Dental Press Implantology

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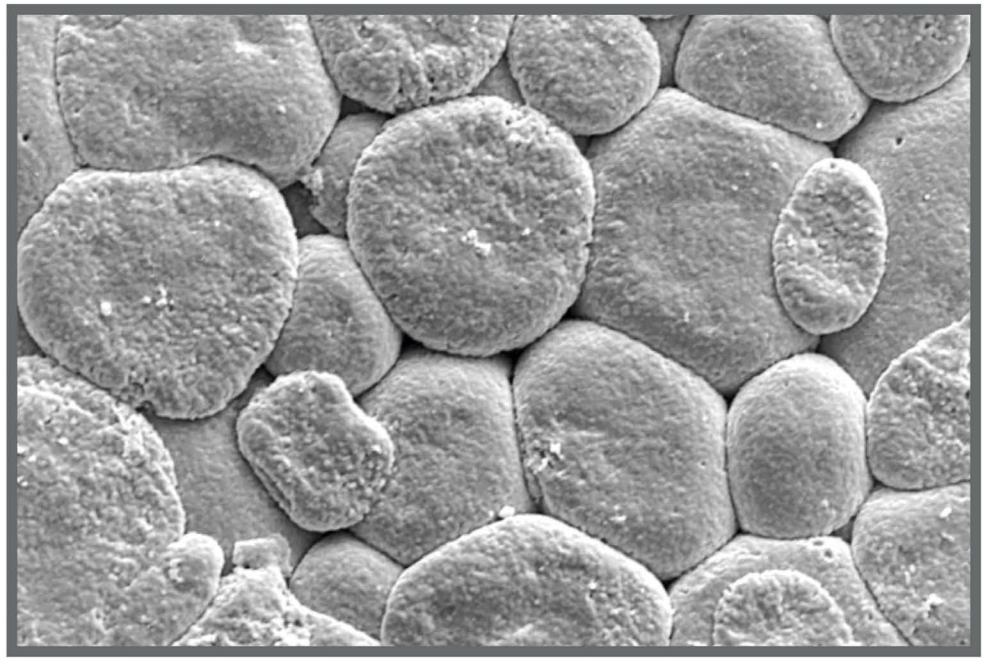

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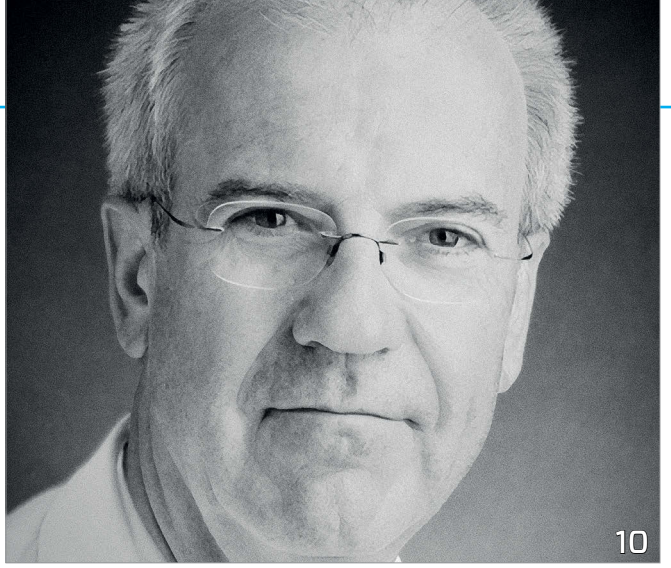
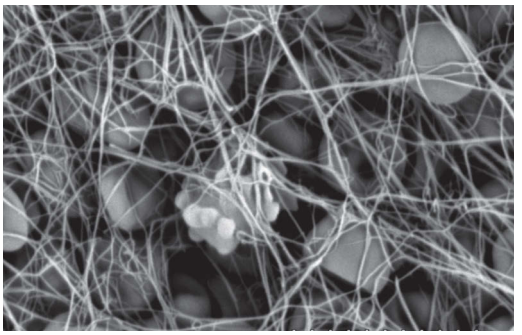


Interview

Explanations and Applications

Ask the Expert

Image and Science



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COVER
Inner face of a Procera coping by sinterization of metal oxides in which the granules were compressed at high pressure and temperature, without the glassy phase (Source: Renato Savi de Carvalho PhD thesis of - "Ask the expert" article, on page 38).

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César Arita
in memoriam

Briefly, according to technical routines and recommendations, the editorial of a journal should present relevant opinions of the publishing team or board of directors about a topic of general interest for its readership. It may also specifically focus on the sequential organization of the topics or articles chosen for a certain issue.

Exceptionally in this issue, the Dental Press Implantology journal, represented by its chief-editors, Professor Carlos Eduardo Francischone and Professor Alberto Consolaro, has offered us space to express all our sadness and grief for the sudden and unexpected passing of a learned exponent of Brazilian dentistry (Sept 14, 2012). At the age of 45, with 24 years of professional experience, at the climax of his career and his life, Professor Dr. César Augusto Arita has left us.

A list of a considerable number of renowned professors and dentists that had the privilege of contacting him or the opportunity to know César Arita would certainly reveal a natural and predictable convergence towards the same conclusion: He was a diplomat of Dentistry! A skillful supporter and disseminator of scientific knowledge. A talented speaker. A sensitive and mordant critic of unprofessional ways and improvisations in our profession. An up-to-date, pragmatic and restless thinker. A man with a refined education. A qualified holder of sophisticate culture and incontestable intelligence, always framed by a subtle and highly refined sense of humor.

Uncountable friends and close relations would be much more capable and prepared to provide details and rich reports of all that was built under Professor César Arita's influence and guidance, and that he has effectively influenced the evolution of Dentistry as a science, art and profession. In truth, it would be very easy and even bureaucratically simple to dwell on his exemplary and admirable professional resume, abundant and fully accessible in the Internet or social networks. However, the purpose of our editorial today, within the limits of only two characteristics of César Arita's profile — humility and simplicity — is to report on a fact that occurred a very short time ago, during his last class, on September 10 of this year, in the São Leopoldo Mandic School of Dentistry, in Campinas, Brazil, where he had very recently joined the faculty of the Master's and Doctorate Programs in Implantology. Without predicting, in any way, what was about to come four days later, he intuitively decided to change the direction of his class about the concepts of Occlusion, Dental Prosthesis and Oral Rehabilitation, which he knew

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in depth, and drew attention to the importance of social interactions and the richness of human values, exclusively on the basis of experience and free observation, definitively leaving a great, thoughtful lesson imprinted in the memories of all the students present on that day.

At a certain moment, in the middle of his technological and cybernetic class presentation, that born teacher made an abrupt stop and, after a quiet pause of seconds, started philosophically dwelling vehemently on the topic of the intense, true and legitimate essence of human relations that had blossomed exactly there, in the classroom, from the casual meeting of colleagues of all origins, where what really mattered was the reunion of multifaceted currents of thought, responsible for the immeasurable benefits of addition and multiplication, always by means of exchanging, sharing, constructively granting the gifts of personal, human, social and scientific interchange that undoubtedly consolidates positive knowledge and solid friendship. On that day, at a certain point, Professor Arita prophesied: "... we are discussing basic concepts of occlusion in a Doctorate class... therefore, you may think: What does that have to do with my course? What am I doing here? And the simple answer is: In a broad view, any concept, any principle is part of any trajectory. When you teach your classes, you'll face a great challenge: to find a proper connection with your students. How can that connection work if we do not turn our eyes to what is simple, to what is basic? This is the key, and also the challenge! The world today and, above all, young people desire something special to catch their attention, so that they may connect to a specific topic. You have to find that, otherwise you will not be heard...".

By sheer chance and fate, this playful outburst was casually recorded by the cell phone of a doctorate student, Ariádene Cristina Pértile Rosa, as she perceived the didactic and philosophical content of that message, and her sensitive feeling made her record that moment. In the next meeting, immediately after the professor passed away, Ariádene taught the master class with fragments extracted from those insights, bringing back to mind the memories and the awareness of all in the class, in a just and emotional tribute.

How many times in our lives do we involuntarily test our real capacity to withstand hardship or great losses, no matter how old or how personally experienced? The more we can assimilate these hard, unexpected and unwanted blows that life now and then deals us, the more resistance we gain to survive and overcome them, contrary to what we might expect. For that, it is important to hold tight to the good examples left by all those that are extremely significant to us. It will certainly help us to improve and recover our strength faster in face of any possible adversity.

César Augusto Arita, as a human being, was special. Regardless of his oriental origin and his contagious happiness wherever he was, he also managed the feat of expressively "smiling" with his eyes. He had an emperor's name, the physique and moral stature of a "great" man. Maybe to justify the captive shelter of a great heart full of goodness, as well as the strength and space to conquer and welcome endless new friends and discoveries. There was no time left...

However, it consoles us to know that he will remain among us for many years. Not physically any more, unfortunately. But in the living, germinating form of all the ideas that he sowed; in the seeds of knowledge and teachings that he planted, in the ethical position that he held, the examples and the memories that he left...

We dedicate these words and this issue of the Dental Press Implantology journal to this distinguished figure of the academic, scientific and professional circles of Brazilian dentistry, together with special and affectionate reference to his wife, Camila Arita, and his only son, Augusto Arita, equally important and fundamental living cells of his legacy.

Franklin Moreira Leahy
Ariádene Cristina Pértile Rosa
(PhD students of Implantology, São Leopoldo Mandic School of Dentistry).

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A communicate to the Dental Class

I hereby communicate the Brazilian Dental Class that I am no longer professionally connected to the reputable company EXOPRO Ind. Com. Imp. Exp. Ltda. (PI Branemark Philosophy), in which I ended my participation as a shareholder, being definitely away from the functions of *speaker*, scientific consultant and technical manager (specially in the development and application of prosthetic components).

Sincerely,
Prof. Dr. Carlos Eduardo Francischone

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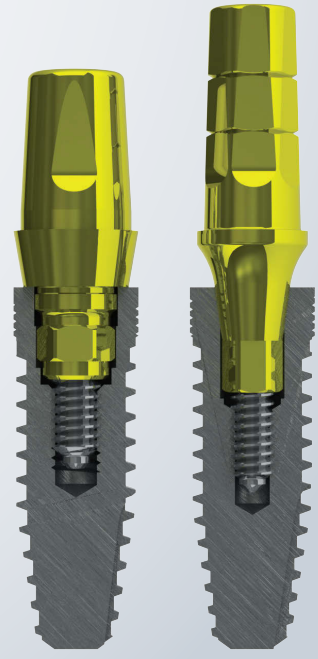

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Georg Watzek

With over 30 years of experience in osseointegration, more than 200 published articles, Professor Dr. Georg Watzek is divided — with remarkable skill — between university life, politics and his private clinic, proving to move comfortably and with great expertise from the scientific knowledge to clinical results, as shown in this interview to the Dental Press Implantology journal.

Committed researcher and professional acting since early 80's, the carrier of Professor Georg Watzek is intertwined with the history of European Implantology. It features a large and experienced view of the entire universe involving osseointegration as a science.

Head of the Department of Oral Surgery of the University of Viena, the renowned professor is dedicated to multiple activities, closely related to the deep study of osseointegration and its applications.

Currently, he is a member of the scientific research committee of the Osteology Foundation in Switzerland, coeditor of the International Journal of Oral & Maxillofacial Implants, member of the Nobel Biocare directors board (Sweden), besides caring his private practice, in Viena.

Invited to lecture at the III International Congress of Implantology, he demonstrated the large experience he gained over the decades as an implantologist, where he discussed several issues related to his presentation, as well as other interesting issues that were a rich source of information to compose this interview.

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Looking at your curriculum, I realized that, as soon as you graduated in medicine in 1970, you started to specialize in dentistry. Had you chosen dentistry before attending medical school or did you choose to be a dentist while you were there? Why did you choose to be a dentist?

Initially, I studied general medicine for becoming a general surgeon. However, towards the end of my studies I decided for maxillofacial surgery. Immediately following the completion of my studies of general medicine I started practical surgical and internistic training at a public hospital in Vienna. Only after having completed this training I began my education and training for dentistry. I only did this because it was also the prerequisite for an employment at the Clinic of Maxillofacial Surgery.

I then started working at the University Clinic of Maxillofacial Surgery in Vienna and in 1982 I was given the offer to establish a Department of Oral Surgery at the School of Dentistry. I accepted this offer and changed to the School of Dentistry of the University of Vienna, where I have remained ever since.

During my time at the Clinic of Maxillofacial Surgery, I also completed various training sojourns at national and international hospital sites, among others at the Clinic of Otorhinolaryngology and the Department of Neurosurgery in Vienna, at the Department of Plastic Surgery of New York University and at the Clinic of Otorhinolaryngology at Columbia University in New York.

In Austria, as in some other countries in Europe, dentistry is a medical specialty. Do you see that as an advantage or a disadvantage? Please explain your point of view.

I am absolutely and definitely in favor of keeping dentistry within the scope of general medicine. If we do not pay adequate attention, dentistry may turn into nothing more than a pure handicraft. I consider general medical knowledge and experience as being essential also for a dentist.

In Brazil, the universities which are most productive in terms of science require researchers to work full time. A university professor is not allowed to have a private practice. Many times, this distance from clinical activities isolates the researcher from the clinical applications of the research. You balance private practice and academic activity and continue to be scientifically productive. How do you divide your time? What is the secret for being so productive? Can you give us an example of a disadvantage of having private practice and academic activities at the same time?

When I joined the School of Dentistry in 1982, hardly anyone ran a private practice adjunctly. During the years of the rise of the Department of Oral Surgery in Vienna, I invariably had assistants who also had a private practice. Retrospectively I can say that I find this very important. When you are only at the clinic you will gradually lose the know-how and the insight into what is happening in private practices. Apart from that, running a private practice after having been active at the university until 16:00 everyday ensured that "my team" gained much more clinical experience than physicians being only at the clinic. They had certainly been motivated to do so by the fact that after obtaining their PhD they would earn better money in their private practices.

Personally, I had always split my time at the clinic and at my private practice in a manner that I spent about two thirds of my working time at the clinic and one third at my private practice. However, I must emphasize that this usually meant a working day of at least 12 hours and that I had frequently also been occupied with scientific problems at the weekends.

The scientific and research work of our team during the last decades was certainly based on the outstanding motivation of my team members. Principally, I consider it as important that the selection of new staff should always be focused on whether they will fit into the team, while their professional qualifications should only be a secondary criterion for selection. A wrong decision or selection in this respect may disrupt the complete team. Personally, I cannot recognize or see any drawbacks for the combination of academic activities and work in a private practice. Physicians relying on this combination will show much more clinical experience as a result of the prolonged daily contact with patients. Naturally, the necessary prerequisite will be appropriate willingness and adequate enthusiasm and zeal for accepting a workload of 12 hours or more, day in and day out.

Once you became a dentist in 1973, you dedicated your life to an academic career. You became a Doctor of Dental Surgery in 1979 and head of the Oral Surgery department in 1982. Finally, in 1983 you became chairman of the Society of Oral and Implant Surgeons. This happened one year after the famous Toronto Conference of 1982. Were you motivated to study implantology by the Toronto Conference? How did you learn about osseointegration?

In 1982, I met Prof. Brånemark for the first time in Gothenburg and I was seriously impressed from the very first moment. The implant he had created was completely different from those being customary at that time. It was scientifically well-founded and consequently also showed a much higher success rate.

Osseointegration is more than 45 years old and you have been involved in this area for 30 years. Please, compare the situation at the beginning of the 80s, and now, in the second decade of this century. How did you describe an implant to a patient at that time and how do you describe it today?

If I try to describe to a patient the possibility of an implantation today, there is hardly any difference to what I said back then.

Today, I still do not promise the patient 100 percent success and, naturally, I advise him/her of possible failures and, in particular, I emphasize that he/she himself/herself will be co-responsible for the success. Naturally, the information provided to the patient is much more detailed and thorough than 30 years ago. This is also due to the legal requirements which have also changed accordingly.

In your experience,how long does a normal student take to learn to install implants? How many implants do you think is a good number to qualify a professional in this branch of dentistry?

Principally, I consider training in implantology for students only important to the extent that they can provide adequate information on implants for patients. During professional dentistry training at the University of Vienna students will be given the opportunity to place implants in the jaws of sheep using appropriate drilling devices.However, they will

not be permitted to insert implants also in human subjects. Generally, this will be reserved for the time of postgraduate training.

Generally, I believe that — as in other fields of specialization — only those things we frequently do will also be done well by us. I would propose to say that the insertion of at least 100 implants per year will be the absolute minimum to gain adequate experience for placing implants in simple cases. Complicated cases should always be reserved for specialized dental surgeons or clinics.

Treated implant surfaces are now one of the most important points of differentiation for the industry. Do you think a treated surface can be considered a revolution in implantology? In private practice, do you apply reduced osseointegration time, as prescribed by the manufacturers?

"Surface" certainly is a topic frequently being discussed by all implant manufacturers and much money is being invested into appropriate research. I cannot imagine this research will ultimately yield any revolutionary findings. However, improvements will certainly be possible and are also to be expected in special cases. Today, the general success rate in implantology is very high, so that there is hardly any margin for significant improvements. However, if we could manage creating surfaces that could keep unchanged bone level at the top of the implant during lifetime, that would certainly constitute a major progress and advance.

Personally, I have successively reduced the healing time of implants. Currently, we have arrived at a time of about 6 weeks for mandibular and 12 to 16 weeks for maxillary implants here in Vienna.

However, these numbers only indicate a certain pattern. There are a number of general disorders that may be forcing us to wait even for 6 to 8 months. For example, this would apply for diabetic patients, very old patients or in post-augmentation patients.

From your experience, what would you say is more important: A treated surface, implant macro design or surgical technique?

In my opinion, surgical experience certainly is of essential importance, followed by implant design and implant surface, both of which can only be secondary complements of an ideal surgical procedure following appropriate prosthetic planning.

Where are we headed? What do you believe will be the next revolution in dentistry?

The next revolution to come in dentistry, which has partly already been implemented, would certainly be the complete disappearance of virtually any impression procedure using impression trays. Today, appropriate scanners may already achieve perfect results and it certainly will only be a question of time until the technique of impression procedures with impression materials will completely disappear. I am also convinced that exclusively virtual planning of surgery and of the subsequent prosthetic procedures will gain additional ground. In this respect, Nobel Biocare must certainly be considered as the worldwide leader. The completely flapless insertion procedure for implants has already become a routine approach.

I see from Nobel Biocare's website that you have been a member of the company's board of directors since the beginning of 2012. This year, Nobel changed its marketing policy. Can you explain Nobel's objectives in Brazil?

As a member of the Board of Directors I will only have influence on long-term strategic planning, but I cannot influence any action of the company's management — and this is certainly also not my intention. Thus, any possible change in the marketing policy in Brazil will exclusively be a decision of the company management and I will have nothing to do with any such decision. Naturally, it must be the goal to increase the market share of Nobel Biocare in Brazil.

What novelties can we expect from Nobel Biocare in the coming years?

Research has always been one of the particular strengths of Nobel Biocare and it has also essentially intensified research efforts in all fields. This research focuses on implant design, implant surface, improvements in the prosthetic field and, in particular, virtual planning options. In all these fields major progress is to be expected for the years to come.

Brazil is considered a world leader in dentistry. How do European professionals see Brazilian dentistry? What do you think is the Brazilian dentistry's main strength? What is European dentistry's main strength?

The rate at which research efforts and research results of Brazilian dental science have increased over the past years is certainly impressive. Brazilian universities are just about to close up with the top schools of dentistry in the world. From a European perspective, I can only give a judgment of the research results of Brazilian dentistry, but not of its clinical level and quality. However, I am convinced that the quality is on a very high level and should today be comparable to that of the previous top quality level in Europe. The strength of European dentistry is certainly based on its clinical quality in actually all fields of dentistry. However, as regards basic research European dentistry has definitely lost ground versus the USA, China and increasingly also Brazil.

As osseointegration was only introduced to Brazil ten years after the Toronto Conference, we don't have many implants which have been in function for decades. Could you share your experience of osseointegration maintenance and follow-up with us?

Today, we are certainly in a position to maintain the osseointegration of implants for decades. However, this should not be interpreted to mean that there will be no unexpected failures.

If a patient asks me how long an implant offered can be preserved and maintained, I will frequently answer "between 1 and 40 years" and will then add that failure — even after a short time — can never be fully excluded, but that the chances and prospects of maintaining the implant for decades will certainly be within a range of more than 90%. However, I also make the patient understand that preservation of the implant will also essentially depend on the patient's cleaning and living habits.

Keratinized peri-implantary tissue has an important role in peri-implantary bone protection. Is it essential? If so, how can we be sure to have this specialized tissue around implants? If not, do we have to treat non-keratinized peri-implantary mucosa differently?

The question for the need of keratinized peri-implant tissue is almost as old as modern implantology itself. Certainly peri-implant keratinized tissue will be positive and essential for the long-term prognosis of an implant. All the more so, as this fixed gingiva will essentially facilitate oral hygiene.

However, the fact that this keratinized peri-implant tissue is not necessarily needed is also substantiated by the high success rate with implant-supported, highly atrophic mandibles which hardly ever show any keratinized peri-implant tissue and where it can neither be achieved by surgical means in the long run nor be maintained and preserved.

Peri-implantary disease can be partially understood as periodontal disease. The presence of biofilm, non-keratinized mucosa and malocclusion are factors which may be present in both peri-implantitis and periodontal disease. Is there any predictable treatment for peri-implantitis? Can you describe it?

I do not believe that the presence of a biofilm, a keratinized mucosa or a malocclusion are primary factors inducing development of peri-implantitis. However, they may very well contribute to the aggravation of a pre-existing peri-mucositis or peri-implantitis.

Do you consider marginal bone loss to be a pathological or physiological event? Please explain your point of view.

Generally I consider bone loss around implants, but also around teeth — though to a very limited extent — as a completely physiological event. It is well known that under physiological conditions bone around teeth will be subject to successive reduction as from the age of about 20 years. Therefore, this can also be accepted as still being physiological for implants after the first year — to an extent of up to 0.1 mm annually. It would be a fundamental mistake confusing bone loss of such limited extent with a diagnosis of peri-implantitis.

Some maxillary sinuses have a greater buco-lingual aspect. Others present anatomical variations and septa. What is the influence of maxillary sinus anatomy on the success of sinus augmentation? Is there any kind of maxillary sinus that is easier to treat? Is there any kind of maxillary sinus that is impossible to fill?

Familiarity with the anatomy of the maxillary sinus must be considered as an essential factor for the success of a sinus lift procedure. Therefore, the absolute prerequisite is appropriate diagnostic evaluation. The treating physician must be familiar with the anatomical structures to be treated and, in particular, what the condition of the sinus floor will be like.

Principally, the rule must be observed that the longer the tooth loss dates back, the easier the sinus lift procedure will be, because the flatter and smoother the sinus floor will be. A sinus lift procedure immediately following the removal of a molar will invariably be associated with an increased risk of perforation of the sinus mucosa because of the unevenness of the sinus floor as a result of the roots. This also holds to a similar extent for a single tooth gap which may require a sinus lift. In such cases the mucosa in the vicinity of the gap must be detached from its support and the neighboring sinus floor may be highly uneven in many cases and prove extremely resistant to surgical detachment of the mucosa. Naturally it will probably be possible to perform a sinus lift in virtually all of the cases, even if, just to give an example, root tips covered with only a thin bone layer protrude into the sinus lumen. However, such cases will require the highest surgical skills on the part of the treating dentist.

It belongs to one of my basic principles to emphasize that implants will always be feasible, but the amount of additional measures and also the risks involved may be extremely variable.

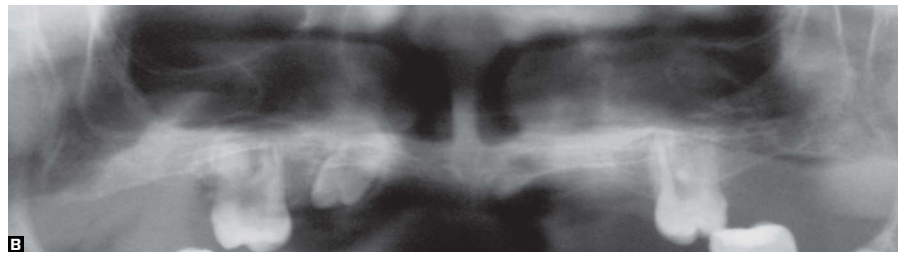
Is there any relation between maxillary atrophy and the thickness of the Schneiderian membrane?

To my knowledge, there is no correlation between a maxillary atrophy and the thickness of the Schneiderian membrane. The thickness of this mucous membrane will only vary as a consequence of previous inflammatory processes. Naturally, a Schneiderian membrane slightly thickened as a result of a chronic inflammatory process will be ideal for a beginner. However, a physiological membrane is extremely thin with only 30 μm. This makes it by far thinner than the skin of a raw egg, which is frequently used for training of the sinus lift procedure, but also thinner than the sinus mucosa of any known experimental animals.

You gave a very interesting presentation about ectodermal dysplasia in children. The initial treatment phase used prostheses supported by palatal onplants. Please explain the development of this specific kind of implant. Are they produced commercially or only to order?

The so-called onplants were propagated by Michael Block from the USA many years ago as support for maxillo-surgical procedures. However, they have never really gained essential importance.

We have been inserting these implants for many years in children, if there is no other possibility for improving or ensuring adequate prosthetic retention in edentulous or nearly edentulous children. This onplant technique is complemented by an appropriate drill making the palatal surface even to ensure optimum contact between these onplants and bone. They are currently manufactured by Nobel Biocare only upon our special request and can no longer be purchased commercially.



