implants than for external connection implants.

Conclusions. Osseointegrated dental implants with internal connections exhibited lower marginal bone loss than implants with external connections. This finding is mainly the result of the platform switching concept, which is more frequently found in implants with internal connections. (J Prosthet Dent 2016;116:501-506)

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Stefan Vandeweghe, Hugo De Bruyn

A within-implant comparison to evaluate the concept of platform switching. A randomised controlled trial

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Key words *bone loss, implant, platform switching, southern implants, wide body*

Purpose: To evaluate whether platform switching could preserve marginal bone around implants up to 6 months after loading.

Materials and methods: 15 patients were selected for a randomised controlled trial. Each patient received one customised wide body implant, with the external hex connection located eccentrically, allowing an extra 1 mm switch on one side. The hex was positioned at random at the mesial or distal side and the implant was loaded after 6 months of non-submerged healing. Patients were examined at 3, 6 and 12 months after surgery, during which a radiograph was taken to evaluate bone levels. At 12 months, the mucosal thickness was measured using a perio-probe.

Results: All implants survived and the mean overall bone loss, calculated from both the switched and non-switched side, was 0.39 mm (SD 0.33, range 0.00–1.45), 0.85 mm (SD 0.59, range 0.10–2.50) and 0.80 mm (SD 0.46, 0.26–1.89) after 3, 6 and 12 months, respectively. The bone loss continued up to 6 months but stabilised thereafter ($P = 0.615$). Significantly more bone loss was observed at the non-switched side compared to the switched side at 3 months (0.51 mm versus 0.28 mm, $P = 0.019$), 6 months (1.05 mm versus 0.64 mm, $P = 0.002$) and 12 months (0.94 mm versus 0.66 mm, $P = 0.002$).

The mean mucosal thickness was 4.22 mm (SD 1.45; range 1.50–7.00), and was not significantly different between the switched and non-switched sides ($P = 0.882$). However, using a post-hoc analysis with the mean thickness as a threshold, the mean bone loss was only significantly different between switched and non-switched sides when the mucosa was thicker than 4.22 mm ($P = 0.036$).

Conclusions: The outcome of this randomised trial is in accordance with earlier studies suggesting that that platform switching decreases bone loss by 30%. Although the sample size was limited, it seems that the creation of a biologic width affects peri-implant bone loss to a significant extent and that platform switching is only effective when the mucosal thickness allows the establishment of a biologic width.

Conflict-of-interest statement: *Dr Stefan Vandeweghe was supported by a grant from Southern Implants to conduct the research. All implant materials were provided by Southern Implants.*

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Effect of Different Abutments and Connections in Deformation Crestal Bone

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Cintia Helena Cury Saraceni, DDS, MSc, PhD,‡ Alberto N. Kojima, DDS, MSc, PhD,§ and Mutlu Özcan, DDS, MSc, PhD¶

Statement of Problem: *The use of Morse taper connections is increasing, but little is known about the biomechanical use of abutments and their use in fixed prostheses.*

Purpose: *This study evaluated the transmission of load on the bone implant–supported dentures, varying the type of prosthetic connection and abutment.*

Material and Methods: *Using 4 polyurethane models, 3 implants were inserted into each block, establishing the following groups: (a) external hexagon and Micro-Unit abutments; (b) external hexagon and UCLA abutment; (c) Morse taper and Micro-Unit abutments; and (d) Morse taper and UCLA abutments. The prosthetic structures were cast, and in a universal testing machine, load was applied midway between the implants, with cantilever intervals of 5, 10, 15, 20, and 25 mm. Data were analyzed by Mann-Whitney, Friedman, and Kruskal-Wallis tests ($P < 0.05$).*

Results: *Regarding the prosthetic connection, there was no difference in the use of hexagonal or Morse taper, but the use of Micro-Unit abutment showed lower deformation values than UCLA for the 2 connections.*

Conclusions: *The use of intermediate abutments affects the distribution of masticatory loads: the greater the length of the cantilever, the greater the surface deformation of the bone around the distal implant. (Implant Dent 2016;25:328–334)*

Key Words: biomechanics, implant-supported prostheses, strain gauges, dental implant

If the load transfer of an implant, or from the implant to the surrounding bone, exceeds physiological limits, there may be resulting failures in rehabilitation or even loss of osseointegration.[1]

Among the biomechanical factors involved, the passivity of the metal structure of many prostheses reduces the preload on these implants, thus reducing the tensile forces that the structure may generate.[2] The passive fitting of implant-retained prostheses is believed to allow the prosthesis to adapt with the smallest possible marginal misfit, passively adapting to the retaining component without creating stress in the implant itself or the surrounding bone.[3]

Thus, the prosthesis must be fitted with maximal passivity on the implants or intermediate abutments to achieve long-term success of the rehabilitation.[4] Thus, any factors that reduce the preload force generated on the implant system/prosthesis must be considered and studied.