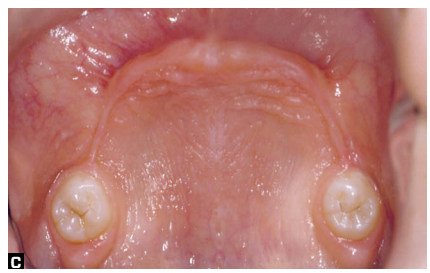
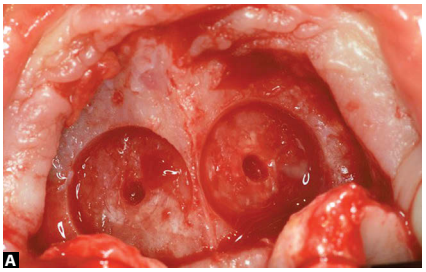


Figure 1 - A seven-year old patient with severe oligodontia. In the maxilla only the first two molars have been developed. The patient also shows a subtotal aplasia of deciduous teeth.



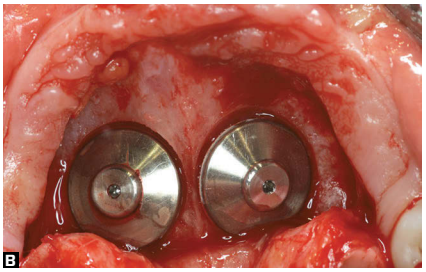
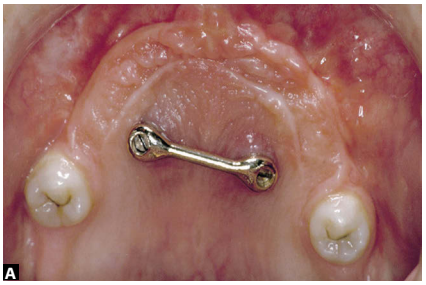
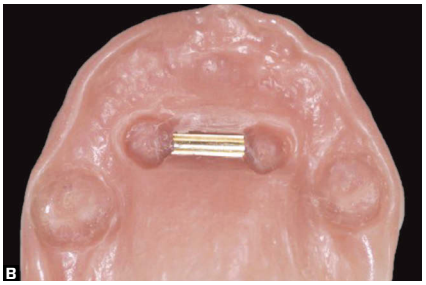


Figure 2 - **A**) Flattened contact area for seating of onplants. **B**) Placement of two onplants on the hard palate. **C**) Postoperative radiograph.





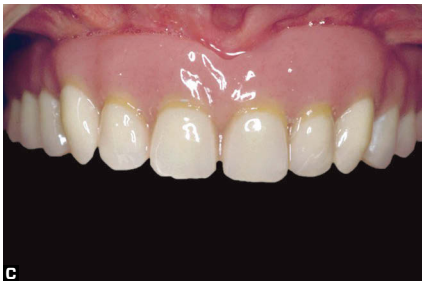
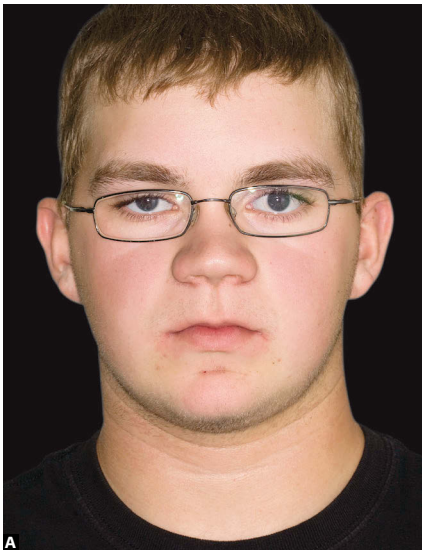
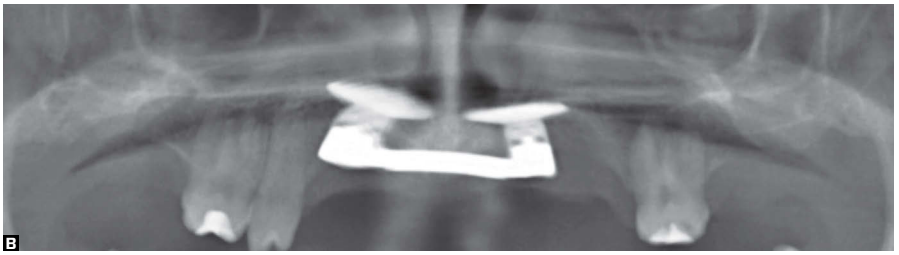


Figure 3 - Status post-fixation of a bar structure for fastening a full denture. For avoiding any growth disturbances of the palatal suture the bar has been divided.





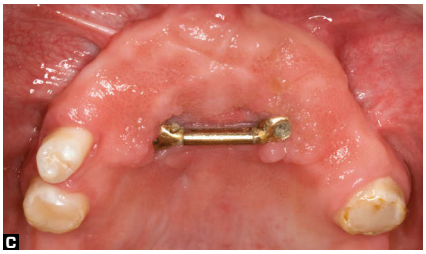


Figure 4 - Situation 11 years later. Unchanged findings apart from a fibromatous tissue around the bar support. The patient currently refuses removal of the onplants and regular augmentation of the maxilla with iliac crest grafts.

By now, we have not seen any losses with these onplants over a follow-up time of up to 15 years. The only problem seen over the years is a fibrous growth mostly around the bar, though this has never yet led to a loss of the implants affected.

What is the psychological impact of ectodermal dysplasia on a child?

I consider the psychological burden for a child with ectodermal dysplasia and a corresponding lack or absence of several, or in frequent cases all teeth, as extremely high. It is well known that without appropriate treatment a disorder of the development of the complete stomatognathic system will be encountered severely affecting the appearance of the children, and later of the adolescents, and this will also be associated with speaking difficulties.

Naturally, social acceptance of such children will also be seriously affected. Therefore, I consider any measures putting the disturbed development of the complete jaw region and the psychological development of such children into the correct pathways as being of essential importance.

In your lecture you also showed a case of dental transplant where premolars were extracted and put in the position of central incisors. The transplant was carried out on a very young child. Implants installed in young patients usually maintain their position while the bone keeps growing. This leads to a palatal position of the implants. Does the same thing happen with transplanted teeth?

We have never seen any subsequent malpositioning of transplanted teeth following primarily regular healing and we can say so looking back at experience in more than 100 patients. Once the transplanted tooth has been integrated it will grow to the same extent as the other teeth. If a malposition should be encountered, it will be orthodontically treated in the same manner as the other permanent teeth. When using the regular standard approach we have never observed the problem of ankylosis of such teeth.

What are the advantages and disadvantages of transplanting teeth instead of using implants?

A major advantage of transplanted teeth versus implants involves the fact that they ultimately will show the same behavior as the own natural teeth and will not represent any obstacle to growth, unless they have become ankylosed after all. Thus, upon regular standard treatment their retention time in the jaw will be equivalent to that of the own natural teeth.

You published an article in Clinical Oral Implant Research journal in 2009 with the title: Are culture-expanded autogenous bone cells a clinically reliable option for sinus grafting? My question is: Are culture-expanded autogenous bone cells a reliable option in private practice?

In my opinion, culture-expanded autogenous bone cells are no option for sinus grafting in a private practice. Generally, I consider this procedure as currently being without clinical relevance, because clinical experience invariably shows that conventional bone substitute materials with their osteoconductive potency will usually be adequate with some notable exceptions in extreme cases. The advantages of culture-expanded autogenous bone cells versus conventional procedures are rather small and the expenses extremely high.

Finally, it would be nice if you could finish with an inspirational message for Latin American dentists.

It is beyond doubt that successful implantation may only be done in a mouth having been fully rehabilitated periodontally. This is a basic requirement for long-term success. As oral surgeon I personally work partly together with dentists, who are hardly involved in periodontal work, while others are intensely occupied with such work. In periodontologists' patients I hardly ever see any failures or cases of peri-implantitis, while this is definitely the case in patients being referred by dentists showing only little additional care for the periodontal condition of the patient. Thus, prevention of peri-implantitis certainly is an initially critical factor. Conservative treatment methods for a peri-implant mucositis will certainly be successful in many cases, while any surgical procedures for treatment of peri-implantitis currently known or used will only show limited chances of success.

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Diagnosis of occlusal trauma: Extrapolations for peri-implant bone region can be done

Alberto **CONSOLARO***

Abstract

Images provide a language to describe the dynamics of bone and tissue. Bone density and space distribution vary and indicate greater or lower reaction and adaptation to functional demands, such as masticatory loads, on natural teeth or osseointegrated implants. In rehabilitation, load distributions have to be planned, and the remaining teeth and their relation with neighboring bone should be evaluated. The detection of bone responses to pre-existing occlusal trauma may provide a more accurate evaluation of masticatory conditions and parafunctional habits, that is, a true functional history of remaining teeth. Occlusal interference and overloads take months or years to induce classical signs and symptoms of occlusal trauma as a clinical entity. When a tooth has pulp necrosis and signs of occlusal trauma, the evaluation of history, as well as all tests, should be directed to the diagnosis of superposed dental trauma even when posterior teeth are affected. There is no scientific basis to confirm that occlusal interferences and overloads lead to pulp necrosis. A frequent question: Up to what point should orthodontic forces be applied to osseointegrated implants? Orthodontic forces are not greater, in any situation, than occlusal forces in terms of intensity, amplitude and variability. If an implant can bear masticatory loads, it may also receive orthodontic forces resulting from anchorage.

Keywords: Occlusal trauma. Occlusion. Gingival recession. Tooth trauma. Abfraction.

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Introduction

Bone remodels constantly, and the whole skeleton is fully renovated at a mean of 4 to 10 years, depending on the age of the person under examination.

Constant remodeling offers bone the opportunity to adapt to daily functional demands. Greater or lower trabeculae density and greater or lower cortical thickness are directly associated with the functional demands applied to each region.

Occlusal trauma is a form of rearrangement of bone and periodontal structures to respond to greater functional demands:

1) Expansion of the periodontal space to make the ligament broader so that the fibers stretch more and absorb forces better.
2) Thickening of the alveolar cortical or lamina dura for a firmer insertion of periodontal fibers.
3) Increase of bone density around the periodontal ligament to accommodate to forces that have greater frequency or intensity.

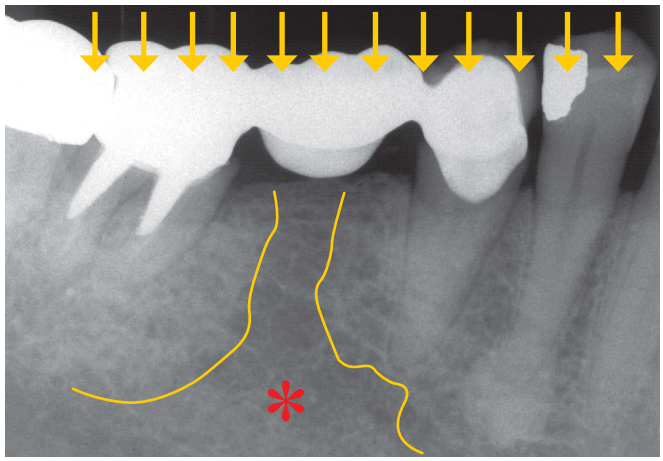

Figure 1 - The bone area which receives masticatory forces present denser trabecular bone, with thicker trabeculae and smaller marrow spaces — a process known as sclerosis or bone condensation. In some places, the spaces are not even identified in radiographic images, such as in the first premolar periapical region. In the area outside the lines, bone sclerosis appears more than in the central region defined by the two lines and the asterisk, clearly by the lack of masticatory load in the site. Bone dynamism meets the functional demands.

Figure 1 describes this bone dynamics: In areas of masticatory function, bone increases its density and becomes focally sclerotic, whereas bone trabeculae become thinner and marrow spaces larger in toothless areas.

Around an implant that receives loads (Fig 2), there are also adaptations similar to those seen in trauma or occlusal overloads. Around submersed osseointegrated implants, peri-implant bone has no trabecular density increase immediately surrounding its osseointegration interface.

Bone biology and physiology fascinates us in our attempt to understand the signs and symptoms of a known clinical event, as occlusal trauma, and to see how they occur, particularly in the areas of peri-implant bone.

Occlusal trauma: Concepts and undue comparisons

Occlusal trauma and its clinical and imaging variables are hardly seen in the training programs for undergraduates and graduates. Consequently, an accurate diagnosis and its clinical implications are often ignored when planning and following up some clinical cases.

Moreover, several specialists believe that the causes and possible progression of occlusal trauma are similar to tooth trauma and orthodontic movement, but they are, in fact, completely different entities. The tissue lesions induced by these three events are very different,[9] and their differences may be understood by analyzing the details of the function and three-dimensional aspects of periodontal structures, as shown in Figure 3, designed by Krstic.[14]

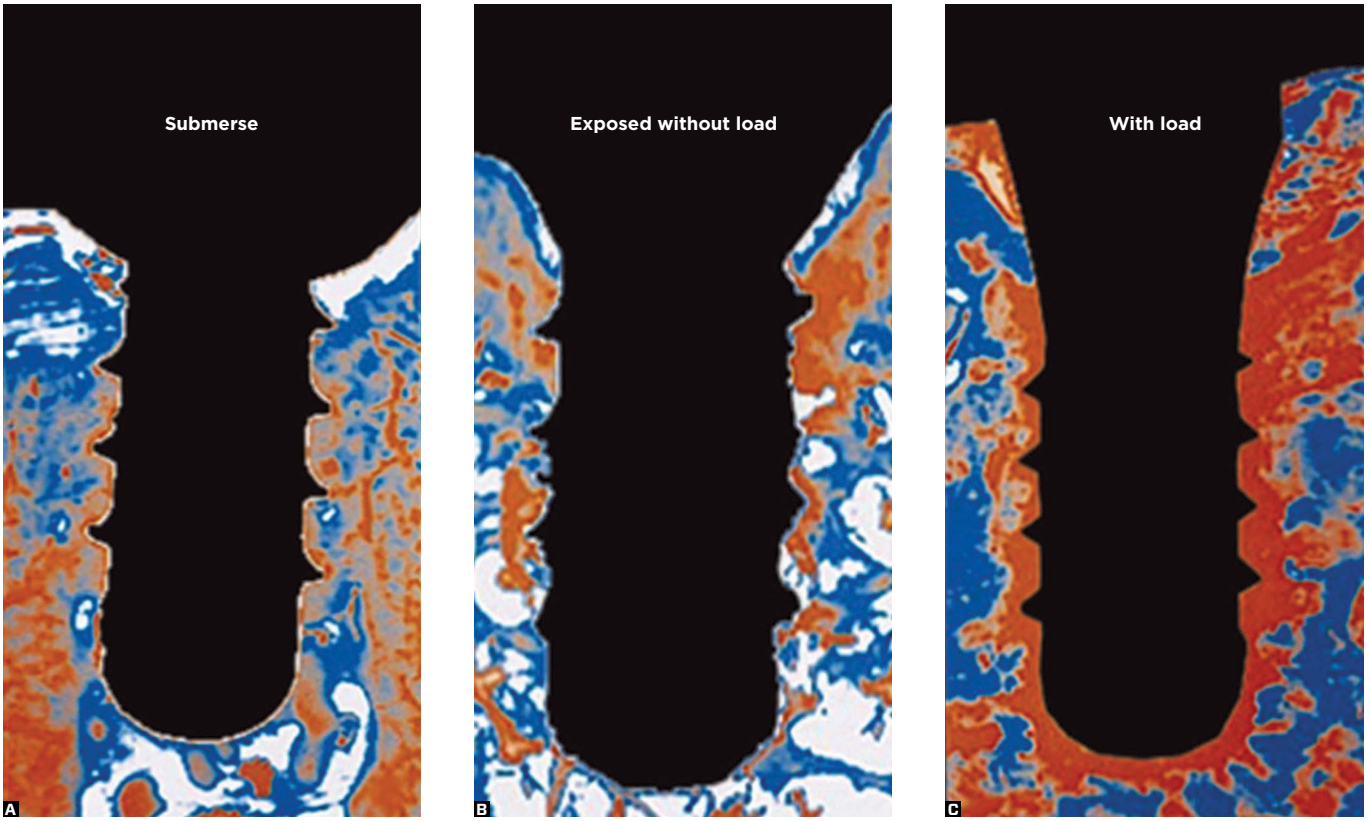

Figure 2 - In these images from Akin-Nergiz et al,[1] the radiographic densitometry in bone areas that received osseointegrated implants reveal differences when they are not subjected to load, for being submerse (**A**); when exposed, but with no masticatory load (**B**); and when exposed and subjected to occlusal loads (**C**). Bone density increases significantly (red areas) when osseointegrated implants receive masticatory load if compared to the original alveolar cancellous bone, in blue.

Orthodontic movement cannot be compared with occlusal trauma.[9] Cell and tissue changes resulting from occlusal trauma in periodontal tissues are completely different from those induced by orthodontic movement.

In dental trauma, forces are abrupt and intense, and their duration is short; the damage caused by dental trauma is the rupture of periodontal components; teeth make contact with or their roots go through the alveolar bone structures, and there is hemorrhage and necrosis of supporting tissues.

These three conditions — occlusal trauma, orthodontic movement and dental trauma — have in common only the physical nature of their causes, translated into forces, although with different characteristics, and no comparisons can be made between the lesions induced in the tissues.

We have set to publish a series of articles about occlusal trauma in journals dedicated to the various clinical specialties. Our purpose is to provide applied explanations and contribute to the specific understanding of the clinical and imaging signs of occlusal trauma in each area of expertise. Several parts of these articles are naturally repeated in their context, text and figures.[5-8] For each area, extrapolations and specific implications are discussed.

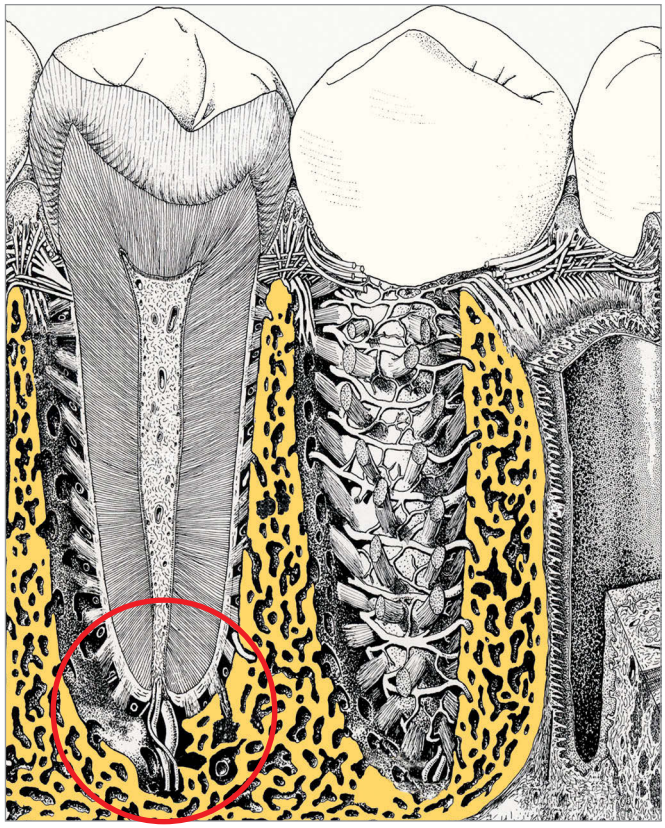

Figure 3 - Two-dimensional and tridimensional aspects of ligament and other periodontal structures. It is highlighted the conformation and extreme organization in the distribution of the collagen fiber bundles, which prevent, even in overload situations, the apex to reach the end of the alveolus (modified from Krstic,[14] 1991).

Occlusal trauma as a clinical condition or clinical entity

The clinical condition or entity known as occlusal trauma has several synonyms, such as occlusal trauma, traumatic occlusion, traumatogenic occlusion, periodontal trauma and occlusal overload.

The name of a certain clinical condition is an attempt to describe the type of lesion or set of changes that its causes produce in the tissues affected. Terminological accuracy and standardization facilitate the retrieval of information available in databases and promote communications between scholars and researchers.

The term lesion means any and all transitory or permanent structural change regardless of its nature. Lesions in periodontal tissues that characterize occlusal trauma may be induced by traumatic occlusion or an overload of occlusal forces upon a single tooth or several teeth simultaneously, depending on each clinical condition under analysis.

The induced lesion known as occlusal trauma, which is a disease or clinical entity, has been classically defined:

1. By Stillman, in 1917,[17] as the result of a situation in which the act of occluding the dental arches leads to lesions in tissue that support teeth.
2. By the World Health Organization (WHO), in 1978, as the damage induced to the periodontium by the pressure of teeth directly or indirectly produced by antagonist teeth.[15,16]
3. By the American Association of Periodontics, as a lesion to tooth-supporting structures resulting from excessive occlusal forces.[15]

The three concepts of occlusal trauma share a characteristic: The damage should result from overloads produced by occluding teeth and by antagonist teeth.

Occlusal trauma in one or more teeth may be associated with parafunctional habits, such as grinding and bruxism. In clinical practice, the causes of occlusal trauma may be associated with premature contacts due to tooth position, inadequate occlusal morphology of antagonist teeth, overloads on lateral incisors when involved in lateral canine guide, and after orthognathic surgeries.

No occlusal interference, such as premature contacts, should be confused with occlusal trauma, a clinical entity or a characteristic condition. Occlusal interference may be the cause of occlusal trauma, but the term occlusal trauma should only be used to identify the clinical condition and its signs and symptoms. Occlusion may be trau-

matic, but may not yet have induced the lesion or disease called occlusal trauma.

Occlusal trauma should not be compared to orthodontic movement

Human teeth are prepared to receive high occlusal loads, which result in movements of intrusion into the alveoli, mostly during mastication (Fig 3). A lesion to all this apparatus indicates that the forces are too strong and persistent, that is, repetitive. Even in this condition, the periodontal ligament, with a mean thickness of 0.25 mm (250 μm, Fig 3), prevents the tooth from touching the apical alveolar cortical surface, and this structural organization ensures the perfect physiological functioning of the system of tooth attachment into the alveolus.

The periodontal ligament is a delicate membrane over the root surface, attached to the alveolar bone. Fifty percent of its structure is made up of vessels (Fig 3). It is efficient for intrusive forces, but not for lateral forces, and when the plan is to move teeth orthodontically,[9] the movements planned are inclination or displacement, and the forces are often less intense, always much lower than those involved in occlusal trauma, and applied slowly in a dissipating way.

After each device activation, periodontal tissues return to normal, and new forces may be applied under similar conditions: Mild, at a single moment and dissipating.[9] Practically all aspects are different when comparing orthodontic movement and occlusal trauma, particularly in terms of induced cell and tissue reactions and their consequences.

One of the main objectives of clinical practice in orthodontics is to correct occlusal disorders, particularly those associated with the relationships between the maxilla and the mandible, as well as between dental arches. However, orthodontic education in general does not provide detailed and adequate training in detecting occlusal interferences more accurately. In the clinical specialties of dentistry in Brazil, there are dentists specialized in the analysis, diagnosis and correction of occlusion and temporomandibular disorders.

During orthodontic movement, some occlusal interferences are promoted, but they are temporary and do not usually last long enough to induce significant lesions in the supporting periodontal structures. The typical changes of occlusal trauma are produced by the prolonged action of trauma forces on the same site.

At the end of orthodontic treatment, a careful occlusal analysis should be conducted before patient discharge, and a natural "accommodation" along the subsequent months should be expected.[4] However, in several cases the patient complains of and presents with typical occlusal trauma in certain teeth during the treatment.

Occlusal trauma and orthodontic treatment do not induce pulp necrosis, but dental trauma does!

Occlusal trauma promotes cell and tissue changes that are completely different from the phenomena induced by orthodontic movement.[9] Occlusal trauma is characterized by repetitive and intense forces. In orthodontic movement, forces are extremely lighter and applied only once, slowly and progressively. In 3 to 6 days, they dissipate gradually, and in 7 to 10 days they disappear, in humans.[9] In both cases, it is not possible to induce rupture or partial lesion of the vascular bundle. Although the periodontal ligament has a mean thickness of 0.25 mm (250 μm), its organization and functioning ensure that the tooth does not touch the apical alveolar cortical surface during the high forces of mastication, which would smash the vascular bundles at the point where it enters the apical foramen (Fig 3).

The abrupt, intense and short forces of dental trauma, however, may lead to the rupture of periodontal components, as teeth touch or their roots go through the al-

veolar bone structures and produce hemorrhage and necrosis of supporting tissues. The sudden displacement by intense and short forces ruptures the vascular bundle at the entrance of the root canal, at the apical foramen. Dental trauma of the concussion type often occurs without the patient clinically presenting with clinical signs of discomfort or pain.

In orthodontic movement, forces are much less intense than in dental trauma, and are applied slowly and in a dissipating way, although the device is activated at a single time periodically. These characteristics of the forces applied in orthodontic treatment have justified the results of several studies about the absence of significant changes to the dental pulp.

There is no basis to support the suggestion that orthodontic movement may induce pulp necrosis. The higher the force applied for orthodontic movement, the less efficient and inductive of tooth displacement, with still lower chances of inducing pulp necrosis. Also, there is no basis to claim that pulp necrosis is induced by occlusal trauma: When signs suggest it, dental trauma should be defined as the cause.

In occlusal trauma, forces are repetitive and intense, but not comparable to those of dental trauma, in which the force is unique, sudden and intense. Occlusal forces, even those found in overloads, cannot bring the dental apex into contact with the bone in the bottom of the alveolus and cannot smash or injure the vascular bundle. The human periodontal ligament has been designed to absorb and dissipate intrusive forces, which are predominant in movements of mastication and deglutition.

Occlusal trauma in the mineralized structures and abfraction

In the areas of occlusal interference, occlusal trauma determines the presence of areas of wear promoted by attrition.[12,13]

At the same time, excessive pressure or force eccentricity promotes three-dimensional distortions of the mineralized dental structure. Such distortions are called temporary and repetitive distortions.[10,11]

A deflection is the act or effect of moving away from a line that had been followed and going into a different direction. Such line may be the long axis of a tooth. A tooth deflection, in which the long axis is not followed, may produce traction in one side of mineralized structures and compression in the other side.

Cement and dentin are deformable, whereas enamel is not. Dentin has a mean 60% of inorganic components and 40% of organic components, mostly proteins and water. Cement, in turn, is made up of 50% organic and inorganic components. Dentin and cement form a relatively flexible structure and do not produce any structural changes.

Enamel, which is 96% mineral components, has a minimal or irrelevant capacity of deflection. On the side of compression during tooth deflection resulting from occlusal trauma, for example, enamel resists its effect, but not on the side of traction, where enamel does not resist and has early fractures or cracks in its delicate cervical area. This process, when repeated, may lead to fragmentation and enamel structure loss, clinically known as abfraction (Figs 4 and 5). Abfraction is very common, particularly among young people, and affects mostly premolars.

Cracks may not be visible on the cervical enamel of premolars. Patients, however, may complain of intense sensitivity to temperature and food variations in these "intact" teeth. If a tooth has a wear and a V-shaped recession surface (Figs 4 and 5), abfraction, although at an initial stage and not yet detectable, may be suspected, as it may explain the increased sensitivity.

Radiographic signs of occlusal trauma in periodontal tissues

The compression of the periodontal ligament due to occlusal trauma reduces vessel caliber and disorganizes fibers and cells. Therefore, cell stress is induced, and mediators are released and accumulate at a greater rate in the periodontal ligament, particularly those that may locally define a greater or lower rate of bone remodeling.

Local bone remodeling mediators have a two-phase effect: When accumulated at very high levels, they promote bone resorption; at slightly higher levels, they induce bone formation.

The forces applied to a tooth act as a lever with intra-alveolar rotation and fulcrum between the apical and middle thirds of the tooth root. In occlusal trauma, forces tend to be well distributed along the periodontal ligament, and the overload promotes slightly increased levels of bone remodeling mediators.

The tissue dynamics of occlusal trauma is radiographically confirmed by the thickening of the lamina dura (Figs 6, 7, 8 and 9). It increases bone deposition on the alveolar cortical bone and the resistance of this structure, and elongates collagen fibers. In other words, periodontal structures adapt to better absorb the increased occlusal forces.

In primary occlusal trauma, collagen fibers should be renewed at a higher rate, and the longer and better organized their bundles are, the greater the absorption or buffering capacity of excessive forces applied repetitively. Radiographs show an irregular broadening of the periodontal space because the ligament undergoes constant structural reorganization (Figs 6, 7, 8 and 9).

The forces in occlusal trauma are excessive and eccentric, but periodontal tissues adapt by thickening of the alveolar cortical bone, increasing the density of the adjacent trabeculae and irregularly expanding the periodontal space. Such changes occur along and around all tooth roots and adjacent tissues (Figs 6, 7, 8 and 9).

At the cervical area of periodontal tissues, very intense and persistent occlusal trauma due to the lever formed by the tooth lead to stretching/traction or excessive compression of the periodontal ligament. In this cervical region,

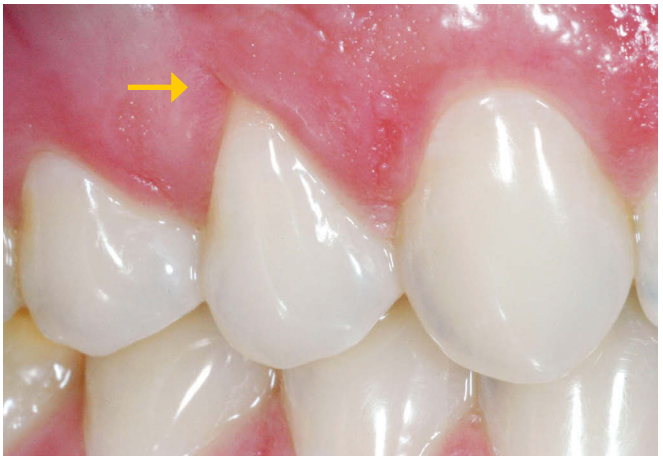

Figure 4 - V-shaped gingival recession, with a slight fissure on its end (arrow) and related to occlusal trauma.

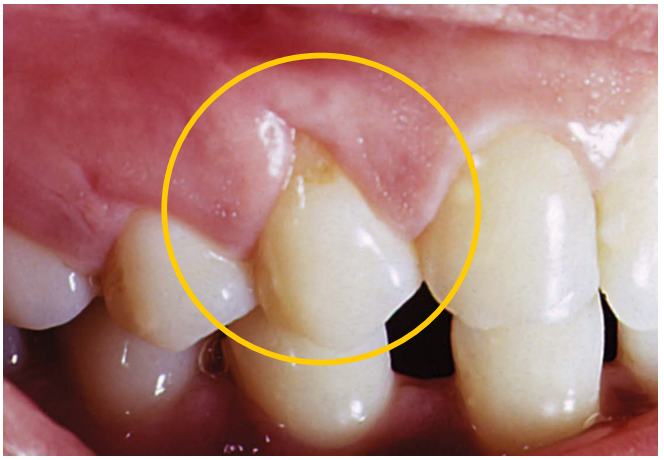

Figure 5 - V-shaped gingival recession in a tooth with abfraction: Two clinical signs of occlusal trauma.

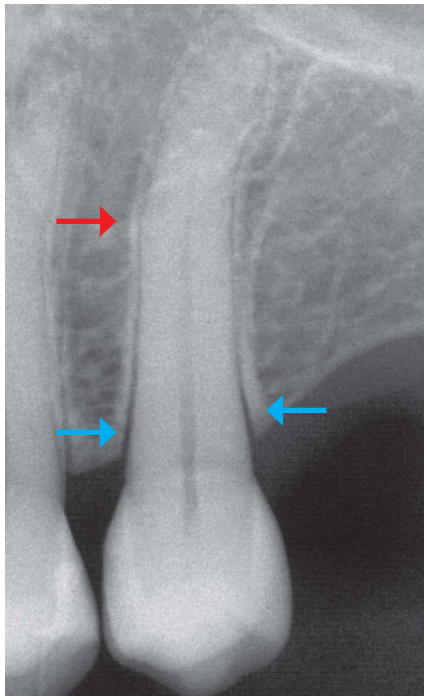

Figure 6 - Lamina dura thickening and periodontal space broadening (red arrow). It is highlighted the V-shaped bone resorption in the cervical region of alveolar bone crest (blue arrows): Initial aspects of occlusal trauma.

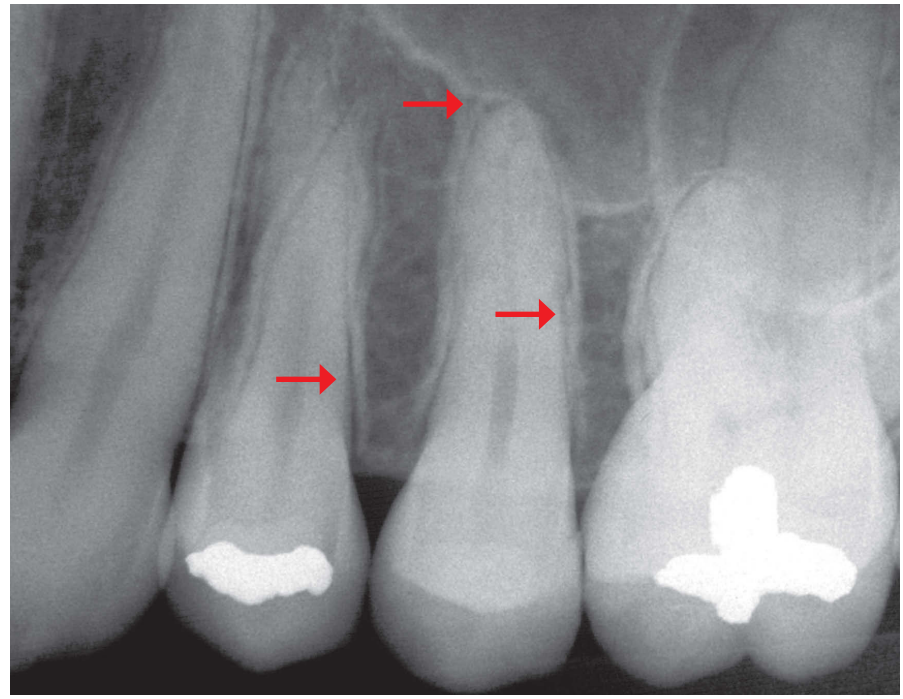

Figure 7 - Lamina dura thickening and periodontal space broadening (red arrows), associate to occlusal trauma. It is highlighted the slight increase of alveolar bone crest density.

the accumulation of mediators may increase as much as to predominantly promote bone resorption. The plane of the lamina dura surface — parallel to the tooth — may be angled in this region, indicating a V-shaped bone loss (Figs 6 and 9).

Such bone loss, seen as a "V" in imaging studies, is a sign of vertical bone loss but clinically with no periodontal pocket at careful and adequate probing. The simple elimination of the primary cause, that is, primary occlusal trauma, may restore bone to its previous level.

The first signs of occlusal trauma may, therefore, be defined as: Thickening of the lamina dura, irregular increase of periodontal space, V-shaped vertical cervical bone loss (Figs 4 to 9) and increase of apical bone density or bone crest sclerosis (Figs 10 and 11). These signs are a result of the attempt of periodontal tissues to adapt to new functional demands. Areas of inflammatory root resorption may appear at a substantially long time after that (Figs 12 and 13).

Consequences of occlusal trauma on the free buccal surface of the periodontal ligament and of the alveolar cortical bone

The same tissue and cell phenomena that occlusal trauma may induce in the alveolar bone crest surface of the periodontal ligament, under the same type of load and, consequently, of deflection, may also be induced in the free buccal surface.

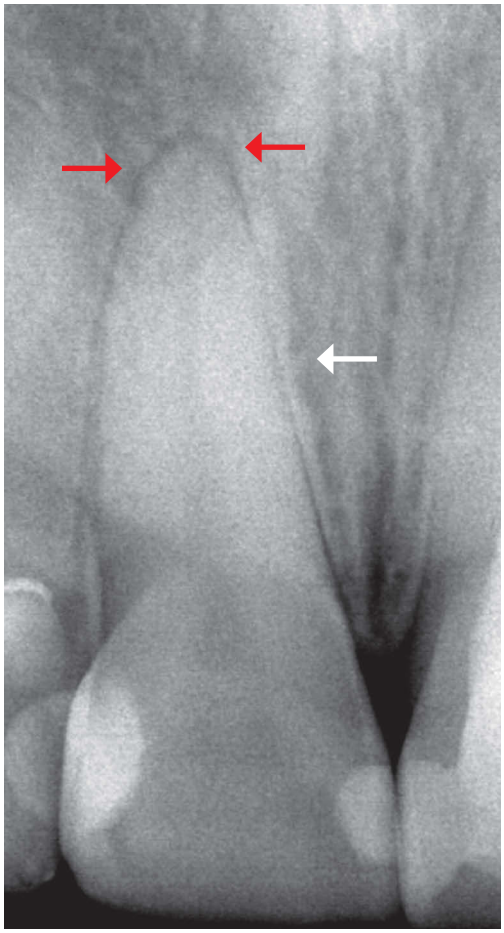

Figure 8 - Occlusal trauma with lamina dura thickening (white arrow) and broadening of periodontal space, with periodontal bone density increase (red arrows).

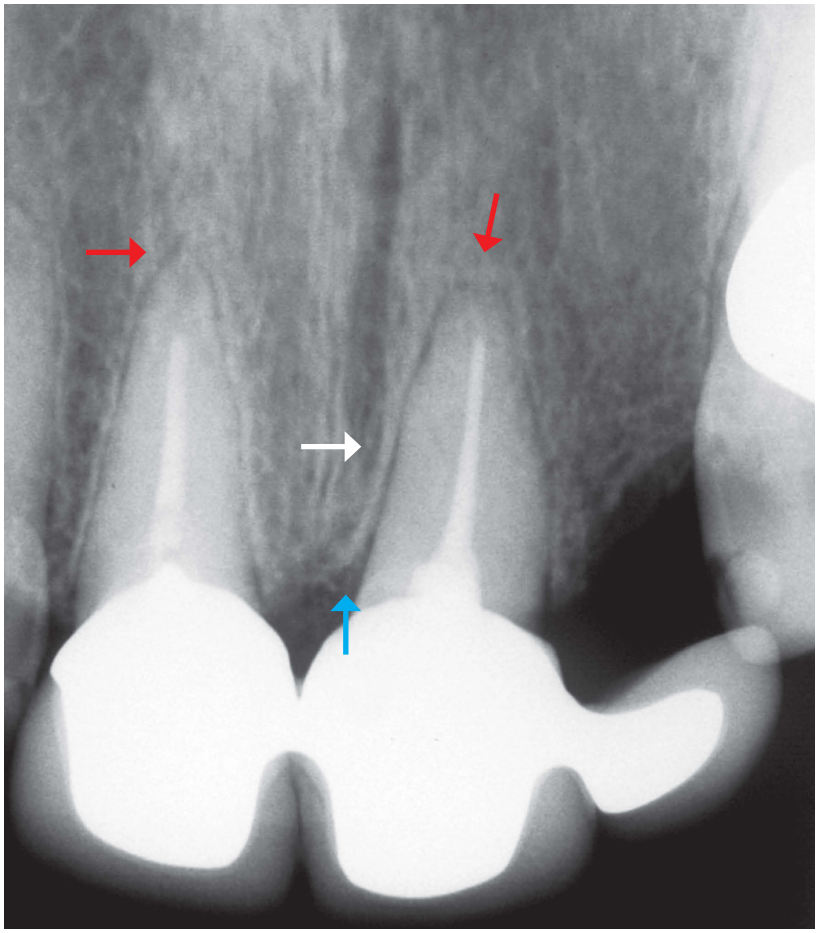

Figure 9 - Occlusal trauma with lamina dura thickening (white arrow), broadening of periodontal space with bone density increase (red arrows) and vertical bone loss (blue arrow).

However, the buccal cortical tends to be very thin, and very little resorption on its periodontal face may result in loss of cervical height and V-shaped bone dehiscence over the buccal face of the root that was affected (Fig 14).

The areas of buccal bone dehiscence are locally distributed, and the increase of their size is a gradual and slow process. Its detection using imaging studies is very difficult, although some sophisticate CT scanners bring the promise of doing it according to careful criteria. Fenestrations may also be associated with this condition (Fig 14).

At the onset of buccal bone dehiscence, first the periosteum persists locally for a indefinite period. When there is no bone to recover and protect the periosteum, and without vessels to nourish it, the periosteum tends to be fixed in the bone margins of the dehiscence area, which leaves the root surface exposed to gingival and periodontal connective tissues.

V-shaped gingival recession in occlusal trauma and how it occurs

Primarily, occlusal trauma may promote gingival recession, particular V-shaped recession (Figs 4 and 5). Some authors,

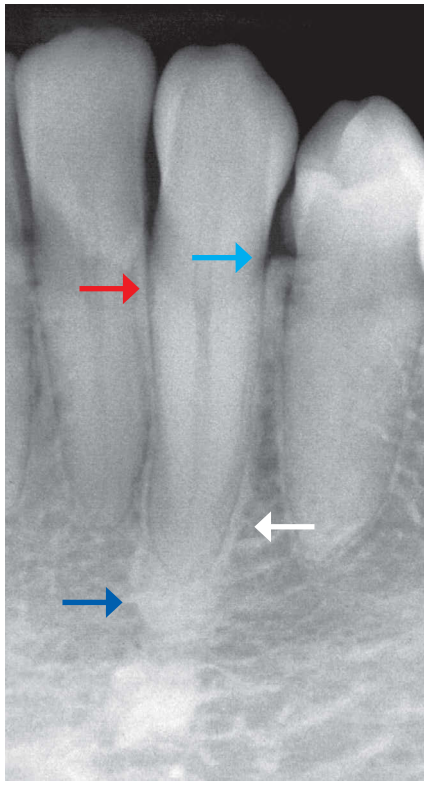

Figure 10 - Occlusal trauma with lamina dura thickening (white arrow), broadening of the periodontal space (red arrows), with periodontal and periapical bone density increase (light blue arrow) and V-shaped vertical bone loss (green arrow).

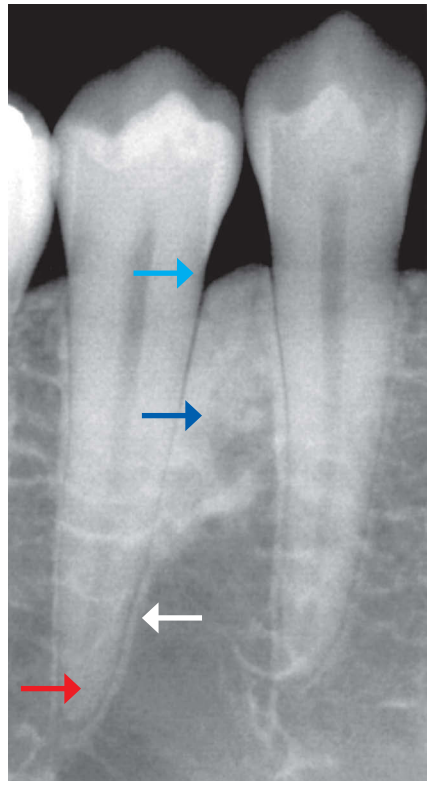

Figure 11 - Occlusal trauma with lamina dura thickening (white arrow), broadening of the periodontal space (red arrows), with periodontal bone density increase in the bone crest (light blue arrow) and V-shaped vertical bone loss (green arrow).

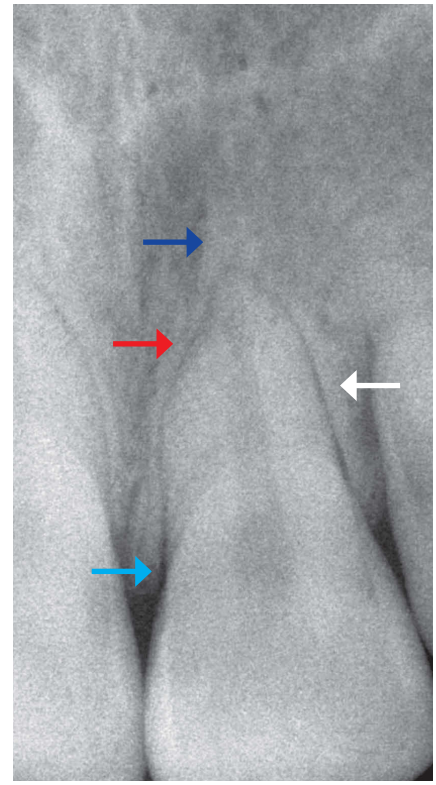

Figure 12 - Apical inflammatory radicular resorption associate to occlusal trauma, lamina dura thickening (white arrow), broadening of the periodontal space (red arrow), with periapical periodontal bone density increase (dark blue arrow) and V-shaped vertical bone loss (light blue arrow). This phase with inflammatory apical resorption occurs after a long period of overloading.

particularly the Scandinavians,[1,15] have not accepted this finding in concept and believe that for gingival recession to occur, it should always be associated with the accumulation of bacterial plaque. This position has generated controversy and polemic discussions about the topic.

One of the reasons that led Scandinavians to suggest the need of a bacterial plaque for gingival recession to occur in occlusal trauma was the focus of their studies and concepts: They compared occlusal trauma to orthodontic movement, and even called it "orthodontic trauma".[15]

Gingival recession may be generalized and affect several or almost all teeth. There may be several associated causes for its occurrence, described as atrophic changes of periodontal tissues.

U-shaped or circular recessions are closely associated with the presence of bacterial plaque and the consequent chronic inflammatory periodontal disease, frenular insertions, inadequate brushing and other less frequent events. V-shaped or angled gingival recessions have a small fissure in their most apical extremity. This type of recession is di-

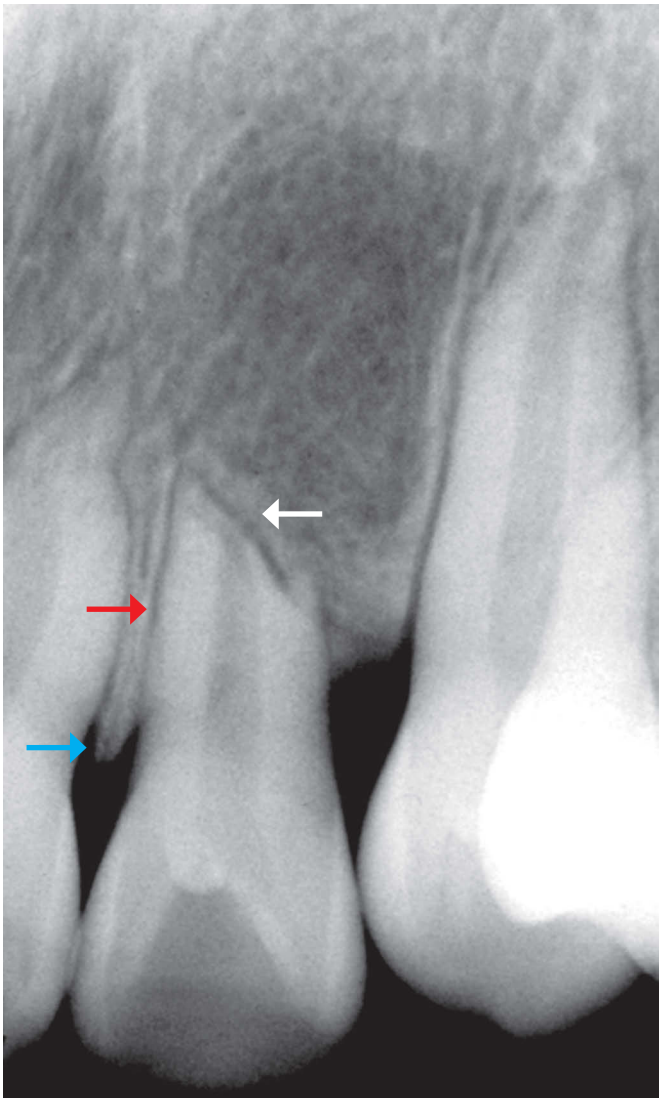

Figure 13 - Plane and more advanced inflammatory apical root resorption, associated to occlusal trauma, with lamina dura thickening (white arrow), broadening of the periodontal space (red arrow) with periapical periodontal bone density increase in this area and V-shaped vertical bone loss (blue arrow). This phase with inflammatory apical resorption occurs after a long period of overloading.

rectly associated with occlusal trauma[16] (Figs 4 and 5) and are commonly associated with abfraction.[3,10,11] At the initial stages in most cases, the elimination of occlusal trauma leads to the regression or reduction of this V-shaped recession.[16] In many of these cases, it is not possible to define a direct association with bacterial plaque accumulation.

Buccal bone dehiscence, as seen previously, temporarily brings together two very similar structures that fuse and reorganize as a single structure along time. The buccal alveolar cortical bone extends between the periosteum and the periodontal ligament, sometimes very delicately.

The periosteum is composed by two different and continuous layers of fibrous connective tissue. The very fibrous outer layer has few cells and naturally continues the inner layer, which has a richer variation of cells and more vessels. This inner layer is the direct interface between the periosteum and the cortical bone, and it is crossed by fibers that are strongly attached to the mineralized area of the cortical surface.

In human skeletons, the bone surface is not recovered by periosteum only in tendon attachments and alveolar cortical bone. The periodontal ligament acts as the periosteum on the alveolar surface. This suggests that the periodontal ligament is another form of periosteal organization.

When cortical bone is lost due to resorption and buccal dehiscence in teeth with primary occlusal trauma, the two structures should, for some time, juxtapose, but should reorganize individually in the long run. Without the presence of bone in the region and with the unification of periosteum and periodontal ligament, the two structures do not have any other active function. Because of dehiscence, the fibrous connective tissue produced under this condition gradually extends an elongated connective attachment to the attached gingiva, to a point that is very distant from the level of cervical bone.

Due to the absence of bone, the periosteum and the ligament are joined by contiguity or proximity, and the result is an elongated connective attachment and a modified biological distance between junctional epithelium and the cervical bone level. If occlusal trauma persists, it is not possible to maintain the attachment of the periodontal fibers to the cement when it has no function, because, as there is no bone, there is no counterpart to the anchorage.

The periodontal fibers without anchorage and the neighboring periosteum without bone gradually reorganize as normal gingival connective tissue. Hyperplasia and epithelial migration should be associated with this long connective attachment and the production of long junctional epithelium, which may resist and persist when the gingival level is at a normal height by a certain period of time under occlusal trauma.

Because of continuous occlusal trauma, the gingival tissue follows the level of bone dehiscence and forms a V-shaped gingival recession. Recessions are classified as periodontal diseases with atrophic changes. As it has no function, gingival connective tissue, increased due to bone loss, tends to change volume and organization in a way that is similar to that found in the gingiva of normal teeth, but this exposes the root buccally.

Tissue volume in cases of gingival recession decreases because of the adaptation of periodontal tissues to a new function and because there is no more bone in the area of dehiscence. The volume is reduced by means of constant and normal tissue remodeling, which reestablishes normal tissue proportions between bone, submucosal connective gingival tissue and mucosa, sulcus and junctional epithelia.

While the gingival level is preserved, despite vertical bone loss and as long as there is no periodontal pocket, the elimination of primary occlusal trauma may still reverse the process, even when bone loss is substantial. When the root has already been exposed in the mouth, reestablishing the gingival level usually demands surgery with or without gingiva or bone grafting.

Criteria for the diagnosis of occlusal trauma

Primary occlusal trauma, still mild and incipient, may be detected clinically (Figs 4 and 5) according to 3 factors:[4,10-13]

- Wear surfaces in the area of interference.
- Abfraction, especially in premolars.
- Discrete V-shaped recession.

These three signs practically confirm and describe occlusal trauma clinically, but only one or two of these signs may be present in some cases. Before the appearance of the V-shaped recession, when only the wear facets and abfraction are present, these signs should suggest that the clinician may conduct a careful periodontal analysis and examination (Figs 6 to 13) in periapical radiographs searching for signs such as:

- Increased thickness of the lamina dura.
- Irregular thickening of the periodontal space.
- Vertical V-shaped cervical bone loss.
- Bone sclerosis in the periapical area or in the interdental bone crest.
- Inflammatory root resorption, more common in advanced stages of occlusal trauma.

The wear surfaces due to attrition[12,13] and the abfraction[10,11] should be corrected, but only after the occlusal problems, even when gingival recessions are already present.

An early diagnosis greatly improves the prognosis of the V-shaped gingival recession, and the elimination of occlusal trauma may lead to spontaneous regression in several clinical cases.