The type of abutment has a direct influence on the load distribution on the bone. One approach to minimize distortions incorporated during the manufacture of prosthetic infrastructures is the use of intermediate abutments between the prosthetic infrastructure and the implant's prosthetic platform. In addition to fitting, the use of these abutments allows better distribution of the stress patterns generated by masticatory loads.[5]

The morphology and design of the prosthetic connection directly influence bone remodeling.[6,7] Studies compared external and internal hexagon type prosthetic connections and noted that the internal design has a larger contact area that extends deeper into the implant, which leads to greater stability of the connection and better load distribution around the bone.[5,8–10] The implant design biomechanically influences the distribution of loads only in cases of implants fitted immediately after extraction and does not affect cases of late loading.[11]

A high stress value can cause various undesirable consequences, such as the loss of the fastening screw, fracture of the set screw or of the implant itself

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Implant platform switching concept: a literature review

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Abstract. – BACKGROUND: The platform switching concept involves the reduction of the restoration abutment diameter with respect to the diameter of dental implant. Long-term follow up around these wide-platforms showed higher levels of bone preservation.

AIM: The aim of this article is to carry out a literature review of studies which deal with the influence of platform-switched implants in hard and soft oral tissues.

MATERIALS AND METHODS: All papers involving "platform switching" that are indexed in MedLine and published between 2005 and 2011 were used. Clinical cases, experimental and non-experimental studies were included, as well as literature reviews.

RESULTS: In our search, we analized 18 clinical cases and 3 reviews. The results indicate that peri-implant bone resorption is reduced with platform switching system.

CONCLUSIONS: All papers written by different researchers show an improvement in peri-implant bone preservation and satisfactory aesthetic results. Further long-term studies are necessary to confirm these results.

Key Words:
Platform switching, Crestal bone remodeling, Crestal bone loss, Biologic width, Bone implant contact (BIC).

Introduction

The goal of modern implant therapy entails more than just the successful osseointegration of the implant. A successful result must also include an esthetic and functional restoration surrounded by stable peri-implant tissue levels that are in harmony with the existing dentition[1,2]. The maintenance of peri-implant bone is a major factor in the prognosis of prosthetic rehabilitation supported by implants; the crestal bone loss can also lead to a collapse of soft tissues and adversely affect the aesthetics of implant-prosthetic elements.

After the insertion of the implant and its prosthetic connection, crestal bone undergoes remodeling and resorption processes[3]. In particular, after one year from the prosthetic restoration, the crestal bone levels resulted approximately 1.5-2 mm below the implant-abutment junction (IAJ)[4]. Although the etiological factors underlying bone loss have not been fully established[5], the main causal factors of crestal bone loss are occlusal overload and peri-implantitis. Regarding the submerged implants, some studies have correlated the loss of bone tissue with the relations between IAJ and bone crest[6]. Given that a sufficient dimension of peri-implant mucosa is necessary to allow for proper epithelial-connectival attachment, where the size of the tissues is not suitable this would generate a certain peri-implant bone resorption to ensure the stabilization of an attack with adequate biological width. In particolar, soft tissue inflammation localized at the implant-abutment interface following the attempt of the same soft tissues to establish the biologic width, would be responsable for a certain bone loss[7].

Many Authors, however, have identified in the presence of a microgap at the implant-abutment interface, resulting in bacterial colonization of implant sulcus, the possible etiologic mechanism[8]. It is likely that there is a bacterial leakage within the implant system, after its prosthetic connection, with subsequent penetration of bacteria and their products within the microgap between implant and abutment. This would cause an inflammatory process close to the crestal bone, resulting in bone support loss[9].

It was pointed out, however, that the resorption resulting from biological processes after prosthetic restoration change with the use of a platform switching model[10].

In an attempt to improve long-term bone maintenance around implants, a new implant-to-abutment connection referred to as "platform switching" has been proposed[4].

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Assessment of Marginal Bone Loss around Platform-Matched and Platform-Switched Implants - A Prospective Study

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The aim of the present study was to perform a software-assisted radiographic assessment of the effect of platform-switching on marginal bone loss (MBL) around dental implants. Forty patients requiring a dental implant in non-grafted partially edentulous mandibles were enrolled and categorized into implants receiving a platform-matched abutment (control group) or implants with a platform-switched abutment (test group). Standardized digital periapical radiographs were taken at the time of implant placement (T0), at implant loading (T1) and 1-year after functional loading (T2). Software-assisted radiographic assessment of the MBL horizontal, vertical and area changes was performed and compared between time intervals (T1-T0, T2-T1 and T2-T0). Mean radiographic horizontal MBL (hMBL) and vertical MBL (vMBL) from implant placement to 1-year after implant loading (T2-T0) were significantly increased around platform-matched when compared to platform-switched abutments (1.04 mm vs 0.84 mm, $p<0.05$) and (0.99 mm vs 0.82 mm, $p<0.05$), respectively. Additionally, bone loss area (BLa) was greater (0.77 mm2 vs 0.63 mm2; $p<0.05$) for platform-matched compared to platform-switched abutments. Platform-switching has a positive impact upon the amount of bone modeling after loading implants with internal hexagon connection.