In rare cases, pain may be detected during vertical percussion. Moreover, patients rarely report the feeling that the tooth is the first to make contact during occlusion.

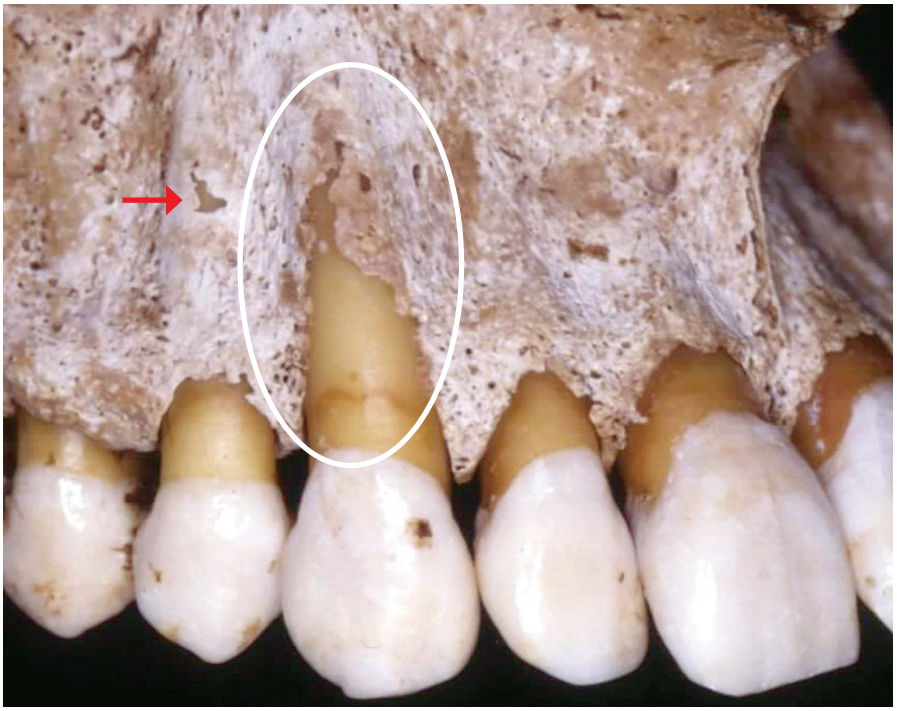

Figure 14 - Vestibular cortical bone of the upper canine with dehiscence and vestibular cortical bone of the first premolar with small fenestration (arrow). It is highlighted the reduced thickness of the buccal alveolar cortical bone.

These two signs are characteristic of apical periodontitis induced by tooth trauma and associated with pulp necrosis due to pulpitis.

Grafts in V-shaped gingival recessions associated with occlusal trauma

Severe gingival recession may indicate that the root surface was exposed in the mouth for a long time, under the action of bacterial plaque, which irreversibly contaminates the root structure with lipopolysaccharides (LPS).

Cementoblasts do not repopulate the surfaces contaminated by LPS to form new cement layers, not even after intense scaling or treatments with different acids and antimicrobial substances. In other words, it will not be possible to reattach periodontal fibers to those surfaces, not even after gingival grafting.

In some of the cases described in the literature, the best outcome from surgical procedures — microscopically analyzed — was the accumulation of fibroblasts and the formation of collagen fibers parallel to the scaled and treated root surfaces, without attachment of perpendicular or functional periodontal fibers. This happens in simultaneous or alternate gingiva and bone grafts.

The very satisfactory clinical result of these surgical procedures using gingival grafts result from the formation of a long junctional epithelium and the maintenance of the postoperative gingival level for an indefinite time. Epithelial cells manage to colonize these dental surfaces that were previously exposed in the mouth and contaminated by LPS after scaling and planing.

Unfortunately there is no solid evidence to confirm these clinical results because of the different methods when conducting clinical and experimental essays. No method is available to study the reattachment of fibers to surfaces previously exposed in the mouth for a long time and under the action of bacterial plaque.

Is there occlusal trauma in dental implants?

How can we adopt criteria to define up to what degree of trabecular density or bone sclerosis around an osseointegrated implant should be considered normal? What parameters should be used to conclude that the bone around the implant is discretely inflamed (osteitis) and, therefore, with sclerosis or condensing?

Up to 1998, little was known about the peri-implant reactions under the effect of orthodontic anchorage loads. Akin-Nergiz et al.[1] evaluated peri-implant bone densitometry under these conditions and found results that may be summarized according to two figures:

» In Figure 15, published by Akin-Nergiz et al,[1] the images in red correspond to the bone that is more densely organized, regardless of the compression or traction loads orthodontically applied to the osseointegrated implants used as anchorage.

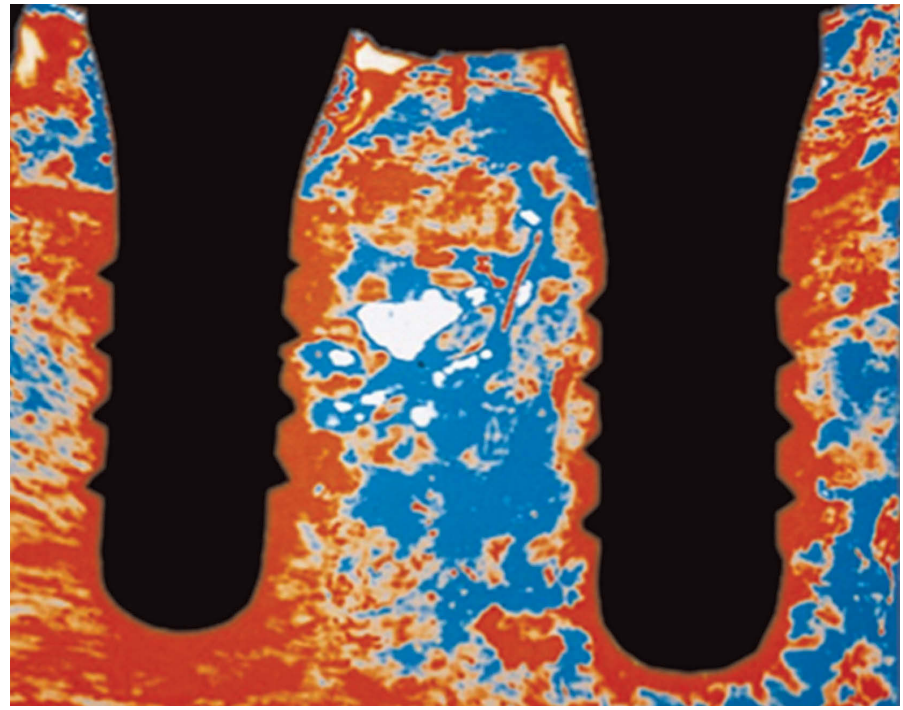

Figure 15 - In this image from Akin-Nergiz et al[1] study, radiographic bone densitometry of areas where two osseointegrated implants where subjected to orthodontic load. It is highlighted the increased bone density (in red) in the areas of compression and tension sides, when compared to the original alveolar cancellous bone, in blue.

» From the same study conducted by Akin-Nergiz et al,[1] Figure 2 shows three bone images of osseointegrated implant areas, and more dense bone trabeculae were induced in the one exposed to masticatory loads. To what point this may generate lesions similar to occlusal trauma? Unfortunately we have not advanced to that point in studies of peri-implant pathologies.

Final considerations

Images provide a language that reveals the dynamics of bone and tissue. Bone density and space distribution vary and indicate greater or lower reaction and adaptation to functional demands, such as masticatory loads on natural teeth or on osseointegrated implants.

Clinical diagnosis and procedures defined according to images should be based on signs and symptoms. Strict criteria should be followed, and specialists should use their previous knowledge. Occlusal trauma, seen as a clinical event, should be included in the differential diagnosis of apical periodontitis and dental trauma.

In rehabilitation, it is fundamental to plan loads distribution and to evaluate the remaining teeth and their relation with neighboring bone. The detection of bone response and pre-existing occlusal trauma may favor a more accurate evaluation of masticatory conditions and parafunctional habits — a true functional history of remaining teeth.

The sclerosing osteitis type of increase in periapical bone density, associated with a tooth whose pulp is vital may suggest a diagnosis of occlusal trauma even when there is inflammatory root resorption.

When a tooth has pulp necrosis and signs of occlusal trauma, the evaluation of history and tests should be directed to the diagnosis of superposed dental trauma even when posterior teeth are affected. Below are some conditions that may indicate dental trauma of the concussion type, which may lead to pulp necrosis in posterior teeth:

» Anchorage of surgical levers in neighboring teeth during extractions.
» Accidental impact of instruments, such as forceps, during surgical procedures.
» Sliding of probing instruments during gastroesophageal examinations.
» Movements of the laryngoscope during general anesthesia procedures.
» Presence of candy and other foods in the mouth in leisure and sports activities during sudden movements, such as when riding a motorcycle or roller coaster.

Occlusal interference and overloads take months or years to induce classical signs and symptoms of occlusal trauma as a clinical entity. The correction of such interference and occlusal overloads in general interrupt the onset of these signs and symptoms.

Interferences and occlusal overloads do not necessarily indicate that the signs and symptoms of the clinical entity called occlusal trauma are present: They may take many months to be identified clinically and in imaging studies.

A usual question: Up to what point can orthodontic forces be applied to osseointegrated implants? Orthodontic forces are usually not greater, in any situation, than occlusal forces in terms of intensity, amplitude and variability. If an implant may receive masticatory loads, it may also be exposed to the forces of orthodontic anchorage.

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How to achieve long-term stability on bonding zirconia/alumina structures?

Renato Savi de **CARVALHO***

Nothing seems to be more frustrating for dentists than the often recurrent displacement of an indirect restoration. Such clinical setback leads to self-criticism about their professional skills, which may also be silently questioned by their patients at the same time and raise serious concerns. For this reason, questions about which cementing techniques and agents are more appropriate for each particular clinical situation have always been raised during the phase of crown and prosthesis cementing. The desire to make retention last and to ensure that they are kept attached to the posts has led several authors and clinicians to constantly seek procedures and materials that are more reliable and adequate for that purpose.

Both dentists and the dental industry systematically seek alternatives to optimize esthetics in dental treatments. This is confirmed by the interest in adhesive systems and techniques that may ensure a better performance of composite resin restorations, or the special attention that has been paid to gingiva surrounding prosthetic crowns, either supported by implants or not. This latter has even gained the status of pink esthetics and is currently the focus of special attention.

The demand for better esthetic results is growing, and the use of densely sintered oxide-based structures, particularly alumina and zirconia, as replacements for metal copings in the traditional metal-ceramic crowns is irreversible. Such change has effectively translated into a substantial esthetic gain, so that it has become the first choice when the aim is to have crowns and restorations that respond to esthetic appeals. This is a fact! However, at the last moment of crown placement, questions about the ideal way to cement crowns haunt most of those that use such technology. The relevance of this question deserves a more profound analysis.

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Ceramics in dentistry

Characteristics such as biocompatibility, resistance to wear, action of chemical agents, chemical and color stability, thermal expansion coefficient similar to that of dental structure and, mainly, satisfactory esthetic results soon made ceramics the material of choice in the restoration of teeth when using indirect methods. Since 1774, when Duchateau and Chemant devised and produced the first total prosthesis with porcelain teeth, much has been studied to improve prostheses and to expand the use of porcelain in dentistry.

About one century later, in 1886, the first full porcelain crown was manufactured, which gave rise to an era of contradictions between optimism and uncertainties that has lasted until today, when the ideal way to manufacture and cement a ceramic crown seems not to have been defined yet. Introduced by Land and Taggart, and called "jacket crowns", these exclusively ceramic restorations reinforced by alumina and feldspar, or those cast using refractory dies, often failed because they had an inadequate marginal fit, low mechanical resistance and little technical sensitivity, as there was no supporting structure over which the porcelain cover could be applied.

In 1962, conventional crowns and prosthesis with a metal structure as support for the ceramic cover were designed by Weistein. Called metal-ceramic restorations and used almost exclusively with zinc phosphate cements, they have reduced the difficulties in this area and achieved its best performance in the last decades, with extremely satisfactory results that ensured their good acceptance and use until today. However, cases of allergy to metals, reported even for pure gold,[1] gingival reactions and, mainly, the request made by patients and professionals for better esthetic solutions were the trigger to seek ways to eliminate metal structures or replace them with nonmetallic materials.

McLean and Hughes, in 1965, described the manufacture of crowns using aluminized porcelain (conventional feldspar porcelain that incorporates 50% of aluminum oxide) over a platinum plate or refractory die. As they did not have a metallic appearance, these crowns were a real esthetic advance.

The history of ceramics evolution also features more or less successful attempts to manufacture metal-free crowns using milled ceramics, injected and infiltrated with glass.

Based on the functional success achieved by metal-ceramic prostheses, it was clear that the presence of a supporting structure was fundamental for the good performance of esthetic porcelain covers and, in consequence, of all restorations. Its elimination would simply represent a regression to a time of high failure rates.

In 1991, using CAD-CAM technology, the Procera™ crowns were released. Supported by alumina and, more recently, also zirconia structures — respectively produced using the process of aluminum oxide (Al_2O_3) and zirconium (ZrO_2) sintering — they represented an important contribution for the resolution of previous difficulties. They satisfactorily replaced the metal base even in areas submitted to high masticatory forces.[2] Since then, over 8 million of these crowns have been manufactured all over the world.

With a flexural strength of over 680 MPa, translated into success rates of over 95% after 5 to 10 years, the alumina and zirconia structures covered with porcelain have led the search for esthetic and functional excellence. This type of restoration successfully replaces the traditional crowns based on metal cast copings, and they provide precise marginal fit and mechanical resistance without impairing esthetics.[3,4]

When such a stage of evolution is achieved, dentists understandably want to also make sure that their restorations remain functional for a maximum length of time. Therefore, previous studies were consonant with those that aimed at improving adhesive cementation. The clinical use of fixed prostheses retained by means of adhesive systems depends on stable and durable bonding between resins and ceramics. Therefore, the wish to develop esthetic prostheses that may be both cemented and bonded has become stronger and motivated the search for the ideal cementing technique and agent.

The structure obtained by dense sintering of oxides (aluminum and/or zirconium) may add relevant esthetic and mechanical proprieties to the crown. However, it also compromises its adhesive cementation, performed after the internal side of the restoration has been treated with hydrofluoric acid and silane or an adhesive agent, common in pure ceramic restorations, because that acid, as any other acid, is inefficient when used with densely sintered alumina or zirconia.

Is it possible to use etching with alumina or zirconia?

Alumina and zirconia are materials obtained by compacting metal oxides under high temperatures. This process, called industrial sintering, produces a structure composed of almost only these oxides (Fig 1) and, differently from feldspar porcelain, free of silica. If there is no silica available to be removed during the interaction with acid — which should produce an irregular surface due to the exposure of non-etching crystals —, acid etching of this material is ruled out. The absence of silica also compromises silanization, because the silane agent, with its chemical affinity for silica, cannot establish any molecular connections.

Because etching, as well as silanization, is not possible, the bonding of these crowns to resin cements is very likely compromised. This hypothesis has been confirmed and seems to be, up to the moment, the issue that has raised questions and set limitations to the ideal cementation for this type of prosthesis. After the displacement of crowns manufactured with this material, resin cement often remains on the prosthetic retainers, and no cementing agent remains on the internal surface of the displaced restoration, at least according to superficial clinical examinations.

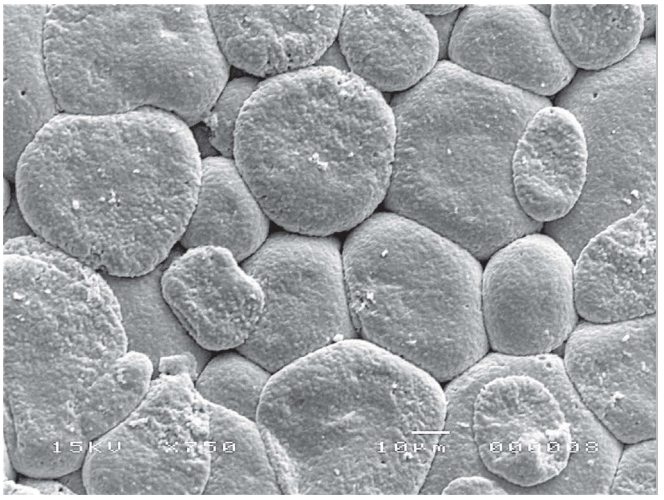


Figure 1 - SEM image of the inner face of a Procera® coping obtained by sintering of metal oxides. It is possible to observe the granules compacted by the industrial sintering with high pressure and temperature, as well as the absence of a vitreous phase (silica). (Source: Carvalho,[6] 2009).

As they have different structures, it is, in theory, impossible to replace metal with ceramics without reducing the mechanical resistance to fracture. Therefore, to obtain dental ceramics with greater resistance, the industry has invested in two directions: Improvement of their intrinsic quality by means of incorporating aluminum oxide to feldspar; and development of porcelain supports in a substrate that adds resistance to it.

Ceramics used in dentistry have different structures, characteristics and applications, and may be divided, for better understanding, into:

a) Base ceramics: Composed by oxides (aluminum, magnesium or zirconium) that have a high mechanical resistance, but an extremely unfavorable esthetic appearance.
b) Leucite-reinforced ceramics or lithium disilicate-reinforced ceramic: Its mechanical resistance is lower than that of base ceramics, but it may, after the application of esthetic coating, look like natural teeth.
c) Porcelains: They have the best esthetic result but the worst mechanical resistance. Essentially composed of feldspar, they have a high elasticity modulus and low tenacity, characteristics that translate into absence of deformation in face of application of a load and little resistance to crack propagation.

Methods available for the manufacture of ceramic restorations

Different methods are available to produce ceramic restorations in the laboratory. They are classified into three categories: Milling, pressing and sinterization.

Two or more methods may have to be associated depending on the type of clinical results expected. The Procera™ crowns, either based on alumina or zirconia, are good examples of the successful association of two methods. In the case of a fully ceramic crown, ceramic copings (base) may be produced by milling followed by industrial sintering of some metal oxide that will be later coated with feldspar porcelain using the bake technique.

Milling requires the drilling of a ceramic block until the shape desired for the restoration is obtained. Two techniques can be used for that: CAD-CAM and the pantographic technique. Milling requires the use of sophisticate equipment and micro-cameras for intraoral imaging of cavity preparation and milling units.

Moreover, the fit of prosthetic restorations produced using this technique is not precise. Therefore, milling has been the least used technique to manufacture ceramic elements directly in the clinic, and its use has been limited to the industrial production of copings, with quite interesting results in terms of dimensional accuracy and fit.

Pressing is similar to the system used to obtain metal restorations by investment casting, in which a wax pattern is included in a ring with refractory material and taken to the oven for evaporation and creation of a counter model. After that, the ring is placed in a special ceramic oven where ceramic tablets are melted and injected into the empty space. After the removal of the coating, the restoration is rough and non-esthetic, and should receive color and surface finishing.

For that purpose, two techniques can be used: Makeup or stratification. In the first, dies are applied to the external surface of the restoration and baked in a porcelain oven. The second consists on the application of feldspar porcelain over the pressed structure after it is partially waxed to cover the edges, but leaving space so that the coating porcelain can be added to give it an esthetic shape.

In the pressing technique, leucite-reinforced porcelain may be used (in case of units) and lithium disilicate-reinforced ceramics (that have greater flexural resistance, and is good for units or small fixed prostheses). When compared to the restorations manufactured only with feldspar porcelain, pressed restorations have a higher intrinsic mechanical resistance and can also undergo acid etching, which ensures excellent bonding to the resin cementing agent.

Sintering is defined as the process that can convert a porous material into a dense and strong material by means of transformations at high temperatures. To produce ceramic restorations, there are three techniques that use sintering: Baking, infiltration and industrial sintering under high pressure and temperature.

In the same way, the infiltration technique also produces ceramic copings with high mechanical resistance based on the compaction of metal oxides (aluminum, zirconium or magnesium). These copings produced using either technique (infiltration or industrial under high pressure and temperature) are called base ceramics and should be coated with esthetic coating materials, such as feldspar, aluminum or low fusion porcelains, which, once taken to the baking oven, will give an anatomic and esthetic form to the restoration.

Ceramic crowns should not, therefore, be understood to be produced exclusively by means of porcelain bake. Equivocally, this idea gained force because bake is the oldest and most versatile method to produce ceramic restorations. Bake should be understood as the addition of porcelain (powder + liquid) over a structure or base (refractory, ceramic or metal coping) and later baking in an oven specifically for that purpose. This method ensures excellent shape and esthetics, because a wide combination of porcelains, with different hues and optical characteristics may be used in successive stratifications.[5]

Treatment of the inner surface of the restoration

It is common sense among those that defend adhesive dentistry that there are three ways to bond different structures: Physical, chemical and physical/ chemical. It is understandable, therefore, that clinicians and researchers attempt to expand, as much as possible, the nature of bonding combining these three modes.

The creation of micro-porosities or roughness on the inner surface of ceramic restorations, similar to those observed in tooth tissue after acid etching, went from speculation to primordial objective when the purpose was to bond resin to ceramics. Success, credibility and clinical and scientific confirmation were achieved when purely ceramic restorations, basically composed of feldspar porcelains containing a vitreous (silica) and a crystalline phase, started receiving hydrofluoric acid etching.

The silica selectivity for this type of acid produces hexafluorosilicate, removed by water rinsing. This exposes the crystals of the crystalline phase (Fig 2) and, consequently, creates some superficial roughness, similar to a honeycomb, extremely useful for the micromechanical inclusion of a resin, and, consequently, a physical bond.

Associated with this technique, a bifunctional component (silane) is applied. It can bond to the vitreous phase of porcelain by means of chemical bonds and to the organic phase of the resin, which ensures even better adhesive properties to the porcelain/resin combination. Its chemical strength, in addition to the mechanical interweaving mentioned before, also acts upon its adhesive interface.

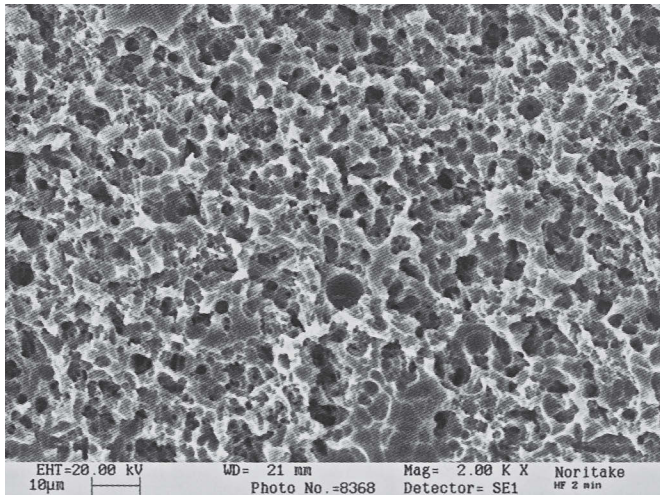


Figure 2 - Feldspar porcelain surface after fluoride acid etching. (Source: Carvalho[6], 2009).

The combination of these two patterns of adhesiveness (physical and chemical) occurs spontaneously because of the fluidity of silane that permeates and infiltrates the spaces and pores left in the ceramic surface after acid etching. This produces an interesting microstructural and chemical weaving with the silica remaining in porcelain, as well as with the organic portion (methacrylate groups) of resin cements.

How to produce irregularities in densely sintered zirconia?

According to the previously described principle of reliability of physical, chemical and physicochemical connections, we have tried to reproduce similar micro-retention on ceramic restorations based on densely sintered oxide structures. However, the lack of a vitreous phase that may be partially removed by acid interactions (the best known and most important way to create micro-retentions on ceramic surfaces) in this type of ceramics precludes the creation of micro-rugosities and blocks the chemical connections with silane and adhesive agents. Therefore, other ways of creating roughness on the surface of dense, highly crystallized ceramics, have been sought, and the methods developed have basically focused on physical attacks to its structure.

Mechanical abrasion due to aluminum oxide particle acceleration against the alumina structure has been studied by several authors.[7,8] Developed in the 40s as an alternative to low speed engines (the first high speed engine appeared in the end of the 50s), this type of blasting, often using aluminum oxide grains with diameters of 50 or 100 µm and hardness close to that of alumina crystal found in ceramic structures, creates roughness similar to that left by the hydrofluoric acid on feldspar porcelains and facilitates resin penetration and bonding. As an alternative to this type of etching, abrasion by spraying of 1 to 3 µm synthetic diamond particles has been tested, and produced even more marked rugosities on densely sintered alumina. When associated with a silane agent that may infiltrate these porosities, although a chemical connection is not established because of the lack of silica, it seems to be an interesting technique to increase the strength of union between resins and densely sintered alumina.

This method of creating surface roughness in ceramics has also found opposition in those that classify it as innocuous or blame it for the generation of micro-cracks and, consequently, structural weakening. Moreover, in some cases, it may compromise an area previously adequate for bonding, such as in the case of unprocessed Procera™ crowns, because it smoothens the surface instead of producing micro-retentions.[9]

Some authors have tested the addition of silica to alumina structures to create a "chemically favorable" environment for silane to interact before cementing with resin agents. This incorporation of silica is possible when using a specific equipment, so that the structure of alumina may be blasted with aluminum oxide grains coated with silica at a high speed. Some reports demonstrated that, as a result of this impact, the silicate particles of aluminum oxide may penetrate over 15 μm into the ceramic or metal substrate. After coating with silica, the alumina surface may become chemically more reactive to the silane agent, which may ensure bonding where it was not possible before.

Moreover, the micro-topography of the ceramic surface may be affected, having more or less rugosities, which is also relevant to ensure penetration and physical adhesion of fluid resins.[10]

Chemical bonding between resins and ceramic surfaces may also be obtained by using plasma sprays. Plasma is a gas partially ionized in a high power generator containing ions, electrons, and neutral particles. The ionization of ceramic surfaces for adhesion may confer it better chemical reactivity, very likely due to the establishment of more than one type of electronic and covalent connections.