Key Words: dental implant, platform switching, marginal bone loss, digital radiography

Introduction

Modern clinicians often choose implant therapy as the first treatment option to replace missing teeth. Morphological bone changes should be expected after tooth extraction and implant placement that may result in challenging situations and compromise aesthetics (1). Early identification of surgical and prosthetic factors that induce detrimental effects upon the peri-implant tissues becomes crucial in routine procedures.

Peri-implant marginal bone loss (MBL) at the shoulder-abutment connection has been associated with biological complications that may trigger inflammatory events and further progressing to peri-implant diseases. Peri-implant tissue adaptations may result from the presence of biological width following implant rehabilitation, bacterial colonization at the implant shoulder-abutment interface and stress concentration at the implant shoulder during function (2,3).

Platform switching advocates the concept of using smaller diameter abutments than the implant platform in order to reduce the amount of peri-implant MBL (4). The horizontal inward repositioning of the implant-abutment interface was responsible for confining the bone remodeling away from the outer edge of the implant and thus preserving the peri-implant tissues. Numerous studies evaluating the clinical outcomes of platform-switching have shown long-term promising results (5,6). Moreover, studies including different diameter of implants (7), implant surfaces (8) and abutment connections (9) have been addressed as possible confounding factors to consider when selecting an implant system for platform switching.

To the authors' knowledge few studies examined the implant connection as a potential variable with a biological impact, rather than a mechanical effect upon MBL around platform-switched implants. Thus, this prospective study aimed to evaluate the effect of platform switching on implants with internal hexagonal connection. The work hypothesis was that implants with a platform-matched abutment have greater MBL than implants with a platform-switched abutment.

Material and Methods

Subject Selection

This study was approved by the Ethics Committee of the Dental School of the Universidade de São Paulo (Opinion 401 778). Patients undergoing dental care at the Dental Center of Military Police of São Paulo (COdont) and at Center of Excellence for Prosthodontics and Implant Dentistry (CEPI) of the Dental School, University of São Paulo were enrolled, treated and followed up within a 15-month interval. For each group, 18 patients were initially included, based on a statistical sample size for

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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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Three-dimensional finite element analysis of platform switched implant

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PURPOSE. The purpose of this study was to analyze the influence of the platform switching concept on an implant system and peri-implant bone using three-dimensional finite element analysis. **MATERIALS AND METHODS.** Two three-dimensional finite element models for wide platform and platform switching were created. In the wide platform model, a wide platform abutment was connected to a wide platform implant. In the platform switching model, the wide platform abutment of the wide platform model was replaced by a regular platform abutment. A contact condition was set between the implant components. A vertical load of 300 N was applied to the crown. The maximum von Mises stress values and displacements of the two models were compared to analyze the biomechanical behavior of the models. **RESULTS.** In the two models, the stress was mainly concentrated at the bottom of the abutment and the top surface of the implant in both models. However, the von Mises stress values were much higher in the platform switching model in most of the components, except for the bone. The highest von Mises values and stress distribution pattern of the bone were similar in the two models. The components of the platform switching model showed greater displacement than those of the wide platform model. **CONCLUSION.** Due to the stress concentration generated in the implant and the prosthodontic components of the platform switched implant, the mechanical complications might occur when platform switching concept is used. ***[J Adv Prosthodont 2017;9:31-7]***

KEYWORDS: Platform switching; Dental implants; Implant abutments; Dental implant-abutment design; Dental implant-abutment interface

INTRODUCTION

Platform switching, also known as diameter shifting, is a technique combining an implant with a reduced diameter abutment.[1,2] The concept was introduced in the early 1990s after development of a wide diameter implant that was connected to the standard abutment.[2,3-5] Since it was introduced, the technique has been evaluated by many researchers; it was proposed that connecting the smaller diameter abutment to a larger implant could help prevent crestal bone loss.[2,6-12] In addition, it is reported that platform switching is beneficial in establishing biological width and produces excellent esthetic results.[13-15]

Other than the suggestion that platform switched implants produce satisfactory esthetic results, their advantages can be summarized in terms of biological and biomechanical aspects.[9,10,16-18] Biologically, marginal bone preservation is explained by the change in the micro-gap location, which might be related to inflammatory cell infiltration and reformation of biological width.[10,16] The relocation of the micro-gap might serve as a defense mechanism against bacterial penetration and limit inflammation in marginal bone.[9,17] In addition, platform switching generates a larger surface area for soft tissue attachment.[18]

Mechanically, platform switched implants are known to redistribute stress and ultimately affect peri-implant marginal bone loss.[19] Stress redistribution is reported to be achieved by centralizing stress.[20] It was also stated that prosthetic loading

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Platform Switching: Biomechanical Evaluation Using Three-Dimensional Finite Element Analysis

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Purpose: *The objective of this study was to evaluate, using three-dimensional finite element analysis (3D FEA), the stress distribution in peri-implant bone tissue, implants, and prosthetic components of implant-supported single crowns with the use of the platform-switching concept.* **Materials and Methods:** *Three 3D finite element models were created to replicate an external-hexagonal implant system with peri-implant bone tissue in which three different implant-abutment configurations were represented. In the regular platform (RP) group, a regular 4.1-mm-diameter abutment (UCLA) was connected to regular 4.1-mm-diameter implant. The platform-switching (PS) group was simulated by the connection of a wide implant (5.0 mm diameter) to a regular 4.1-mm-diameter UCLA abutment. In the wide-platform (WP) group, a 5.0-mm-diameter UCLA abutment was connected to a 5.0-mm-diameter implant. An occlusal load of 100 N was applied either axially or obliquely on the models using ANSYS software.* **Results:** *Both the increase in implant diameter and the use of platform switching played roles in stress reduction. The PS group presented lower stress values than the RP and WP groups for bone and implant. In the peri-implant area, cortical bone exhibited a higher stress concentration than the trabecular bone in all models and both loading situations. Under oblique loading, higher intensity and greater distribution of stress were observed than under axial loading. Platform switching reduced von Mises (17.5% and 9.3% for axial and oblique loads, respectively), minimum (compressive) (19.4% for axial load and 21.9% for oblique load), and maximum (tensile) principal stress values (46.6% for axial load and 26.7% for oblique load) in the peri-implant bone tissue.* **Conclusion:** *Platform switching led to improved biomechanical stress distribution in peri-implant bone tissue. Oblique loads resulted in higher stress concentrations than axial loads for all models. Wide-diameter implants had a large influence in reducing stress values in the implant system.* Int J Oral Maxillofac Implants 2011;26:482–491

Key words: *biomechanics, dental implants, finite element analysis, platform switching, prosthesis*

Since the introduction of osseointegration, new alternatives for prosthetic treatment have become available to patients based on the placement of endosseous titanium implants in edentulous areas. The replacement of missing teeth by means of implants has become a predictable treatment modality for both completely and partially edentulous patients.[1–4] Ten-year surveys of fixed prostheses on natural teeth reveal a survival rate of approximately 75%.[5] In contrast, success rates for endosseous implants are greater than 90%.[6–8] Because a high success rate has been achieved, implant treatment options have expanded to include immediate and early implant placement and loading after tooth extraction. However, conventional two-step surgery and delayed loading techniques are still relevant.[9,10]

One challenging aspect of implant therapy is placement and subsequent restoration in the esthetic zone,[6] because the level of peri-implant bone support and the soft tissue dimensions are critical factors

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The Influence of Soft Tissue Thickness on Crestal Bone Changes Around Implants: A 1-Year Prospective Controlled Clinical Trial

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Purpose: *The aim of this clinical trial was to evaluate the influence of gingival tissue thickness on crestal bone loss around dental implants after a 1-year follow-up.* ***Materials and Methods:*** *Forty-six implants (23 test and 23 control) were placed in 19 patients. The test implants were placed about 2 mm supracrestally, whereas the control implants were positioned at the bone level. Before implant placement, the tissue thickness at implant sites was measured with a periodontal probe. After healing, metal-ceramic cement-retained prostheses were constructed. According to tissue thickness, the test implants were divided into A (thin) and B (thick) groups. Intraoral radiographs were performed and crestal bone changes were measured at implant placement and after 1 year.* ***Results:*** *Mean bone loss around the test implants in group A (thin mucosa) was 1.61 ± 0.24 mm (SE; range, 0.9 to 3.3 mm) on the mesial and 1.28 ± 0.167 mm (range, 0.8 to 2.1 mm) on the distal. Mean bone loss in test group B (thick mucosa) implants was 0.26 ± 0.08 mm (range, 0.2 to 0.9 mm) on the mesial aspect and 0.09 ± 0.05 mm (range, 0.2 to 0.6 mm) on the distal aspect. Mean bone loss around control implants was 1.8 ± 0.164 mm (range, 0.6 to 4.0 mm) and 1.87 ± 0.166 mm (range, 0.0 to 4.1 mm) on the mesial and distal aspects, respectively. Analysis of variance revealed a significant difference in terms of bone loss between test A (thin) and B (thick) groups on both the mesial and the distal.* ***Conclusion:*** *Initial gingival tissue thickness at the crest may be considered as a significant influence on marginal bone stability around implants. If the tissue thickness is 2.0 mm or less, crestal bone loss up to 1.45 mm may occur, despite a supracrestal position of the implant-abutment interface.* INT J ORAL MAXILLOFAC IMPLANTS 2009;24:712–719