The incorporation of low fusion porcelain granules (porcelain pearls), either silanized or not, to the alumina surface may also generate interesting roughness for the mechanical infiltration of resin cements. This structural change of the alumina and zirconia surface has been tried in some studies, and results have been extremely satisfactory, because granules promoted micro- and macro-mechanical infiltration of the resin. Observations after shearing tests revealed that the pearls remained bonded to the ceramic surface after the adhesive fracture of the resin. When this technique is used, the porcelain granules should be applied only during the last bake or during glazing, and the thickness of the layer should not be greater than 5 μm, which might lead to poor adjustment or difficulties in the fit to the prosthetic retention.

The cementing agent

Cavity and coronal preparations should be adequate for retention and resistance, but the success of fixed prostheses is strongly dependent on the cementing procedure, and dental cements play important role in the success of indirect restorations.

Together, the loss of retention and the displacement of prosthetic crowns are the second most frequent cause of failure of this type of treatment. Moreover, cements should act as a mechanical barrier to the penetration of fluids and oral microorganisms into the interface between restoration and prosthetic retention. Therefore, cements should bond different materials and interact with both surfaces that they contact. Bonding here may be mechanical, chemical or a combination of both.

An ideal cement should, moreover, support tension and compression strengths; be resistant to fracture; have good fluidity over the structures with which it interacts; have adequate viscosity and film thickness, so that it does not compromise the placement of the restoration; not disintegrate in the oral cavity; be biocompatible, and to ensure enough working time for the operator during handling.

Historically, a large part of the high-resistance ceramic restorations have been cemented to their retentions using zinc phosphate or glass ionomer cements. The first has been clinically used for about one century, whereas the latter approaches its forth decade, time that grants them credentials as agents and confirms their clinical success in the middle and long runs. Their use requires mechanical retention because these water-based cements work, primarily, by frictional retention. When it is compromised, adhesive bonding systems are recommended.

In the last decade, resin cements have been the first choice because of some advantages: Adhesiveness to several substrates, low solubility, biocompatibility, satisfactory esthetics, thin film, good marginal fit and reinforcement to restoration. In addition, zinc and ionomer cements have low resistance to shearing, compression and traction. Its use should be avoided to cement ceramic restorations that have no metallic or ceramic structures for reinforcement. Therefore, resin-modified cements have been intensively studied to select characteristics and commercial brands that may have more advantages.

Bonding similar to that obtained between "resin and tooth tissues" is expected between a resin cement and ceramics, a connection in which monomers penetrate the tooth matrix that has been prepared and later polymerized to promote micromechanical bonding by means of formation of a hybrid layer. In a similar way, the inner surface of ceramic restorations should be prepared to optimize its interaction with resin agents. This previous preparation is the most important step to ensure the longevity of adhesion between two materials. However, though secondary, there are particular characteristics of the cement agents, their monomers and bonding agents that may affect the occurrence and maintenance of the adhesive phenomenon.

Adhesive stability for densely sintered ceramics may also be obtained by using adhesive systems or cements with 4-meta or methacryloyloxydecyl dihydrogen phosphate (MDP). By means of chelation, the phosphate ester radicals form a chemical bond to metal oxides (major components, almost exclusive, in this type of ceramics), such as chromium, titanium, zirconia and alumina, which increases their adhesive strength.

Some cements that have these components are available in the market. Panavia F™ (Kuraray Medical Inc, Okayama, Japan) is the best known adhesive cement resin that contains MDP. Shearing strength studies of this material showed its superiority to other conventional Bis-GMA compounds without this adhesive monomer.

Final considerations

As discussed above, resin cements establish three types of bonds with ceramics: Physical, chemical and physical/chemical. For resin cements to establish a physical bond with the ceramic surface, this surface should have some type of irregularity for the resin to penetrate before polymerization and to ensure the micromechanical weaving of the two materials after polymerization. Chemical adhesion is achieved by the interposition of silane, a bifunctional component that can bond, by covalent connections, to the silica in the porcelain and the methacrylate groups found in resin cements. The sum of these two phenomena promotes the third type of union: Physical/chemical.

Dense and highly crystallized ceramics, obtained by sintering metal oxides, do not have a vitreous (silica) phase and, therefore, acid etching or chemical bonding with silane agents cannot be used, which adds importance to their surface texture as a form to provide sites for the mechanical micro-retentions of the cement. Several studies have attempted to find out which ceramic surface treatment better prepares it to interact with resin cements.

Spraying with Al_2O_3 particles has been the method of choice to create irregularities on high resistance ceramics. This technique substantially affects adhesive bonding strength by producing irregularities that favor resin incorporation and increase the energy of the area surface. Although not accepted by some authors,[11] who found cracks and breaks that may result in ceramic fragility after blasting, this technique has proven to be, up to the moment, the best and most frequently used way to roughen dense ceramics. When associated with a resin cement, a material that might seal such cracks and restore the strength to its structure, this technique does not seem to be definitely contraindicated.

Plasma spray use, the increase in low fusion porcelain pearls, silicatization, and roughening using diamond points are some other techniques, though less usual. Each has its own tools, degree of complexity and demand, and all prepare ceramics for adhesive cementation, in an attempt to make it rough or chemically ready for adhesion. Of these, silicatization has been the most frequent, and has been used based on results still unstable. Silica layers are created on the surface of alumina, which enables their silanization. However, the instability of the silane agent, which often reacts while still in its container, together with unfavorable clinical conditions for the use of this product, has raised questions about this technique. Silane comes from the automobile industry, where, after application, products remain in a light oven for some hours for evaporation of its unstable components. Similar results should not be expected when it is used in dentistry, under conditions that are far from ideal.

Metal oxide grains united by industrial sintering have small gaps between each other. Therefore, before cementation, internal blasting of prosthetic crowns manufactured according to this technique or using this material may be unnecessary. In a comparison of pros and cons, we believe that it makes sense not to run the risk of a possible micro-crack or weakening of the structure in the attempt to roughen the surface by using particle blasting when the product already has this characteristic. The attempt to produce a rough surface may induce the weakening of the structure, which seems to be a very high price to pay for a benefit that is already there.

The application of a phosphate primer, which contains methacrylate agents with crossed connections, to alumina surfaces before the application of a resin cement may promote an increase in retention strength.[12] This finding may be explained by the fact that this primer has a better wettability (more fluid) than resin cements (more viscous). The irregularities found on unprocessed alumina or zirconia are better filled by using a combination of primer and resin cement than by applying cement alone. This better filling favors, above all, the physical micromechanical interaction between resin and ceramics, reduces surface tensions in the substrate and increases surface energy, which results in increased retention forces.

It is clear that irregularities on alumina or zirconia are innocuous if they cannot be adequately infiltrated by cement. The analysis of microscopic images of alumina and zirconia structures after cementing followed by shearing confirms that cement, alone, is not capable of permeating the micro-spaces found in the structure, which explains the need of using a primer with greater fluidity. The infiltration of a primer is so intense that scanning, even after shearing tests, did not show any gaps between grains filled with this component (Fig 3).

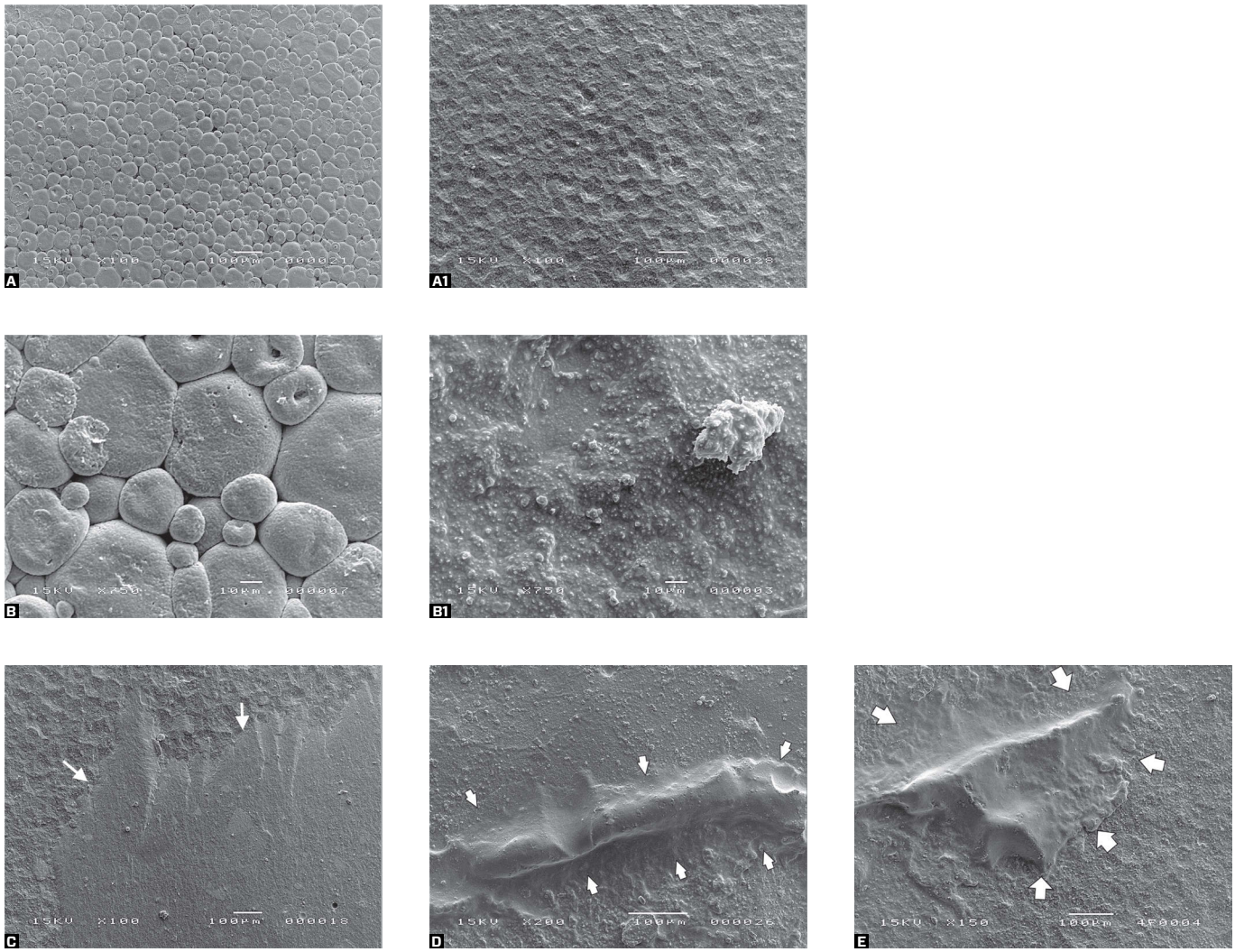


Figure 3 - Comparisons between **A** – **A1** and **B** – **B1** provide a visual analysis of alumina, either infiltrated or not by primer, under two magnifications. Alumina surface in Figures **A1** and **B1** do not have the same pattern of roughness or porosity because they remain infiltrated by primer even after shearing test of cement, to which all surfaces were submitted (magnifications: **A** and **A1** = 100X; **B** and **B1** = 750x. In **A** and **B**, there was total displacement of cement and repeated evidence of grains and inter-grain spaces. **C, D** and **E**) Portions of resin cement adhered to alumina surface after shearing test (white arrows) show cohesive fracture. Exposed alumina surface, where there was cement fracture, remains infiltrated, and primer lost its irregular porous aspect, with gaps. Even after resin cement displacement, primer remains bonded to alumina surface. (SEM. Source: Carvalho,[6] 2009).

The affinity of phosphate primer with oxides also has great relevance for adhesion. Inadvertently, some professionals that work with dental prosthesis "classify" alumina (zirconia) as a type of ceramics, very likely due to their white-yellowish appearance. Densely sintered alumina is composed of 99.5% of metal oxides (aluminum), and this type of primer establishes chemical connections by chelation, and oxides promote a chemical increase in the strength of the union between porcelain and the resin cement.[13] Blatz et al[14] confirmed this finding in a study that classified non-phosphate agents as inefficient when the purpose is adhesion to alumina.

Clinically, after the displacement of crowns manufactured with densely sintered alumina or zirconia, cementing agents can be seen still adhered to the prosthetic retention, but not to alumina (Fig 4). This is usual when dental tissues, such as dentin and, mainly, enamel, are part of the substrate for retention. The possibility of roughening such structures for later penetration of fluid resin ensures some relative stability to the adhesive interface.

Full crown preparations on natural teeth have almost 100% of their area made up of dentin, a mineralized and humid tissue characterized by collagen. The formation of a hybrid layer of resin remains a source of concern because of the variable results obtained since tests started in adhesive dentistry. It is even more critical in healthy teeth, which, in addition to increased humidity, also naturally have internal pulp pressure, a force that pushes fluids to the union line. These fluids compete with the adhesive agent for the occupation of spaces left by acid etching.

It is a consensus that the place of choice for resin adhesion is enamel, and not dentin. Therefore, a disturbing

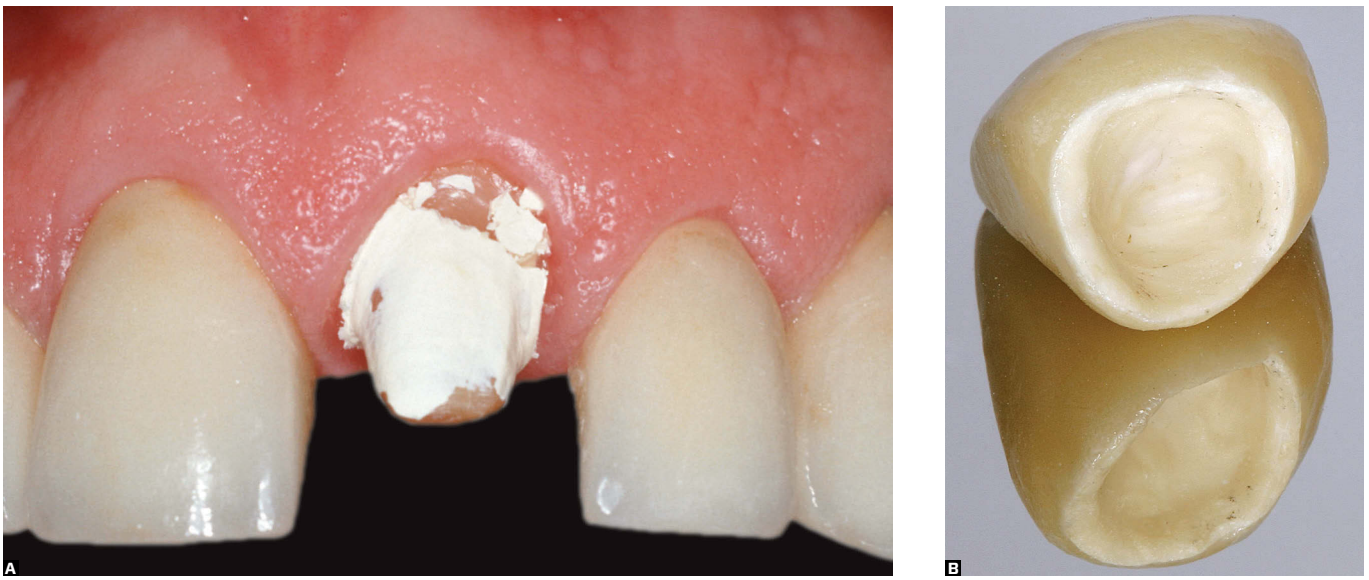


Figure 4 - **A**) Ionomer cement adhered to the prosthetic retainer (dentin) after displacement of an all-alumina ceramic crown (Procera AllCeram™). **B**) Inner area of crown after separation. Macroscopic aspect shows no remaining cement adhered to alumina (clinical case by Francischone CE).

question is raised. How does dentin, which is humid, is better than alumina, a structure that is free of humidity, in terms of strength of adhesion to resins? The explanation seems to lie not only on the greater facility to create roughness in the first one, but also on the attention assigned to the next step of infiltration of some types of fluid resin, a fact that grants some privilege to the diffusion and combination of adhesive agents in its interstice, a procedure that is sometimes overlooked in the second one.

The correct and complete filling of porosities in alumina and zirconia is fundamental to determine their adhesive success. If, after cementation, such irregularities, mainly those located close to the crown margin, remain without cement (or adhesive primers), they will be filled by oral fluids that may promote hydrophilic degradation.

This phenomenon, in addition to the already mentioned crown displacement, may also result in the incidence of caries in the retention structure and changes in the color of the restoration. Because it does not have a gray-metal infrastructure to mask die infiltration, this restoration is more vulnerable to it (Fig 6). Therefore, it is important to increase wettability and filling by the primer to reduce water infiltration into the interface and minimize, therefore, the effects of this type of degradation. Clinical observations confirm greater rates of fracture of the cement-alumina interface than of the cement-prosthetic retention interface.

When repeating the cementation of alumina or zirconia crowns that were displaced by any reason, several use internal blasting with aluminum oxide particles even when all the cement remains adhered. Such blasting is, usually, a repetition, because most times it was already performed at the time of the first cementation. They use this procedure whenever the problem occurs, without concerns about making it weaker and not even questioning the real cause of the displacement. If displacement is repeated, the same techniques used in the previous cementation will most likely be inefficient again.

When the cement remains in the retentions, the crown will probably be as clean as when it arrived from the laboratory. In such case, the application of cleaning agents seems to be more sensible, conservative and better indicated, as it is necessary to remove only saliva and minor impurities. As long as there are no infiltrations, when any type of fluid resin is used, the alumina structure will remain the same, even after contact with resin cements, as shown in Figures 3B and 4B. To submit them again to procedures that are somehow aggressive does not seem to be the best choice. We should, instead, infiltrate them with adequate primers and review other relevant prosthetic aspects.

Resin cements certainly have better proprieties than purely ceramic crowns, but conventional cementation may also be used successfully as long as there is some structure for support and application of porcelain coatings, as well as some frictional retention for preparation. A prosthetic crown is not retained only by its adhesion to the cementing agent. This idea erroneously overestimates the role of cement in the maintenance of a restoration, and may lead to negligent clinical procedures and failure. Care should be taken when extrapolating in vitro results to clinical conclusions. Several other relevant aspects are involved in clinical cases, such as preparations, contact surfaces and occlusal balance, which should be taken into consideration when defining the success of restorative treatments.

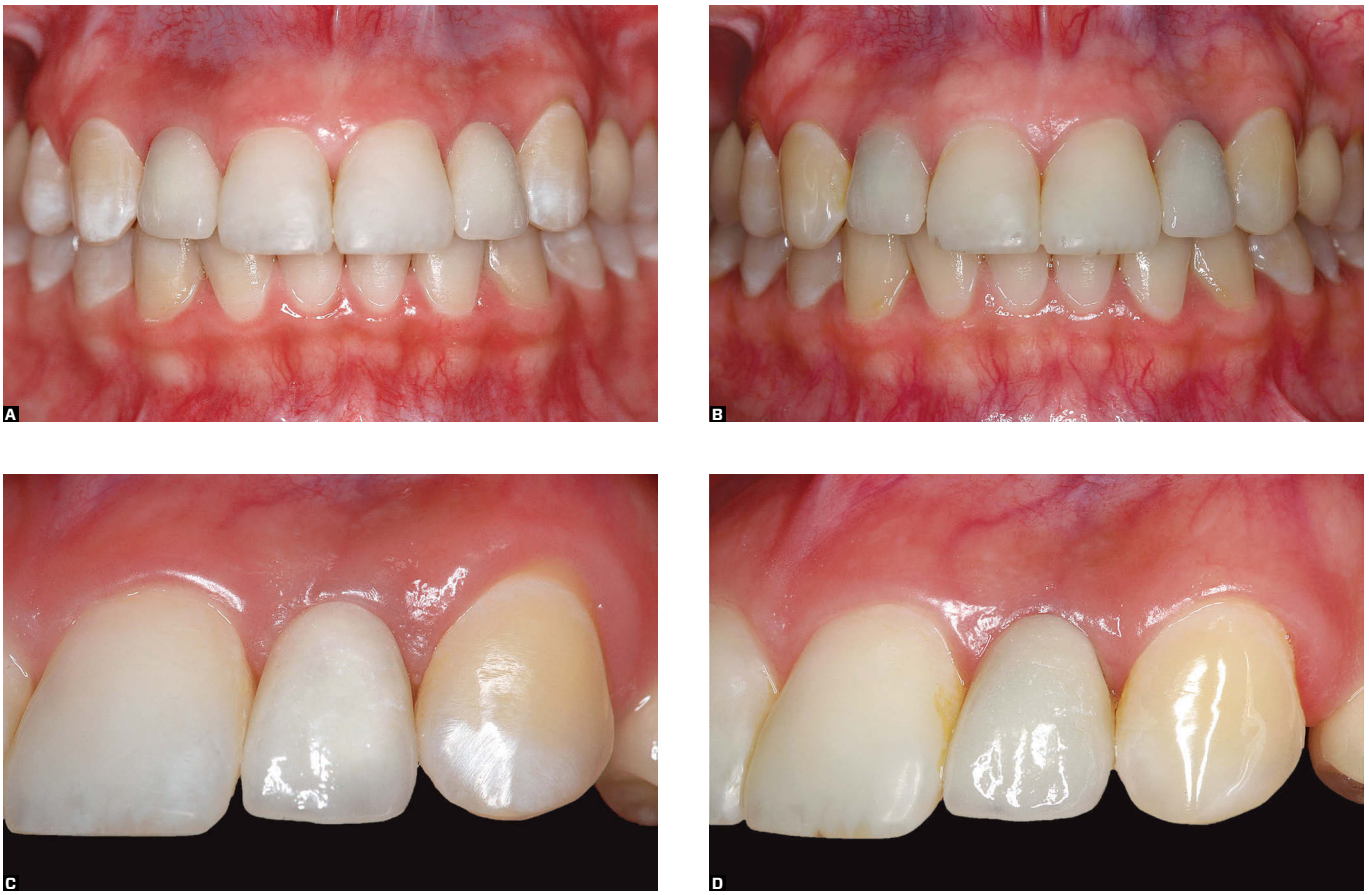
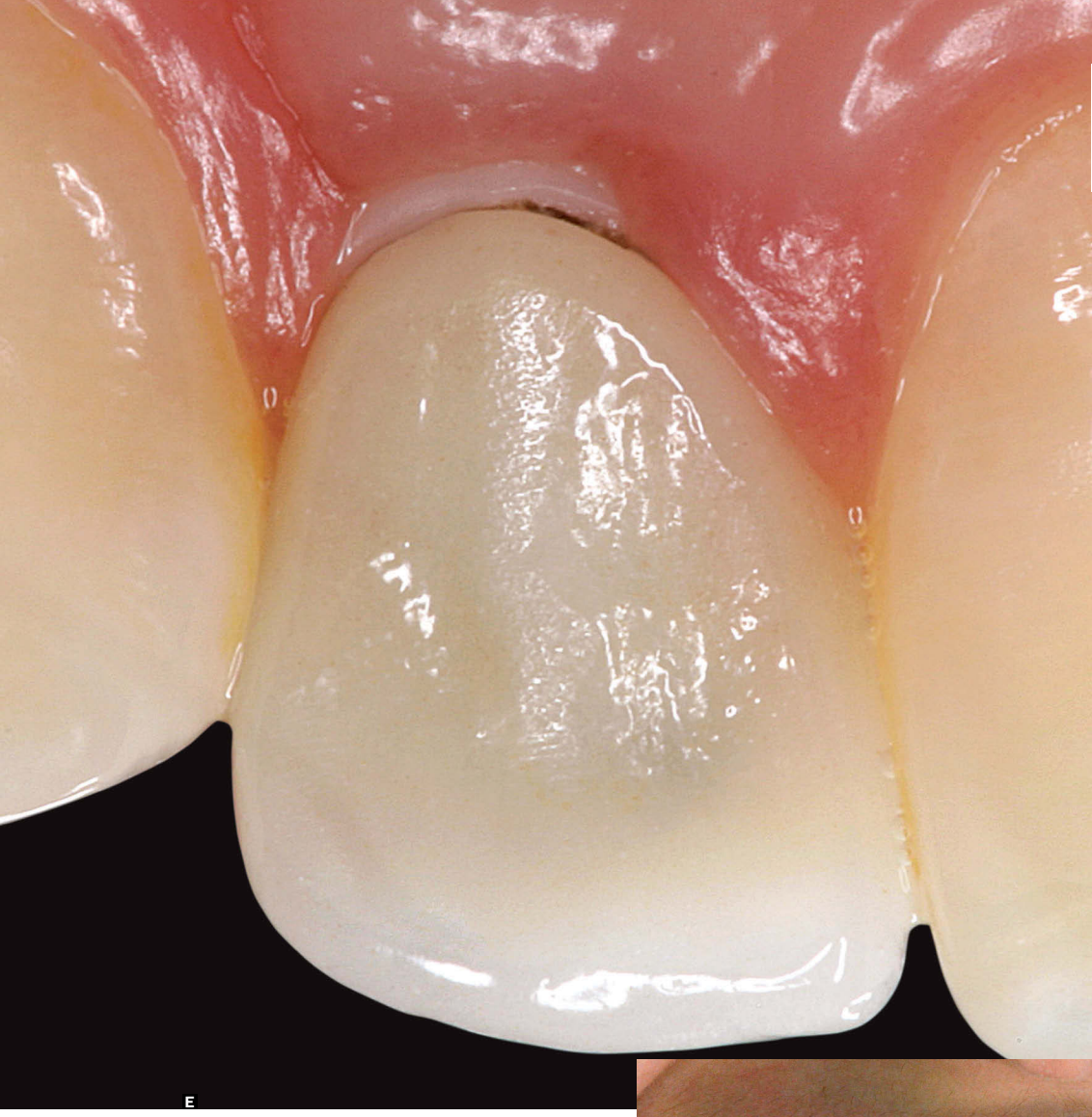


Figure 5 - **A**) Clinical aspect immediately after cementation of two metal free crowns with alumina infrastructure coated with feldspar porcelain in teeth #12 and #22 (zirconia posts over osseointegrated implants). There is good color harmony when compared with natural neighboring teeth. **B**) Six years' follow-up: Visible color change of ceramic crowns, which have a grayish hue. **C**) Proximal view of tooth #22 crown immediately after cementation (original color). **D**) Change of color of tooth #22 crown six years later.



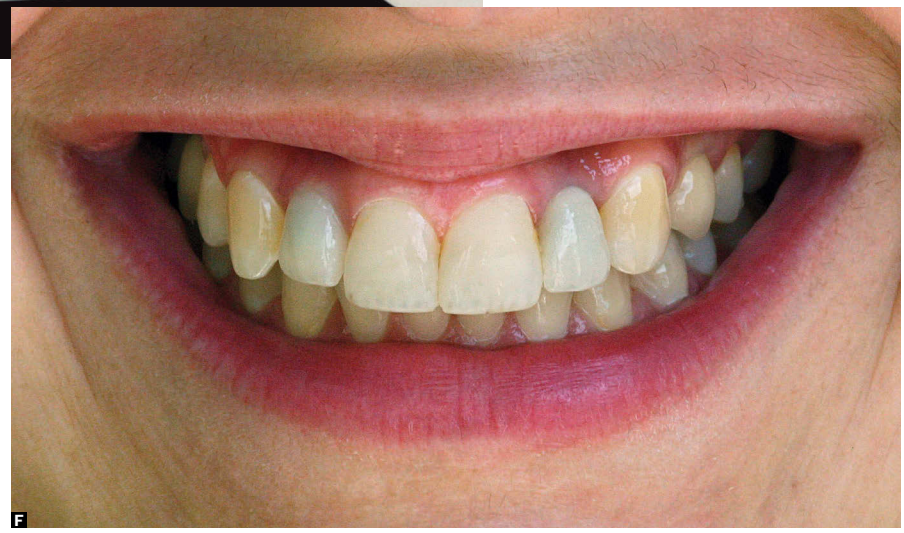


Figure 5 - (continuation) **E**) Detail of lingual aspect, where, in addition to darkening, there is pigmentation on the margin of the crown, probably due to penetration of oral fluids into alumina/cement interface, an area not adequately filled with the cement. **F**) Image captured without any artificial light (no flash) shows more evidently the color difference (clinical case by Francischone CE).

Our culture loves isolated explanations based on two opposed ideas — such as God and the devil, black and white, good and bad, smooth and rough, and right and wrong — to justify our own mistakes or to mask what we do not properly understand. This is part of our contradictions, and it may impair the coherence of our analysis about the ideal way to cement prosthetic crowns.

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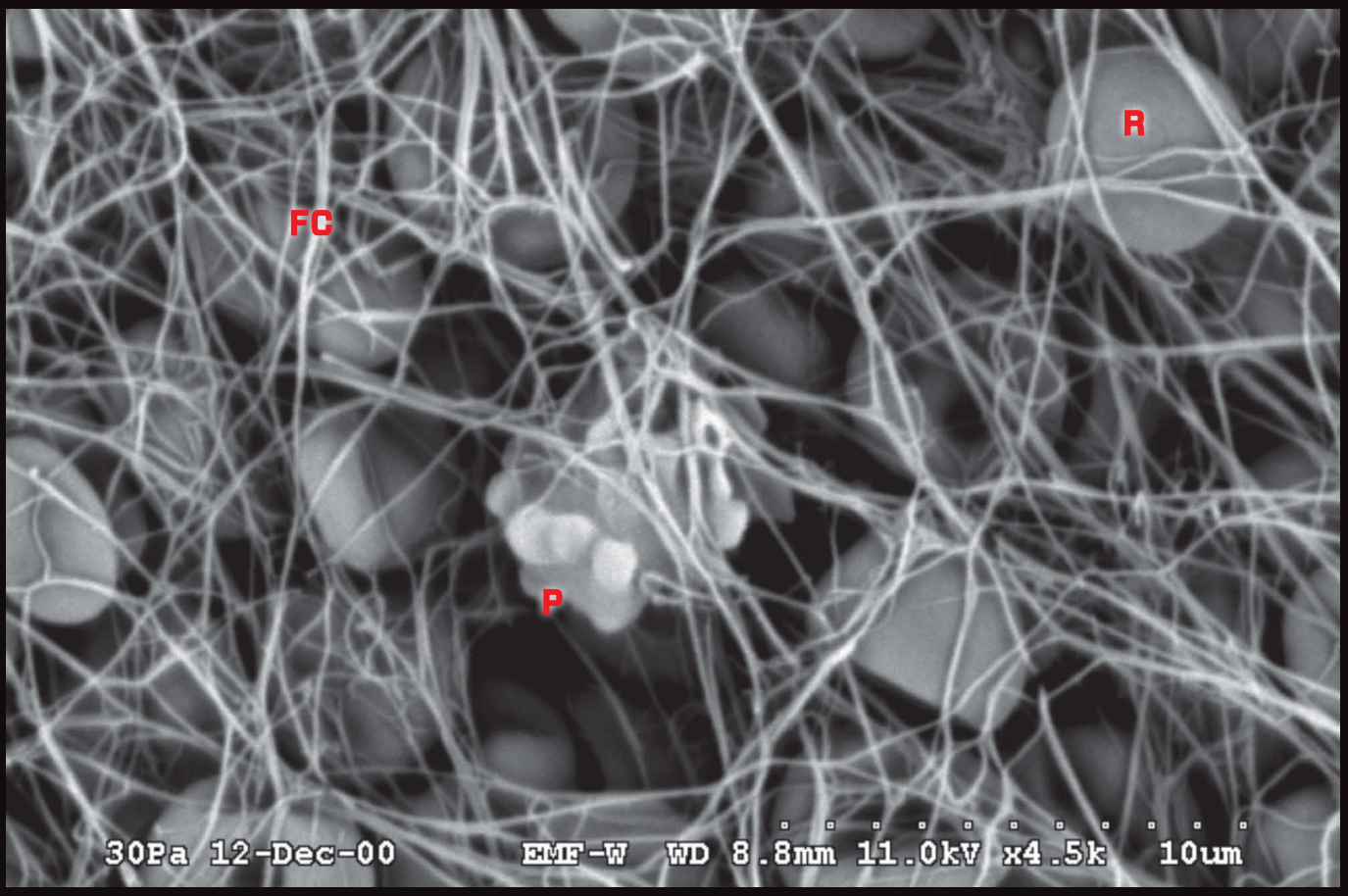
Initial phase of repairing

Dario Augusto Oliveira **MIRANDA***

Fibrin clot (FC), RBCs (R) and platelets(P) in newly formed blood clot, in initial process of repairing, observed by scanning electron microscopy (SEM).



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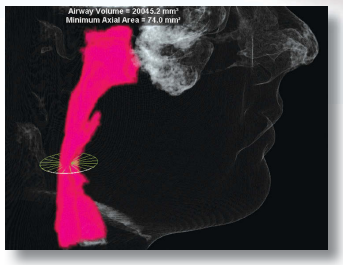
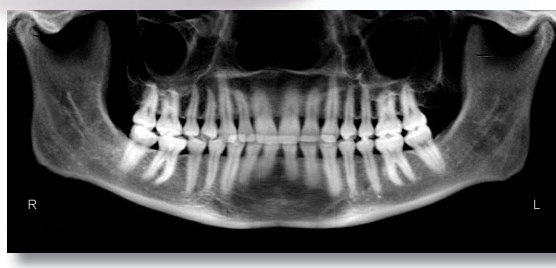
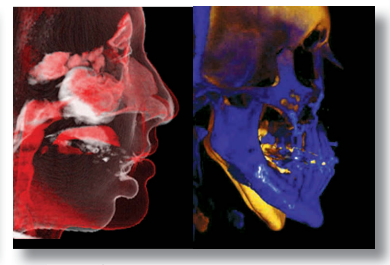


3D airway volume analysis



Panoramic projection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Behavior of peri-implant soft tissue in the interface with titanium: A literature review

Gabriela Farias de **MELO***
Iris **DURÃES****
Emilena Maria Castor Xisto **LIMA*****

Abstract

The soft tissue's adhesion to titanium, biologically capable to preserve and protect the peri-implant structures contributes to peri-implant mucosa's stability and maintenance of pink esthetics. Thus, the object of this study was, through a literature review, to describe the interaction between the titanium used in the prosthetic and implant components and the soft tissue to the maintenance of the stability and health of peri-implant tissues. It was concluded that the peri-implant soft tissue's stability is one of the criteria of success to rehabilitation with implants, once the establishment of an intimate relation between the soft tissue and the titanium of the implant, as well as the prosthetic components, promote a protective barrier to penetration of bacteria and its metabolic products, favoring the implant's long-term performance.

Keywords: Dental implants. Titanium. Oral mucosa.

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Introduction

The treatment with dental implants is an established option in terms of functionality and durability.[25] However, taking the treatment as a whole, its success is defined not only by establishing and keeping the osseointegration, but also by the stability in peri-implant tissues (contour, color, texture), by the presence of keratinized tissue, interdental papilla, gingival contour in harmony with the adjacent teeth, as well as an adequate sealing between the soft tissue and the titanium, consisting in the creation of peri-implant soft tissue's contours that cannot be readily distinguished from natural adjacent tooth.[14]

Some authors[1-4] highlighted the importance of epithelial and connective tissue insertion around the implant to keep the osseointegration. The success of long-term osseointegrated implants depends on the adherence of the epithelium and of the connective tissue to the titanium surface, protecting the osseous tissue against microorganism from the oral cavity, and this adherence depends on the topography and chemical composition of the biomaterial.[9]

Titanium — commercially pure (c.p.) or in alloys — is usually recognized as bioinert, i.e., neither it releases any harmful substance nor it provokes any adverse reactions on the tissue.

Its biocompatibility is related by its capacity to form oxide layers on the surface while in contact with oxygen, hence it is widely used in orthopedic and dental surgeries.[21]

In terms of technology, there was a significant evolution in the manufacturing of implants, prosthetic components and its designs, due to the improvement of materials used and to the treatment applied to its surface. In this development context new parameters were adopted. Besides the functional requirement, the esthetics quality, once discredited, has become highly requested, increasing the expectations from the patients.[25]

Therefore, keeping the gingival health, the esthetics and stability is a prime challenge and special attention must be given to soft tissue and its behavior in face of the diversity of materials used on implant's prosthetic rehabilitations. Such concern begins in the treatment planning phase, ongoing the surgery stages throughout the installation of provisional and definitive prosthesis.

The insertion of peri-implant mucosa around commercially pure titanium implants was studied in different animals as well as in humans.[3-6] However, more studies are needed to understand the connection between artificial materials and living tissues, which type of material allows a better tissue response and what kind of surface is preferred by soft tissue or bone cells. This knowledge would help in the predictability of the response from bone or soft tissues when implants are inserted.[11]

Researches in implantology focus mainly in osseointegration, with only a few studies on the integration between soft tissues and implants. Thereby, the objective of this paper was, through a literature review, to clarify the biological behavior of peri-implant soft tissue contacting the titanium.

Literature review

Biological distance

Histological and radiographic observations suggest that there is a constant distance between hard and soft tissues and the implant, extending apically to the implant/abutment interface, similar to the dentogingival tissue, histologically named biological distance.[20]

After implants insertion, there is a lapse of time for bone remodeling that establishes a space to the insertion of a junctional epithelium. The components of this junctional epithelium have a composition similar to the periodontium after non-surgical treatment of periodontitis. Thus, it is es-

tablished the biological peri-implant space (Fig 1), which has similar dimensions to the biological periodontal space (Fig 2), around 3 mm. Mucosa insertion around the titanium implants was of 3-4 mm high and included two portions: An epithelial component which is around 2 mm and a conjunctive one around 1-2 mm high.[1]

Hermann et al[17] presented a study, using dogs, with the objective of describing the changes that occur on the depth of the sulcus, junctional epithelium length and contact area of conjunctive tissue. This study showed that the biological dimension, which is the combination of soft tissues, did not change in any of the three evaluation periods, however, significant changes were observed in every tissue compartment (depth of the sulcus, junctional epithelium and conjunctive tissue). The depth of the sulcus and the dimension of the contacting conjunctive tissue decreased while the length of junctional epithelium increased. The fact that the total dimension of the biological distance remains the same after the healing process, suggests that the non-submerged one-piece implants allow a physiological stability of peri-implant tissues.

As well as in natural dentition, the biological tissue answers to the implant insertion through formation of periosteum, connective and epithelial tissue, creating a soft tissue strip which keeps the integrity of periodontium. The biological distance determines a minimum dimension of peri-implant mucosa that protects the junctional epithelium and the conjunctive tissue, keeping a sealing around the implant which provides protection against biological and mechanical agents.[24]

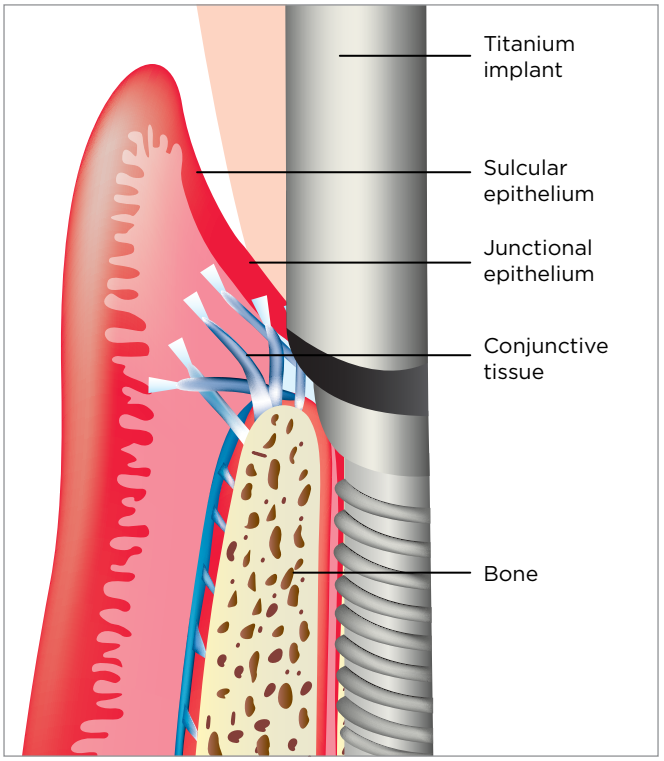

Figure 1 - Insertion apparatus of peri-implantar tissues.[26]

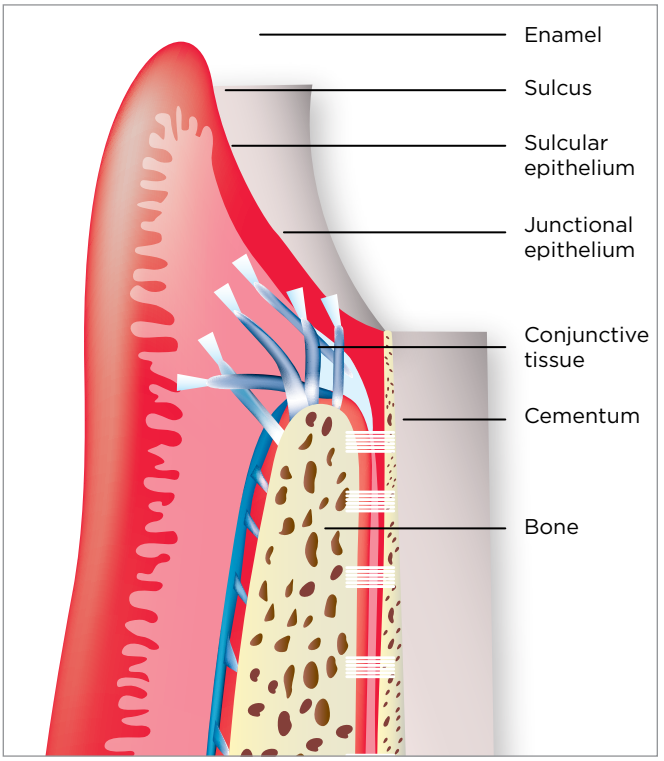

Figure 2 - Insertion apparatus of periodontal tissues.[26]

Epithelial tissue

The characteristics of transmucosal junctional epithelium and the conjunctive insertion in the implant are established during the healing of the implant installation surgery. In this context, it is believed that the epithelium plays an essential role on wound healing, covering all the connective tissue, which is sectioned during the surgery. Thus, the epithelial cells located on the edge of the mucosa, produced by the implant installation, are encoded to divide and migrate through the wounded part until the epithelium restoration. The epithelial cells have the ability to merge to the implant surface and establish a barrier that has common characteristics with the junctional epithelium of the tooth.[29]

Because of the capability of the epithelium to proliferate and move over surfaces, the epithelium found on the edge of the surgical incision crosses the fibrin clot/granulation tissue bridge, which is formed right after the implant installation. Before reaching the implant surface, the epithelium moves 2 mm in coronoapical direction, yielding the junctional epithelium. This migration is interrupted when it finds a connective tissue organized with fibroblasts and collagen fibers adhered to the implant surface.[29]

In the implant site, the apical portion of the junctional epithelium is consistently separated from the alveolar bone by a non-inflammatory, collagen-rich, but cell-poor zone. This zone size is about 1-1.5 mm, it is continual to the junctional epithelium and it establishes an implant-mucosa adherence which sizes 3-4 mm. On the collagen-rich zone, the fibers invest on the marginal bone in a somewhat parallel course to the implant surface.

Adhesion mechanisms

Some studies[1,9,14] demonstrated that the mucosa portion in contact with the titanium abutment surface may be divided in two different zones: A marginal zone which lodges a junctional epithelium and an apical zone, that is composed by a fiber-rich conjunctive tissue.

The laminin is an important component of the basal membrane and seems to be an adhesive stabilizer factor of the hemidesmosome, retarding its cellular motility.[22]

Regis and Duarte,[25] in 2007, as well as Buser et al,[9] in 1992, suggested that the connective tissue on the interface zone is similar to a cicatricial tissue (scarce in cells and vascular structures, but rich in collagen fibers) firmly united to the implant surface.

Hormia et al[18] performed a study using cell culture to investigate the adherence and growth of fibroblasts and epithelial cells on titanium surface. The study suggests that the titanium surface topography influences the behavior of such cells, favoring an apical epithelialization under pathological conditions. These two types of cells show distinct preferences for different molecules and potentiates the insertion of gingival cells in different implant surfaces.[19]

In an experiment made by Lauer et al,[19] in 2001, it was found that gingival keratinocytes have adhesion in three different types of titanium surfaces that were studied: Glossy polished; sandblasted; and plasma-sprayed. Through migration and proliferation, these cells covered the three surfaces. The biggest extension was observed on the polished surfaces and the smallest on the plasma-sprayed ones. This study showed that keratinocytes have more attraction for polished than to rough surfaces. However, it could not be confirmed greater adhesion force on polished surfaces when compared to treated surfaces.

Berglundh et al[8] held a study in 2007 using dogs with the objective of verifying the progression of the peri-implantitis around the implants. They observed, through radiographic and histological exams, that the disease progression is

more favorable on implants that have a more rough surface than on implants that present more polished surfaces.

Connective tissue

In a natural teeth, the dentogingival collagen fibers are firmly inserted into the cementum and into the bone, oriented perpendicularly or obliquely to the tooth surface, posing as a barrier to epithelial migration, thus preventing a bacterial invasion.[13]

The peri-implant biological components are similar to the dentogingival complex in its constitution and in the formation of biological distance. Both tissues react to the presence of plaque with an increase of leukocyte migration through the junctional epithelium and with the establishment of an infiltrate of inflammatory cells in the connective tissue.[4] However, it is important to highlight some differences, such as the collagen fiber disposition and its absence on the titanium surface, which allows the formation of a system more vulnerable to bacterial invasion and mechanical aggressions while compared to the tooth.

The absence of cementum in the implants promote a parallel orientation of the fibers of supracrestal soft tissue in relation to the implant.[3,9] This peculiar arrangement offers less mechanical resistance when compared to periodontal ligaments, being able to affect the prognosis of dental implants, often being observed gingival recession, gingival pocket and bone resorption.[9]

Gargiulo, Wentz and Orban[13] named as connective tissue attachment the region located between the apical portion of the junctional epithelium and the bone crest. Such denomination seems to be appropriate, because there are still contradictions concerning the real adhesion existing between the tissue and the implant and/or the prosthetic component.

Vascular supplement

The vascularization between the periodontium and the peri-implant happens in a distinct way. Studies about the vascular topography of periodontal and peri-implant tissues observed that the gingiva and the supracrestal connective tissue adjacent to the tooth were supplied by blood vessels originated on the periodontal ligament, while the peri-implant mucosa was vascularized by blood vessels originated on the periosteum next to the implant. In both situations, the blood vessels build a characteristic vascular plexus sided to the junctional epithelium.[4]

In teeth, the supracrestal connective tissue showed a rich vascularization, while in a similar region in the implant few or no blood vessels were found.[12] The scarcity of blood vessels next to the implant surface supports the statement of Buser et al,[9] that the peri-implant soft tissue would have a reduced capacity of defense against exogenous irritations, for instance, biofilm.

Defense mechanism against aggression

In teeth, the presence of periodontal pocket, evidenced by increased probing depth, is due to periodontal disease or bone loss.[6] However, in implants it is risky to associate the dental sulcus depth and this disease, as there are reports of stable and rigid implants with probing depth varying from 2 mm to 6 mm.[12]

When an external agent invades the biological depth, the epithelium responds to it by migrating to a place far from the harmful agent, in an attempt to isolate it and create a defensive distance that may assure the peri-implant integrity. This leads to resorption, thus assuring the reestablishment of biological distances.[6,7,24]

Abrahamsson et al[1] demonstrated the existence of an infiltrate of inflammatory cells which is bigger on the interface between the implant and the ceramics abutments when compared to the titanium ones. They also suggested that this fact could be explained by the existence of a larger microgap between implant and

the ceramics abutment. Opposing to this statement, Yüzügüllü and Mhemet[33] observed the existence of a bigger microgap on the implant/titanium interface when compared to the interface between the implant and alumina or zirconium.

Keratinized mucosa

The presence of an adequate strip of keratinized peri-implant mucosa with good thickness conditions offer functional and esthetic benefits to rehabilitations. The main advantages are a greater facility in conditioning the peri-implant tissues and molding, lower occurrence of recessions with abutment exposure, greater facility in peri-implant biofilm control, lower mucosa sensibility during oral hygiene procedures and better protection against infection in peri-implant tissues.[27]

Warrer et al[31] verified that the absence of keratinized mucosa increases the susceptibility and tissue destruction in implant sites. However, the presence of keratinized mucosa was observed with lower frequency in the peri-implant pocket when compared to implants surrounded by alveolar mucosa.

Though, the indispensable need of keratinized mucosa to peri-implant health is controversial. From a clinical point of view, there are no evidences that the absence of keratinized mucosa harms the longevity of implant-supported rehabilitations when oral hygiene is satisfactory. The implants can survive even with a lack of such tissue. This can be observed in patients who received protocol-type prosthesis and were accompanied on the long term, showing fixation stability.[27]

Vertical and horizontal distances and the papilla formation

The proximal bone linked to the adjacent teeth is a precondition to the presence of papilla. The bone presence does not necessarily guarantee that the papilla fill the interproximal space. Nevertheless, in 80% of the cases the spontaneous filling may occur if the design of the prosthesis is taken into account and if the proximal bone is present.[23]

Tarnow et al[30] evaluated the vertical distance from the crest of bone to the height of the interproximal papilla between adjacent implants, independently from the contact point location. A total of 136 interproximal papilla heights were examined in 33 patients. The average papillar tissue height found between two adjacent implants was 3.4 mm, with wide diameter between 1 and 7 mm. The most frequent probing depths were: 2 mm, in 16.9% of the cases; 3 mm, in 35.3% of the cases; and 4 mm, in 35.7% of the cases (totaling 90% of the total). They concluded that caution must be taken when installing two adjacent implants in esthetic areas, as in most of the cases one can expect only 2 mm, 3 mm or 4 mm of soft tissue to cover the inter-implants bone crest.

Grunder,[15] in 2004, related that the ideal inter-implants distance to form papilla would be 4 mm, believing that a 3 mm distance, as Tarnow et al[30] related in their study, wouldn't be sufficient.

Characteristics of the titanium surfaces

The quality of the surfaces has maximum importance to the establishment of a proper relation between the implant and the tissues, which refers to the surface structure as well as its chemical and biological properties. Progress in knowledge regarding these biological effects can provide a better response on the implant interaction with the tissues and its clinical performance.[11]

The implant surface rugosity can be obtained through the manufacturing process or through subsequent treatments involving machining, particle blasting, titanium plasma spray, chemical or electrochemical attack, and a combination of these procedures.[32]

The geometric dimensions of the surface microstructure influence the cellular adhesion, morphology, orientation, proliferation, differentiation, and the production of local factors. The effect of surface topography in cellular adhesion varies according to the type of cell. Human fibroblasts have more adhesion in electropolished surfaces than in treated surfaces. Contrarily, osteoblasts demonstrate more adhesion in rough surfaces than in flat ones.[32]

Until the early 90's the cervical portion of the most of dental implants used to have a machined-surface of Brånemark System® type. The intention was to prevent plaque accumulation when the implants were exposed to the oral environment, which could cause severe problems like peri-implantitis. However, nowadays it is believed that the microgrooves in the neck of the implants can promote improvements to the epithelial tissue adaptation on the long term, though more studies are necessary to confirm the real benefits of this implant structure modification.[25]

Çomut et al[10] observed, on the one hand, an effective formation of mucosa insertion in c.p. titanium surfaces and in hydroxyapatite-revested titanium, with the fibers organized in a parallel orientation in all samples. On the other hand, the insertion of human gingival fibroblasts into c.p. titanium proved to be significantly bigger than in hydroxyapatite, porous and nonporous.[16]

The cells adhesion and its proliferation in a biomaterial depend, among other factors, on the surface wettability which, in its turn, is affected by the roughness of the biomaterial. Implants with moderate surface roughness have clinical advantages when compared to implants with a too-flat or too-rough surface.[2]

Lauer et al,[19] in their turn, observed that after a 6-day period, 28.1% of the titanium flat surface was covered, and after a 12-day period this covered surface had increased to 61.3%. In contrast, in 6 days, the cultivated gingival keratinocytes had expanded less on a sandblasted surface (11.3%) and a plasma-sprayed titanium surface (11.1%). Nonetheless, the adhesion did not seem to be as good as on the two other surfaces examined, though the layers of gingival epithelial cells covered an extensive area of the titanium flat surface.