Key words: *biologic width, crestal bone loss, dental implants, microgap, mucosal thickness*

The concept of early crestal bone loss after prosthetic reconstruction of an implant was suggested by Albrektsson et al[1] more than two decades ago. Since then, many factors have been identified as possible reasons for this phenomenon. Overload,[2] the microgap at the implant-abutment interface,[3] a polished implant neck,[4,5] and others have been discussed extensively; however, the stability of the crestal bone remains controversial. Moreover, the influence of mucosal thickness and biologic width formation on crestal bone loss around implants has been discussed only recently and has received little attention in comparison to other factors.[6,7]

It has been proposed that a minimum of 3 mm of peri-implant mucosa is required for a stable epithelial connective tissue attachment to form.[8] This soft tissue extension is usually referred to as the *biologic width* around implants, and it serves as a protective mechanism for the underlying bone.[9] Some have suggested that if a minimal dimension of gingival tissues is not available, bone loss may occur to ensure the proper development of biologic width.[10] These findings are consistent with prior tooth-related studies, which showed that the establishment of biologic width after tooth crown lengthening involved crestal bone loss.[11]

The transition of alveolar mucosa to peri-implant soft tissues after implant placement is a difficult and complex process. Berglundh et al[12] described the morphogenesis of the peri-implant mucosa and implied that the characteristics of gingival tissues may be important in this process. However, data regarding the relationship between mucosal thickness and marginal bone loss around implants are

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Influence of Thin Mucosal Tissues on Crestal Bone Stability Around Implants With Platform Switching: A 1-year Pilot Study

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Purpose: The aim of this pilot study was to determine what effect thin mucosal tissues can have on crestal bone stability around implants with platform switching.

Materials and Methods: Twelve 2-piece implants, consisting of 6 implants with horizontally matching implant-abutment connection (control) and 6 implants with platform switching (test) were placed in 4 patients. The mean age of the patients was 43 years (range, 37 to 56 yrs). Mucosal tissue thickness at implant sites was measured to be 2 mm or less. Implants were restored with 5 splinted crowns and single 3-unit fixed partial denture. Intraoral radiographs were obtained and crestal bone changes were measured at implant placement and after a 1-year follow-up post-treatment. The statistical significance level was set to P less than .05.

Results: Bone loss around the test implants was 1.81 ± 0.39 mm on the mesial site and 1.70 ± 0.35 mm on the distal aspect. Control implants overcame marginal bone resorption equaling 1.60 ± 0.46 mm on the mesial site and 1.76 ± 0.45 mm on distal measurement. No statistically significant difference was found between control and test implants either mesially ($F_{[1,10]} = 0.746$; $P = .408$) or distally ($F_{[1,10]} = 0.080$; $P = .783$).

Conclusion: Within the limitations of this pilot study it can be concluded that implants with platform switching did not preserve crestal bone better in comparison with implants with traditional implant-abutment connection if, at the time of implant placement, thin mucosal tissues were present.

J Oral Maxillofac Surg 68:2272-2277, 2010

Currently, dental implants with platform switching are considered to represent the newest concepts in avoiding crestal bone remodeling. It seems that the use of abutments with reduced diameter in relation to the implant platform can greatly reduce crestal bone loss to far less than 1.5 mm, a reference point of successful implant treatment after 1 year of loading, proposed by Albrektsson et al.[1] Indeed, a number of retrospective studies reported minimal amounts of bone loss around implants with horizontally non-matching connection, reaching 0.60 mm after 4 years of loading and 0.70 mm after a follow-up of 7.5 years.[2,3] Several controlled clinical trials have shown that implants with platform switching had significantly less bone resorption compared with traditional matching implant-abutment connection.[4-6] These statements can also be supported by data from animal and human histological studies indicating the superiority of modified implant-abutment interface to traditional connection.[7,8]

From a technical point of view, platform switching is a modification of implant-abutment micro-gap, which is found to be one of the major factors respon-

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CLINICAL ORAL IMPLANTS RESEARCH

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The influence of mucosal tissue thickening on crestal bone stability around bone-level implants. A prospective controlled clinical trial

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Key words: allogenic membrane, biologic width, crestal bone loss, thin mucosal tissues, tissue thickening

Abstract

Objective: To evaluate how bone-level implants maintain crestal bone stability after thickening of thin mucosal tissues with allogenic membrane.