In spite of the consensus around the importance of the formation of an effective barrier between the peri-implant soft tissue and the titanium to keep the stability of the gingival margin, more studies are necessary about the mechanisms of such adhesion, as well as other elucidations about the design, surface topography and material composition.

Bone loss and stability of gingival margin

The peri-implant mucosa represents a type of cicatricial tissue created by a surgical intervention without insertion of supracrestal fiber on the cementum; and the peri-implant bone level constitutes a base for the supracrestal soft tissue. In the period between the implant insertion and the abutment connection, a significant quantity of buccal bone loss was reported in a bone thickness < 1.8 mm, measured right after the mounting of the implant. This can negatively influence the topography of the soft tissue and the esthetical result of the restoration.[28]

Repeated installation and removal of the abutment can provoke an aggression to the soft issue, which will respond with mucosa recession. In an attempt to reestablish the biological distance needed to promote a sealing of the soft tissue around the implant head, it happens a bone crest resorption, aiming at creating space for the three main marginal structures: The sulcus epithelium, the junctional epithelium and the area of connective junction.[5] This phenomenon was demonstrated in another study,[1] with monthly changes of the abutment, leading the tissue to a loss of insertion. During the cicatrization process, there is a reinsertion of the peri-implant mucosa with the formation of two zones: Junctional epithelium (2 mm) and connective tissue (1 mm).

Likewise, when the phenotype of the peri-implant mucosa is thin (2 mm or less), bone resorption is observed, sustaining the theory that a minimum soft tissue thickness is required (approximately 3 mm) to reestablish a biological distance.[5]

Hermann et al[17] verified that the bone crest level around the implant screws was located around 1.5 mm to 2 mm below the implant-abutment junction (IAJ). Radiographically, it could be verified that this bone resorption usually reaches the first screw of the implant. One of the theories developed to explain such phenomenon states that a bone remodelling happens due to an inflammation located on the soft tissue of the implant-abutment interface, in an attempt to obtain space for the establishment of a mucosa barrier around the implant head.

One of the difficulties to restore the papilla between two adjacent implants is that the biological width around the implants is re-established apically to the implant-abutment connection. Allied to it, in esthetic areas, the implant is installed approximately 4 mm apical to the height of the soft tissue in adjacent teeth. Another factor that contributes to this difficulty is the difference in the location of the biological space. Between the platform of two implants, this space is subcrestally located, while in normal teeth it is supracrestally located.[30]

On Implantology, the difficulties are increased while attempting to solve the problems that occur in soft tissues after the implant insertion. Prospects are not the same, for example, when it is done a coating in titanium structures of implant, as it happens in several coating techniques for radicular recessions in natural teeth.

Conclusion

The stability of peri-implant soft tissues is one of the success criteria in implant rehabilitations, once the establishment of an intimate relation between the soft tissue and the titanium of the implant, as well as the prosthetic components, promote a protective barrier against the bacterial penetration and its metabolic products, thus influencing the long-term performance of the implants.

Besides, this interaction between the peri-implant soft tissue and the titanium piece depend of some factors that must be taken into consideration, such as: The chemical composition of the material, the surface topography and the periodontal phenotype of the patient.

For this reason, it seems to be evident and justifiable the need of an anticipated intervention in the implant mounting, aiming at the improvement in the quality of peri-implant soft tissues.

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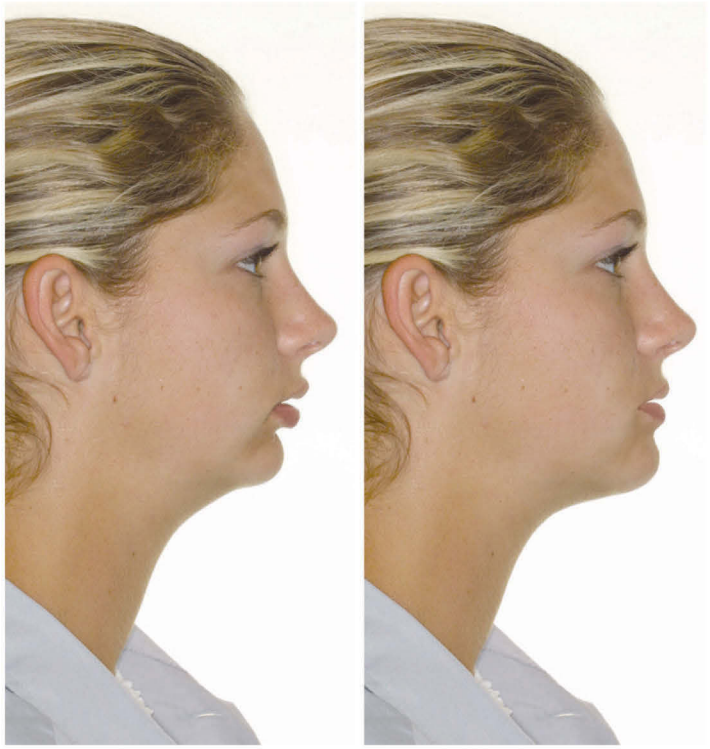

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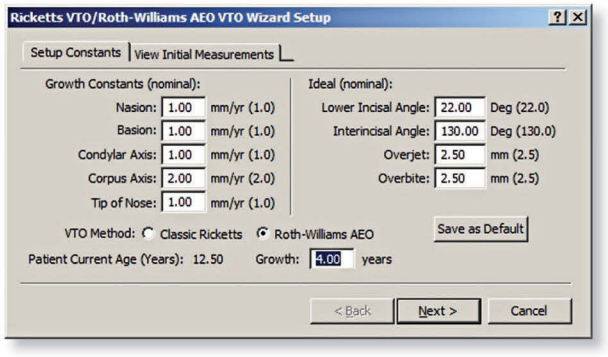

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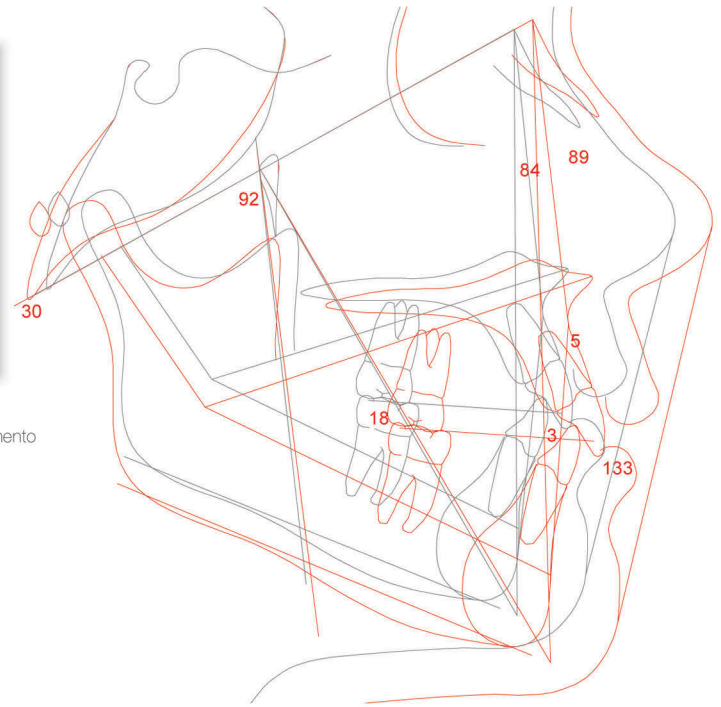

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Immediate loading in anterior region using the clinical crown of the lost natural tooth: A case report

Fernando Vacilotto **GOMES***
Felipe Born **VOLKART****
Luciano **MAYER*****

Abstract

One of the major current challenges in Dentistry is oral rehabilitation after tooth loss due to trauma. Esthetic and functional results, together with periodontal health, define success and prognosis. Implant dentistry provides the resources for the placement of osseointegrated screw-retained implants or cemented prostheses to replace missing teeth. Careful use of provisional prostheses preserves the harmonious architecture of gingival tissues and affects final treatment results positively. This study describes a clinical case of root fracture of the right maxillary central incisor (tooth #11) due to dental trauma. The tooth was extracted, an immediate implant was placed and the provisional prosthesis was fabricated using the clinical crown of the fractured tooth. The use of a fractured tooth for provisional restorations is a viable technique that has good esthetic and functional results and preserves gingival and dental balance.

Keywords: Dental implants. Immediate loading. Tooth fracture. Single implant.

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Introduction

One of the greatest challenges in dentistry is the rehabilitation of patients whose dental function, phonetics, comfort or health of the stomatognathic system is compromised. Osseointegrated implant dentistry has filled this gap and created an important treatment option,[1] for which success is estimated at 95%[2,3] both in immediate and non-immediate loading.[4]

Numerous patients lose teeth due to facial and oral trauma, particularly in the anterior maxilla, which has a greater anatomic projection and is particularly susceptible to this type of injury.[5] Therefore, adequate oral rehabilitation, often immediate, should be provided to restore not only esthetics, but also function and the necessary occlusal balance.[1]

The restoration of a single tooth in the anterior maxilla is challenging, particularly when esthetics is compromised due to trauma to permanent teeth.[6,7] In such cases, the fractured tooth should be carefully removed, if not already avulsed, to preserve the remaining bone walls. After that, an osseointegrated implant should be placed in the socket to ensure that the prosthesis will be held in an ideal position to restore function and esthetics.

Immediate loading has been used in the clinical routine of implant dentistry because of its high predictability.[8] Using this technique, an osseointegrated implant can be implanted and loaded using a provisional structure so that function is restored immediately after the procedure. In addition to comfort and esthetics, there are psychological and functional advantages over the use of partial removable provisional prosthesis.[9]

Provisional prostheses for immediate-loading implants may be manufactured using several techniques. The purpose of this prosthetic treatment step is not only the patient's social rehabilitation and well-being, but also the functional restoration of occlusion and esthetics, as well as the preservation of an adequate gingival and bone structure.[10,11,12] An alternative to provisional prostheses, particularly when treating the anterior maxilla, is the use of the crown of the fractured tooth. This technique may preserve original anatomy and provide good esthetic results, because the natural crown has the same color as the other teeth.

This study describes a clinical case of root fracture of the right maxillary central incisor (tooth #11) due to dental trauma in a car accident. After the tooth was extracted, an immediate implant and a provisional prosthesis, manufactured using the clinical crown of the fractured tooth, were immediately placed.

Case report

A 30-year-old white woman presented with injury to the anterior maxilla resulting from trauma in a car accident seven days before. At the time of the accident, the patient focused her attention on the treatment of the injury to soft tissues and did not realize that the tooth #11 was presenting slight mobility. One week later, increased mobility made her seek dental assistance.

After a careful exam of her trauma history and evaluation of clinical and radiographic findings, a fracture was diagnosed in the middle third of the root of the element #11 (Fig 1). When told about the diagnosis and the fact that the root would have to be extracted, the patient was very upset, but agreed to follow the treatment plan, which required the surgical removal of the fractured portion of the root, the immediate placement of an osseointegrated implant and a provisional prosthesis for implant loading.

At the same time, the patient demanded that the fact that she had lost a tooth should be kept confidential and that no one in her social circles should ever know about it, because she felt that knowledge of such loss would be even

worse than the accident itself. That request was a sign of the level of demand and the difficulty of the case, particularly because it affected a area of high esthetic risk. To obtain the best esthetic and functional results possible, as well as to respond to the patient's expectations of having the provisional match her natural teeth, a careful local and general risk analysis was conducted,[13,14] and plans were made to use the crown of the fractured tooth as the provisional prosthesis for implant loading.

Surgery began with the extraction of the coronal portion of the incisor (tooth #11) with forceps and of the root with a periotome operated gently to avoid trauma, handling periodontal tissues carefully and not using mucoperiosteal separation (Fig 2). Immediately after extraction, the socket was irrigated with saline solution and the walls were carefully examined to check their integrity on all surfaces. An osseointegrated implant was then placed respecting its correct three-dimensional positioning, a determinant factor to preserve gingival esthetics[15,16,17] (Fig 3). Proper locking was achieve at over 40 N/cm^2, and the implant was immediately loaded.

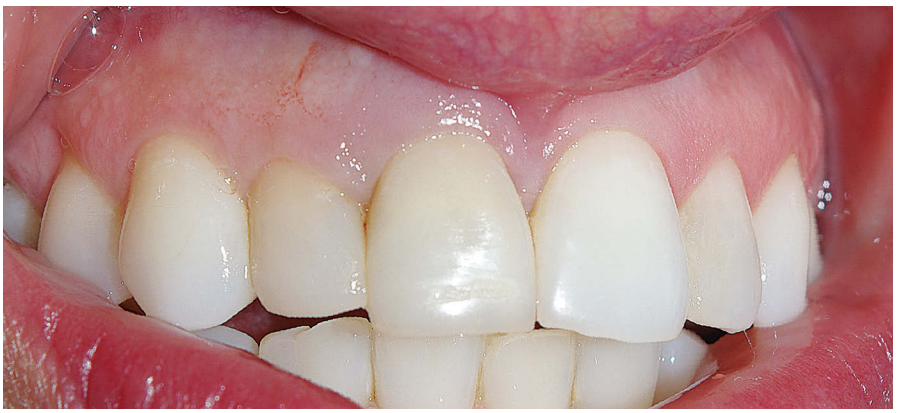

Figure 1 - Preoperative image of a patient who had a horizontal fracture in middle third of the root of right maxillary central incisor. Clinical exam revealed crown mobility. Edema remains in upper lip as late as 7 days after trauma.

To manufacture the implant-supported provisional restoration, the crown of tooth #11 was prepared into a facet (Fig 4), which was then rebased over a provisional using a light curing resin (Fig 5). The quality of the polishing of light-curing resin surfaces, when compared with that of acrylic resins, makes cleaning easier and, consequently, promotes gingival health in the region. However, the cervical contour of

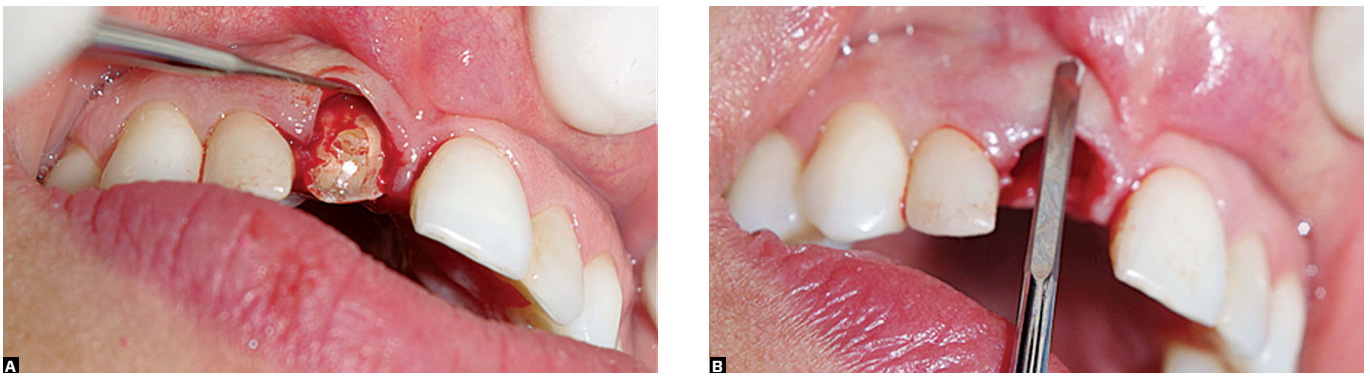

Figure 2 - Surgery to extract the fractured tooth #11 was gently performed using a periotome. **A**) Oblique root fracture extending to about 3 mm below bone crest on buccal face. **B**) Region to which root fracture extended: about 5 mm from gingival margin.

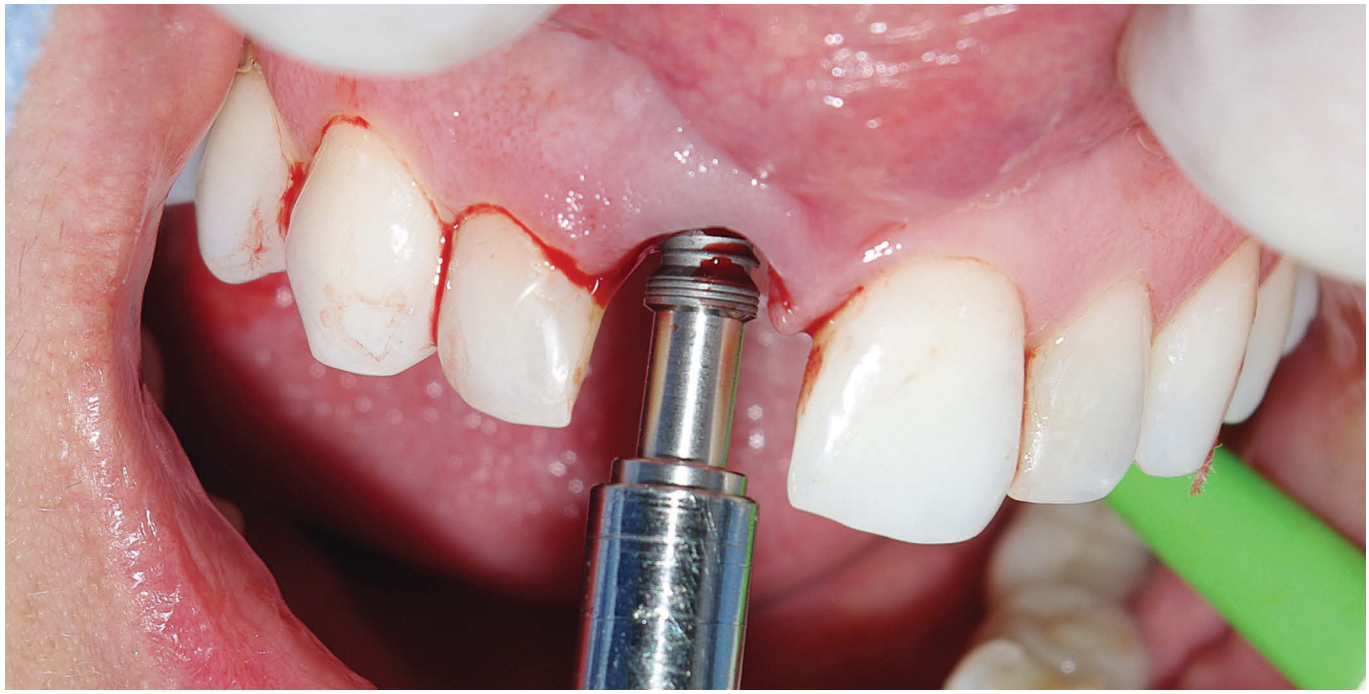

Figure 3 - Osseointegrated implant insertion and correct three-dimensional positioning.

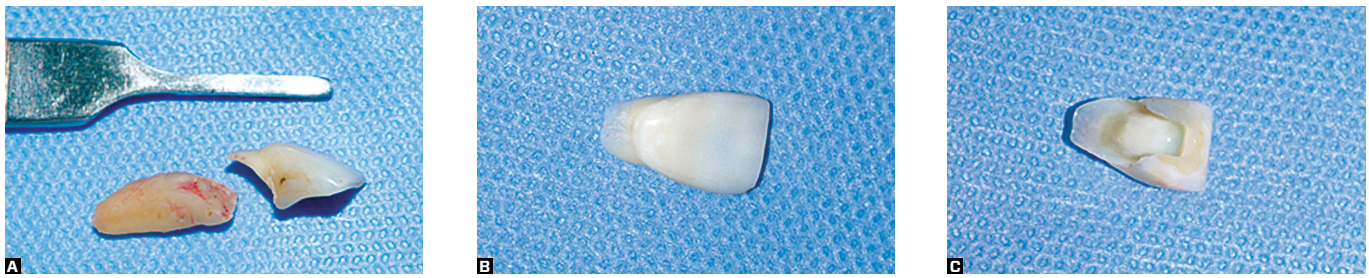

Figure 4 - Freshly extracted central incisor (tooth #11) with separate crown and root portions and, later, preparation of provisional prosthesis using the crown of extracted tooth.

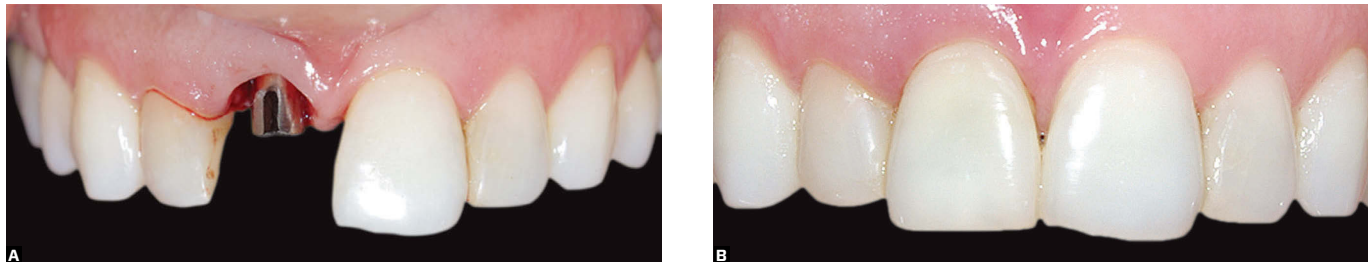

Figure 5 - **A**) Provisional abutment insertion in immediate postoperative phase. **B**) Adjustment of occlusion and proximal contacts of provisional prosthesis fabricated using a facet made with the crown of tooth #11.

the provisional is responsible for tissue stability at the gingiva-tooth-implant interface[18,19] (Fig 6).

Occlusal adjustments were made in the provisional restoration to ensure that it was free of protrusive and latero-protrusive contacts that might lead to trauma and complicate osseointegration during the primary peri-implant bone remodeling phase and might, consequently, result in implant failure.

After 90 days, the definitive restoration was initiated. At that moment, the gingiva was healthy and the concave arch and gingival papillae were not negatively affected (Figs 7 and 8). Stability of peri-implant soft tissues and of emergence profile was favored by the use of the crown of the natural tooth and by its cervical anatomy.[18]

As the original gingival architecture was preserved, the transference of the emergence profile was made with vinyl polysiloxane impression material to fabricate a pillar and a Cercon® zirconium crown (Fig 9). A careful selection of colors and the analysis of the photos of the adjacent tooth, sent to the laboratory, allowed for the post installation and all-ceramic crown cementing at the same time, using a dual-cured resin cement (RelyX™ ARC) (Fig 10).

At the same time, the lateral incisors (teeth #12 and #22) received metal-free ceramic veneers (IPS e.max) to replace large composite resin facets that showed signs of failure. The ceramic veneers were luted using a light-curing resin cement (RelyX™ Veneer).

At the end of the clinical treatment, the patient received instructions about hygiene and the maintenance of each prosthetic unit. A follow-up program for visits every six months was defined so that the level of satisfaction achieved could be maintained for the longest possible time.

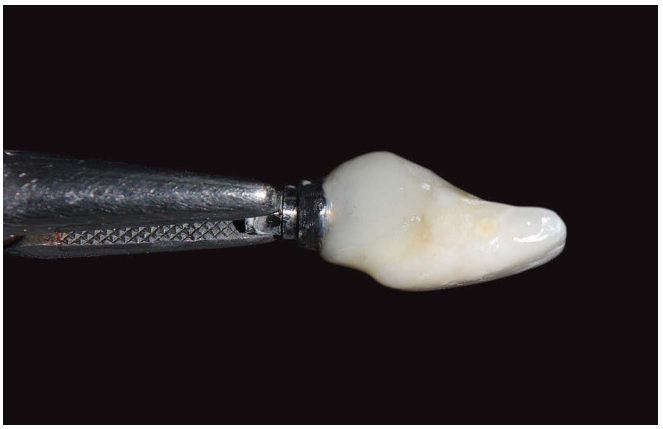

Figure 6 - Lateral view of tooth #11 prepared using a high-speed diamond-tipped drill under constant irrigation. Note the quality of fit, adequate emergence profile and provisional finish that ensured gingival health compatible with patient's esthetic and functional needs.

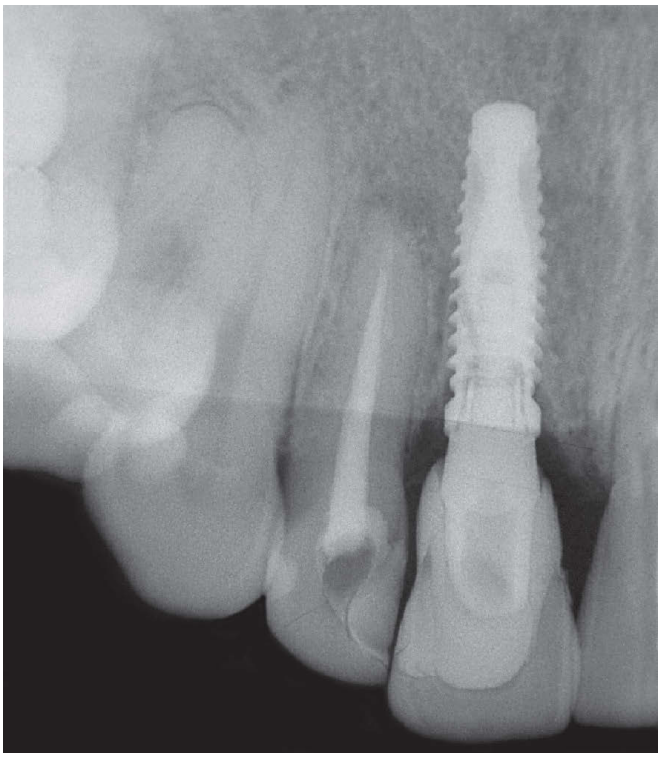

Figure 7 - Periapical control radiograph at 90 days after implant placement.