Materials and methods: Ninety-seven bone-level implants of 4.1 mm diameter (Institute Straumann AG, Switzerland) were evaluated in 97 patients (28 men and 69 women, mean age 47.3 ± 1.2 years). According to vertical gingival thickness, patients were assigned into test T1 (thin, 2 mm or less, $n = 33$), test T2 (thin thickened with allogenic membrane, $n = 32$) and control C groups (thick, more than 2 mm, $n = 32$). Implants were placed in posterior mandible in one-stage approach and after integration were restored with single screw-retained metal-ceramic restorations. Radiographic examination was performed after implant placement, 2 months after healing, after prosthetic restoration and after 1-year follow-up. Crestal bone loss was calculated mesially and distally. Mann–Whitney *U*-test was applied and significance was set to 0.05.

Results: After 2 months, implants in group T1 had 0.75 ± 0.11 mm bone loss mesially and 0.73 ± 0.10 mm distally. Implants in group T2 had 0.16 ± 0.06 mm mesially and 0.20 ± 0.06 mm distally. C group implants lost 0.17 ± 0.05 mm mesially and 0.18 ± 0.03 mm distally. Differences between T1/T2, and T1/C were statistically significant ($P = 0.000$) both mesially and distally, while between T2 and C was not significant mesially ($P = 0.861$) and distally ($P = 0.827$). After 1-year follow-up implants in group T1 had 1.22 ± 0.08 mm bone loss mesially and 1.14 ± 0.07 mm distally. Implants in group T2 had 0.24 ± 0.06 mm mesially and 0.19 ± 0.06 mm distally. C group implants lost 0.22 ± 0.06 mm mesially and 0.20 ± 0.06 mm distally. Differences between T1/T2, and T1/C were statistically significant ($P = 0.000$) both mesially and distally, while between T2 and C was not significant mesially ($P = 0.909$) and distally ($P = 0.312$).

Conclusions: Significantly less bone loss can occur around bone-level implants placed in naturally thick mucosal tissues, in comparison with thin biotype. Augmentation of thin soft tissues with allogenic membrane during implant placement could be way to reduce crestal bone loss.

Crestal bone stability remains one of the most debated issues in implant dentistry. It is considered to be important for cortical bone preservation, longevity of short implants and prevention of peri-implant tissues recession, which usually accompanies crestal bone loss (Bengazi et al. 1996; Ekfeldt et al. 2003). Initial vertical mucosal tissue thickness was shown to be one of the factors having impact on bone stability. Berglundh and Lindhe in an animal study demonstrated that if mucosal tissues are thinned to 2 mm or less, there is significantly more crestal bone resorption after healing, compared with implants in thick gingiva (Berglundh & Lindhe 1996). Linkevicius et al. performed clinical controlled study and confirmed hypothesis suggested in a previous animal experiment. It was found that mucosal tissues of 2 mm or less in thickness may cause bone loss of 1.38 mm, while implants placed in thick tissues had significantly less bone loss of 0.25 mm (Linkevicius et al. 2009). Furthermore, the succeeding pilot study, comparing regular implant/abutment connection implants with platform switching implants have confirmed that distraction of microgap horizontally does not preserve bone in thin tissues (Linkevicius et al. 2010).

Rationally, it can be suggested that thin tissues might be thickened during implant

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CLINICAL INVESTIGATIONS

Prosthetic Abutment Height is a Key Factor in Peri-implant Marginal Bone Loss

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Abstract: *In this study, we analyzed the influence of prosthetic abutment height on marginal bone loss (MBL) around implants in the posterior maxilla. In this retrospective cohort study, the radiographically determined MBL was related to the height of the abutments of internal conical connection implants at 6 and 18 months post-loading. Data were gathered on age, sex, bone substratum, smoking habit, history of periodontitis, and prosthetic features, among other variables. A linear mixed model was used for statistical analysis. The study included 131 patients receiving 315 implants. MBL rates at 6 and 18 months were mainly affected by the abutment height but were also significantly influenced by the bone substratum, periodontitis, and smoking habit. MBL rates were higher for prosthetic abutment < 2 mm* vs. *≥ 2 mm, for periodontal* vs. *non-periodontal patients, for grafted* vs. *pristine bone, and for a heavier smoking habit. The abutment height is a key factor in MBL. MBL rates followed a non-linear trend, with a greater MBL rate during the first 6 months post-loading than during the next 12 months.*

Key Words: sinus augmentation, peri-implantitis, dental implant, dental implant-abutment connection.

Introduction

Various etiologies have been proposed for marginal bone loss (MBL). It has been attributed to inflammation from biomechanical stress due to an incorrect occlusal prosthesis design (Rungsiyakull *et al.*, 2011) or from a foreign-body reaction to cement in the soft tissues around cemented-retained prostheses (Qian *et al.*, 2012). MBL may also be increased by the presence of pathogenic microflora that promote peri-implant inflammation, increasing pocket depth and bone resorption (Lindhe and Meyle, 2008). It has been observed that resorption is reduced with greater distance between the bone and the area of inflammation induced by bacteria in the implant-crown micro-gap (Piattelli *et al.*, 2003).

The bone level around dental implants is significantly affected by clinical decisions about the biologic width (Hermann *et al.*, 2000, 2001). It has been observed that post-implantation wound healing consistently entails bone resorption and, therefore, the establishment of an angular bone defect at sites in which the mucosa is thinner than 2 mm before the abutment connection and remains similar over time (Berglundh and Lindhe, 1996). Significantly greater peri-implant bone loss was also reported when this tissue was thinner than 2 mm, regardless of the position of the micro-gap (Linkevicius *et al.*, 2009). A subsequent study found a similar magnitude of initial marginal bone loss between implants applied with a "platform-switching" or traditional implant/abutment approach in areas with mucosal thickness of 2 mm or less (Linkevicius *et al.*, 2010). These observations indicate that mucosal thickness has a major influence on the degree of early peri-implant bone loss (Wennström and Derks, 2012).

However, some authors found a higher MBL rate with a shorter prosthetics abutment, compressing the initial mucosa thickness, possibly due to a re-establishment of the biological width (Vervaeke *et al.*, 2014). Collaert and De Bruyn (2002) proposed a relationship between prosthetic abutment height and

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CT Scanning and Dental Implant

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1. Introduction

1.1 Osseointegration and bone density

Osseointegrated screw-shaped titanium implants that support dental prosthesis have been used to restore function and esthetics of missing teeth with favorable clinical results. Restoration using dental implants is now the most popular treatment in the field of dentistry. Since Brånemark P-I reported the treatment using titanium-made dental implants for the edentulous patient in 1977, there has been enormous advancement in the field of implant dentistry.

Successful osseointegration, which is an utmost determining factor for the success of implant treatments, has been viewed as the direct, structural, and functional connection existing between ordered, living bone and the surface of a functionally loaded implant (Fig. 1 a to d). Many clinical studies and investigations were performed to propose success criteria for dental implants. Albrektsson et al. report in 1986 was specific for implants with rigid fixation and is widely used today (Table 1).

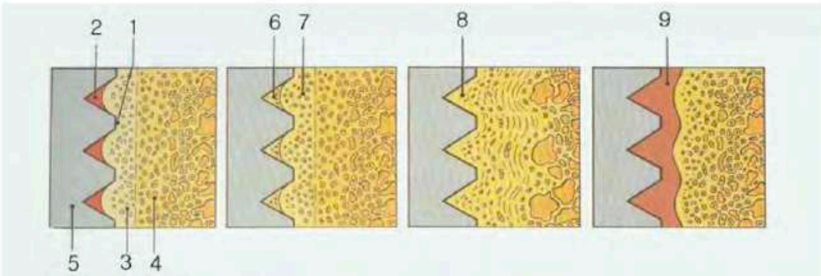

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Fig. 1. Diagrammatic representation of biology of osseointegration

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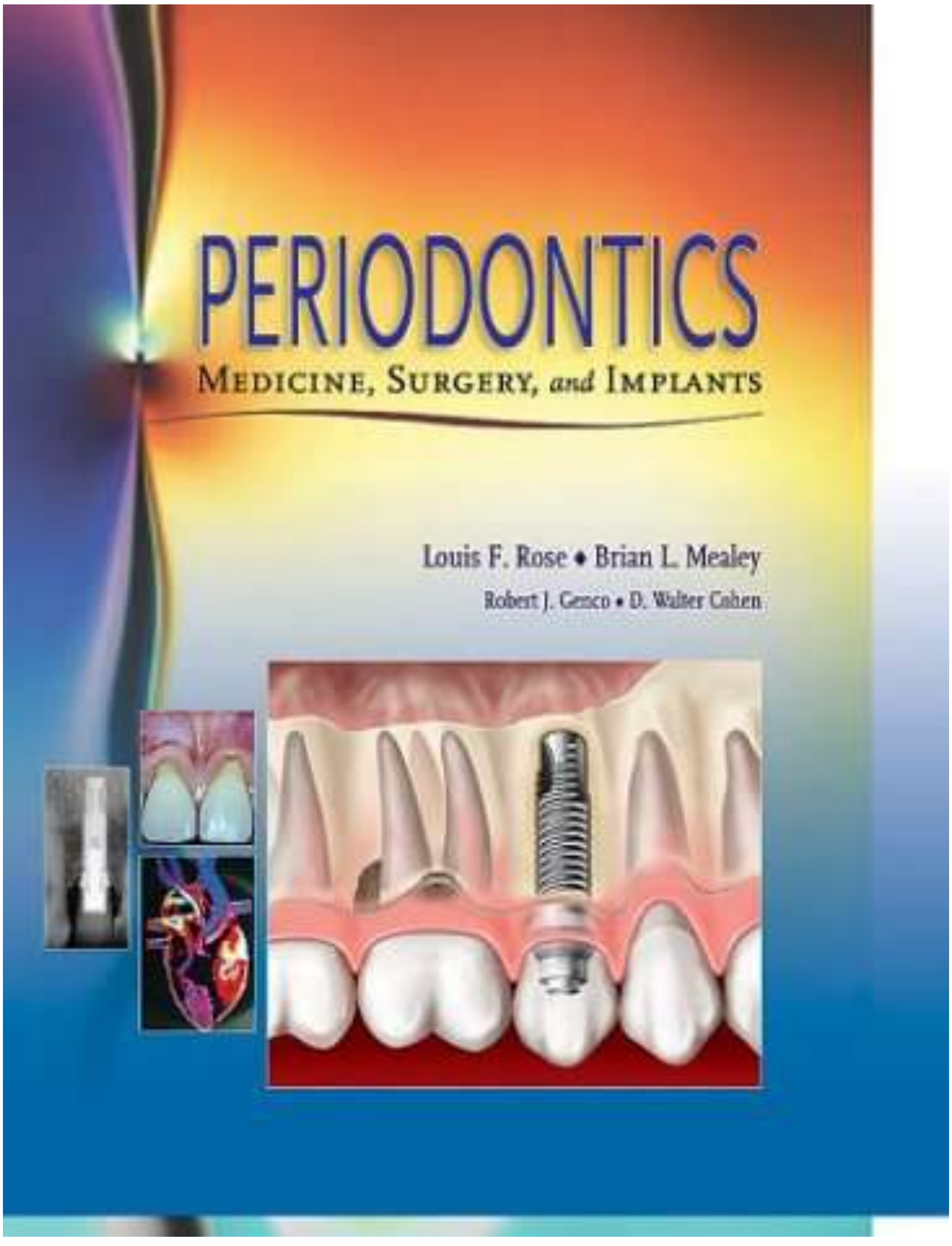

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Review

Methods to Improve Osseointegration of Dental Implants in Low Quality (Type-IV) Bone: An Overview

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Abstract: Nowadays, dental implants have become more common treatment for replacing missing teeth and aim to improve chewing efficiency, physical health, and esthetics. The favorable clinical performance of dental implants has been attributed to their firm osseointegration, as introduced by Brånemark in 1965. Although the survival rate of dental implants over a 10-year observation has been reported to be higher than 90% in totally edentulous jaws, the clinical outcome of implant treatment is challenged in compromised (bone) conditions, as are frequently present in elderly people. The biomechanical characteristics of bone in aged patients do not offer proper stability to implants, being similar to type-IV bone (Lekholm & Zarb classification), in which a decreased clinical fixation of implants has been clearly demonstrated. However, the search for improved osseointegration has continued forward for the new evolution of modern dental implants. This represents a continuum of developments spanning more than 20 years of research on implant related-factors including surgical techniques, implant design, and surface properties. The methods to enhance osseointegration of dental implants in low quality (type-IV) bone are described in a general manner in this review.

Keywords: dental implants; osseointegration; bone regeneration; surface modifications

1. Introduction

Dental implants have become a more common treatment for replacing missing teeth [1]. Consequently, in clinical dentistry, dental implants aim to increase patient satisfaction in terms of improved chewing efficiency, physical health, and esthetics. The global dental implant market is anticipated to grow steadily from US$3.4 billion in 2011 to US$6.4 billion in 2018 [1]. The favorable clinical performance of dental implants has been attributed to their firm bone integration.

In 1965, Brånemark introduced the term "osseointegration" to describe the successful outcome of bone-to-implant integration [2]. Clinically, the process of osseointegration reflects the mechanical anchorage of a dental implant into the jaw bone that persists under all normal conditions of oral function. Overall, bone regeneration related to dental implants in a healthy condition is a complex process and can take up to several weeks. A few days after implantation, several biological events (bone regeneration) are regulated by several growth and differentiation factors that are released in the implant vicinity [3,4]. The process of bone regeneration is formed either on the implant surface (i.e., de novo bone formation, contact osteogenesis) or from the surrounding bone towards the implant surface (i.e., distance osteogenesis) [5]. Finally, bone remodeling occurs by replacing immature with mature bone at the implant site, providing biological (mechanical) stability, which is secondary to primary fixation obtained during implant insertion.

Although the survival rate of dental implants over a 10-year observation has been reported to be higher than 90% in totally edentulous jaws [6], dental implants do fail in some patients. There are many reasons for dental implant failure including an inappropriate diagnosis and treatment

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