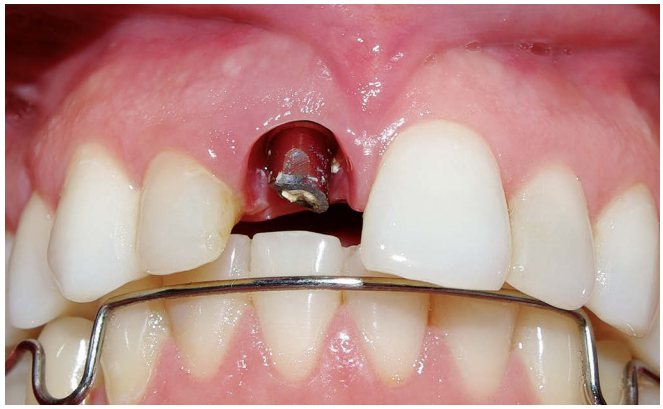

Figure 8 - Provisional prosthesis removal after osseointegration period (90 days). Provisional prosthesis preserved healthy gingiva and original soft tissue architecture.

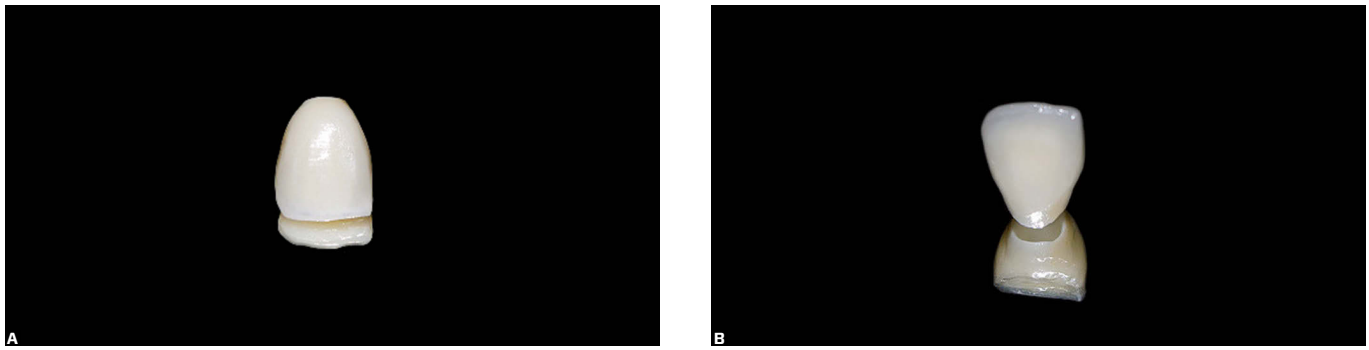

Figure 9 - **A**, **B**) Buccal and palatal views of metal-free ceramic crown of tooth #11 (Cercon™).

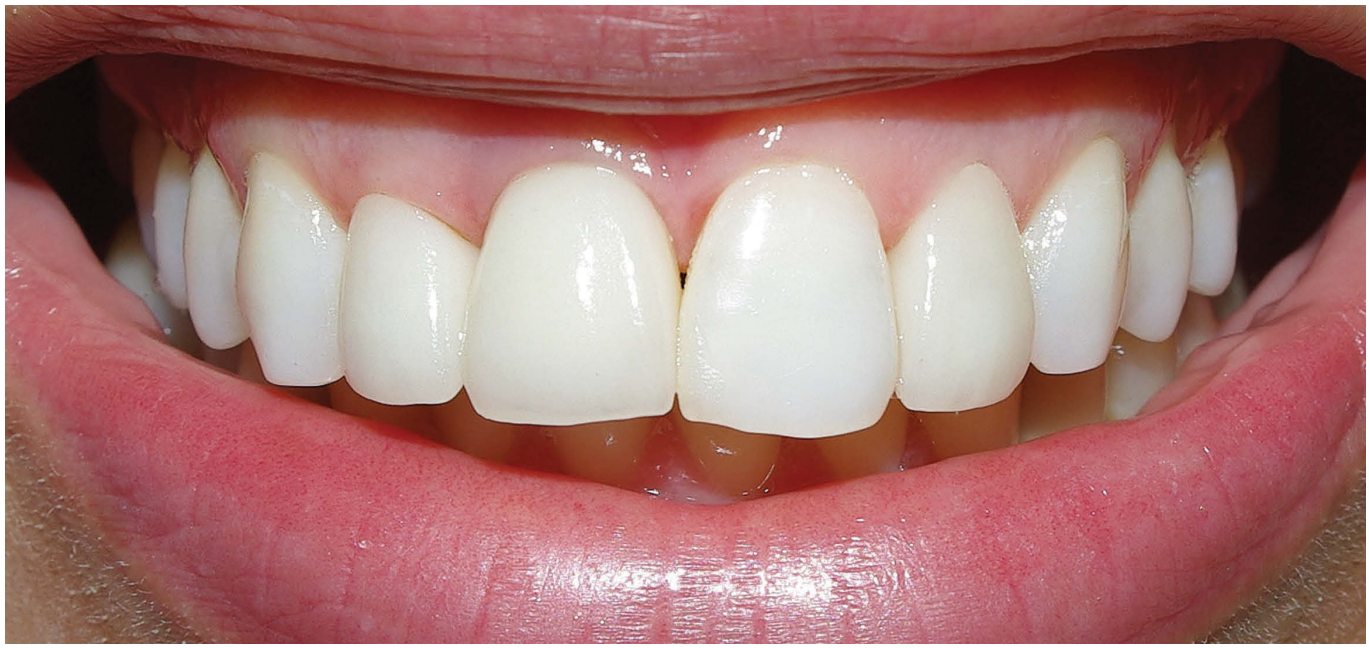

Figure 10 - Patient smile at the end of treatment. Note the esthetic quality, gingival health, harmony of papillae crests and preservation of interproximal papillae.

Discussion

The prognosis of root fractures, such as those that affect the cervical and middle thirds of the root, depend not only on the length of the fracture line, but also on the condition of the pulp and occlusion, on the presence or absence of root fragment displacement, and on the general and oral health of the patient. At the same time, the prognosis should include an adequate treatment plan according to clinical and imaging findings.[5] In the case reported here, the patient had no systemic disorders and, due to facial trauma, had a fracture in the middle third of the root of a maxillary central incisor (tooth #11) and injury to adjacent soft tissues.

The prognosis of cervical root fractures depends on the type and site of the fracture line. Their prognosis is better than that of fractures that follow the long axis of the root. At the same time, transverse cervical fractures have a worse prognosis than oblique fractures, probably because of the possible micro-movements that may occur after treatment and which may lead to further luxation. Such displacements may be caused even by minor impact generated by mastication or occlusion itself.[20,21]

Statistically, maxillary central incisors are the teeth most often affected (75%) in cases of dental trauma, particularly due to their natural projection in the anterior maxilla, which makes them more susceptible to structural injury. Maxillary lateral incisors are also affected by a high percentage of trauma and account for 21% of the cases.[6] Several techniques are available for the restoration of a lost tooth, such as the use of fixed or removable prosthesis and, currently, tooth replacement using osseointegrated implants.[7]

The use of the immediate loading technique may be indicated for all cases in which the immediate application of loads to an implant is possible. However, to increase chances of success and to allow the use of immediate loading with a provisional, initial implant locking pressure should be high, about 40 Ncm^2. Therefore, the measurement of insertion torque at the time of implant placement should determine whether the prosthesis can be placed and the provisional crown fabricated immediately. Also, micro-movements generated by occlusion and mastication should be minimized to avoid intercuspation and eccentric contacts, and the provisional prosthesis should not be removed during the initial phases of peri-implant bone repair.[9,22,23] The surgery protocol should include the evaluation of bone quality and quantity, as well as measures to ensure that the placement of the prosthesis and other components is adequate and to prevent parafunctional habits.[24-27] In the case described here, in addition to an initial locking pressure greater than 40 Ncm^2, careful provisional fabrication and adjustment ensured that the esthetic result was good and avoided centric and eccentric contacts.

A critical factor in implant rehabilitation of teeth in the anterior maxilla is the three-dimensional positioning of implants. Implant insertion at a palatal position in relation to the alveolar ridge (palatal approach) preserves the buccal bone wall and provides better implant locking. Therefore, it reduces the incidence of future gingival recession and implant exposure. A cohort study found that the use of a palatal approach and bone autografts in the socket had successful results in 94% of the cases analyzed. In our case, the use of the palatal approach preserved the buccal wall of the socket, which was filled only with the clot, and kept in place by the edge of the provisional prosthesis itself.[28]

One of the advantages of immediate loading is the restoration of function and esthetics immediately after surgery. Moreover, the adjacent gingival papillae are preserved and a second surgery is not necessary.[9] Also, the use of a removable provisional prosthesis for a long time while

waiting for rehabilitation with a permanent prosthesis may be a problem, but not when the technique described here is used, because the provisional prosthesis is inserted and fixed immediately after surgery. In the clinical case described here, there was an important psychological gain as the use of a partial removable prosthesis was avoided (one of the patient's demands).

Screw-retained provisional crowns may be used in the anterior and posterior maxilla, but cemented crowns are preferred for the anterior maxilla due to the inclination of the premaxilla and the fact that the retention screw may transverse the buccal surface of the tooth. Therefore, we chose implant temporization using the crown of the freshly extracted natural tooth cemented to a provisional abutment. There was an important esthetic gain because the natural gingival contour was preserved. Moreover, the provisional crown served as a model to fabricate the definitive crown after osseointegration was consolidated.

This clinical case showed that using the crown of a tooth with root fracture to fabricate its provisional prosthesis is one of the several possible alternatives for temporization. The preservation of esthetics, as well as of the characteristics of adjacent teeth and of gingival harmony, produced good results, facilitated fabrication of the definitive prosthesis and did not affect the individual characteristics of the patient's smile.

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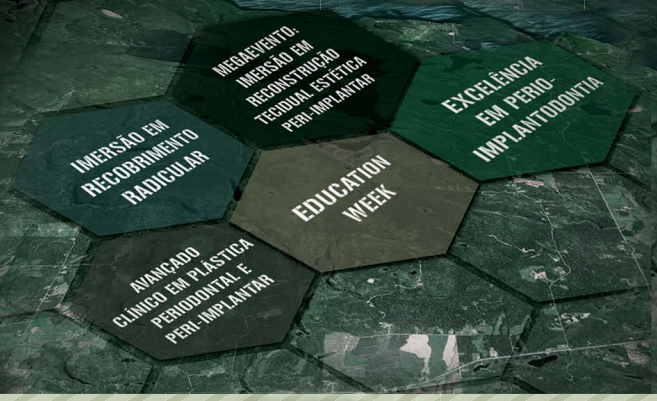

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Surgical maxillary expansion anchored on dental implants: Case report

Marcelo de **WALLAU***
Carlos Fernando R. **CARDOSO****
João Batista **BURZLAFF*****

Abstract

One of the most common transverse discrepancies and a frequent dentofacial abnormality is the transverse maxillary deficiency. Rapid maxillary expansion (RME) is the indicated treatment in these cases, but satisfactory anchorage is difficult to obtain in partially edentulous adult patients, which is a frequent contraindication for this type of orthodontic treatment. This study reviewed previous researches about surgically assisted methods of orthopedic expansion of the maxilla using dental implants as anchorage, and described a clinical case, in which two titanium implants were placed in the edentulous segment and a Hyrax expander was cemented to the provisional crowns, following a protocol described in the literature. Titanium implants remained stable and osseointegrated when forces were applied, which suggests that they may be suitable for orthodontic anchorage and support for maxillary expansion.

Keywords: Orthodontic anchorage. Dental implants. Rapid maxillary expansion.

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Introduction

Osseointegrated implants have proven to be a valuable tool in the treatment of some orthodontic conditions, particularly because an increasing number of adult patients, who have often lost one or more teeth, have sought orthodontic treatment. The use of implants to promote orthodontic movement has been reported regularly in the literature for over 40 years. Currently, the Bränemark system is commonly used when there are edentulous segments in patients that require orthodontic anchorage.[1]

Osseointegrated implants are similar to ankylosed teeth, which do not move when submitted to orthodontic forces. Therefore, they can be used as stable anchorage, as the absence of a periodontal ligament ensures that there will be no cell changes, which would, otherwise, result from tooth movement.

The indicated treatment for transverse maxillary deficiencies, dentofacial anomalies often seen in dental clinics, is rapid maxillary expansion (RME) using Hass or Hyrax expanders.[12]

The results of nonsurgical rapid maxillary expansion in adults are less than satisfactory, because their skeletal maturation reduces the response to expansion forces. Multiple missing teeth, severe buccal dentoalveolar inclinations, gingival recession, alveolar bone loss and mobility of maxillary posterior teeth are contraindications to rapid maxillary expansion in adults. These cases require maxillary osteotomies as an adjunct to expansion.[3]

The tooth-borne Hyrax expander — the appliance of choice in cases of surgically assisted rapid maxillary expansion (SARME) — is easy to clean, does not cause ulcers or erythema in the palatal mucosa, and does not affect the vascularization of maxillary bones.[13]

Before the development of dental implants, maxillary expansion was contraindicated for partially or totally edentulous patients because of the lack of teeth for anchorage. The need of anchorage is one of the greatest limitations in orthodontic treatments, as teeth have to move in response to the forces applied. Implants used as orthodontic anchorage are now a reality.

This study highlights the importance of a multidisciplinary approach, particularly including orthodontics, implantology and prosthetics, which ensures proper anchorage to movement teeth, correcting their position before prosthetic treatments; and the use of implants and abutments for prosthetic rehabilitation. High success rates have been achieved with this approach, and treatment results present long-term stability.[7,11,17]

This study describes surgically assisted maxillary expansion with tooth anchorage and discusses treatment advantages and efficacy based on a brief review of the literature and a clinical case report.

Clinical case report

A 42-year-old woman presented with transverse maxillary deficiency and bilateral posterior crossbite. Her partially edentulous maxilla precluded the use of a tooth-borne expander. She had a deviation of the maxillary dental midline, and one of her main complaints was the difficulty to breathe through the nose, probably due to maxillary deficiency (Figs 1 and 2).

Multidisciplinary treatment planning identified the need to restore function and esthetics, which were compromised because many teeth were missing. A surgically assisted orthodontic correction was chosen for rapid maxillary expansion. The expander had to be anchored at two different points in each half of the maxilla,

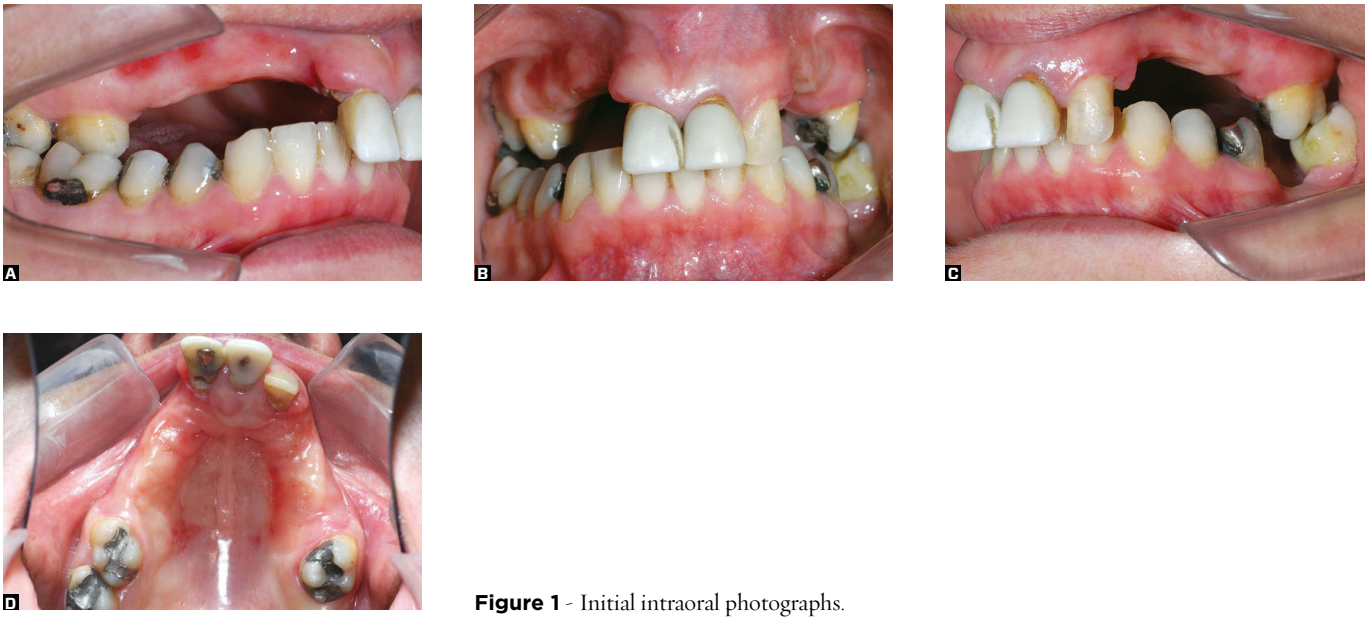

Figure 1 - Initial intraoral photographs.

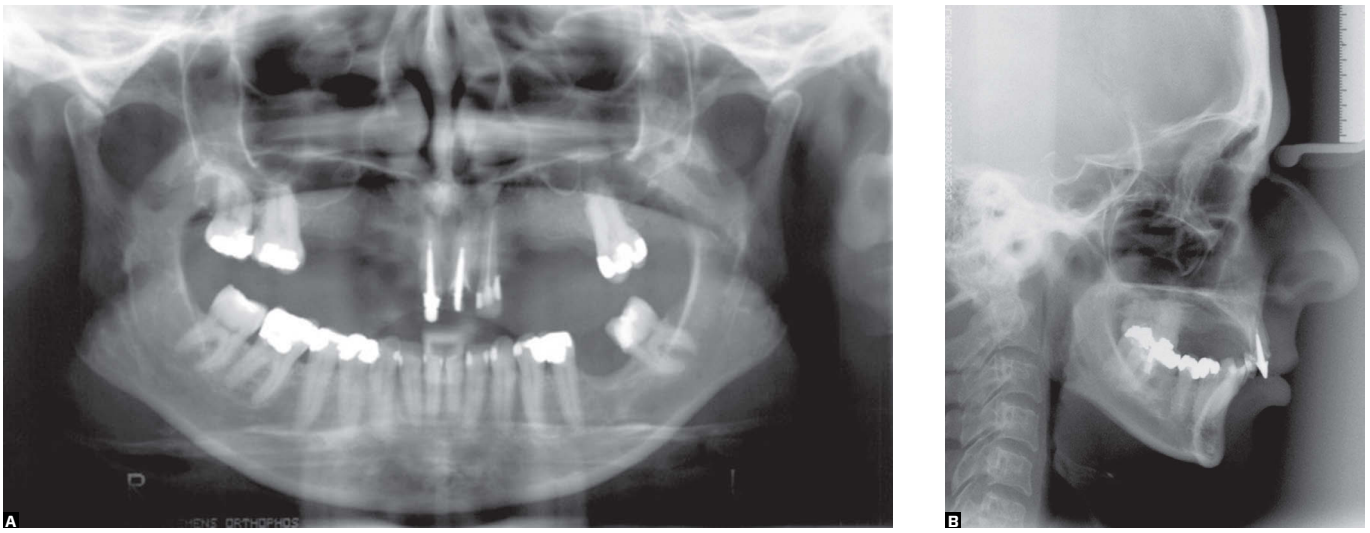

Figure 2 - Initial radiographs.

one in the anterior region, at the level of the first premolar, and another in a more posterior area, in the region of the first or second maxillary molar. Some of the maxillary teeth were missing, and satisfactory intraoral anchorage would not be possible. Therefore, two osseointegrated implants were placed in the region of the left and right maxillary canine and premolar, to be used as fixed anchorage for the expander. The treatment was then planned and conducted according to the following stages.

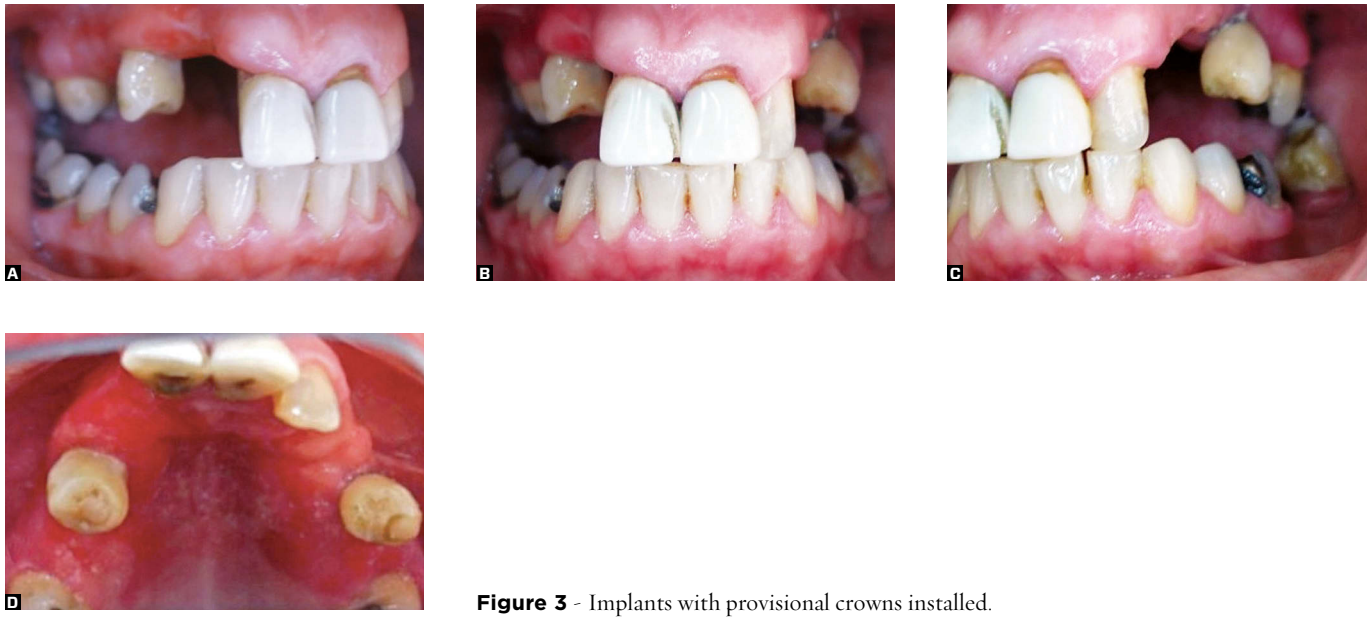

Figure 3 - Implants with provisional crowns installed.

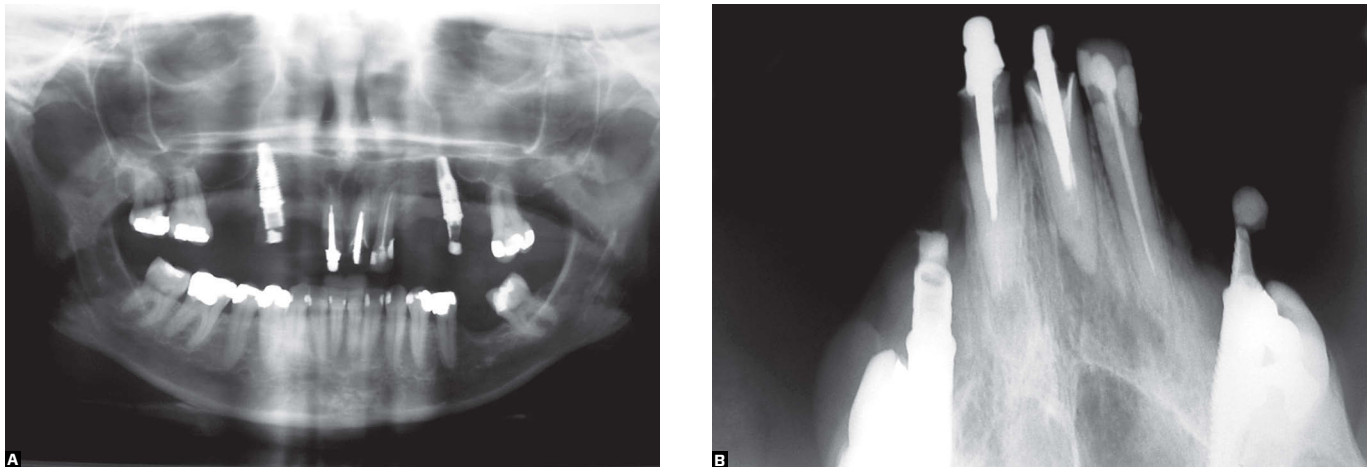

Figure 4 - Radiograph of implants with provisional crowns installed.

Placement of two dental implants in the right and left sides of the maxilla

As the patient did not have premolars and canines in either side, first we placed two dental implants in the region of teeth #13 and #25. The implants were positioned at sites where there were better bone conditions. The implants (Neodent, Alvim II Plus) were 4.3 mm in diameter and 10 mm long.

After three months of osseointegration, the implants were exposed again for the placement of the abutments and the temporary crowns (Figs 3 and 4).

Placement of expander and surgery to expand maxilla

The Hyrax expander was anchored using the two implants (region of teeth #13 and #25) and the teeth #16 and #27, and then the patient was referred to maxillary surgery. The high degree of integration between bone and the titanium implants provided the adequate stability for the anchorage of the expander.

The surgery was conducted in a hospital with the patient under general anesthesia. For the surgically assisted maxillary expansion, it was used a procedure similar to the Le Fort 1 osteotomy, and an osteotome was used for the immediate opening of the midpalatal suture (Fig 5). At this point, the expanding screw was activated three full turns. The appearance of a diastema between maxillary central incisors clinically confirmed the expansion.

Expander activation was resumed on the seventh postoperative day; the patient received instructions to activate the expander one full turn everyday (2/4 in the morning and 2/4 in the evening) until the transverse deficiency was overcorrected and the lingual tip of the maxillary cusps touched the buccal tip of the mandibular cusps. After the third full turn of the screw, incisors received the impact of maxillary expansion, characterized, from that point on, by a direct relation between the size of the diastema between incisors and the amount of orthopedic effect induced by expansion (Fig 6).

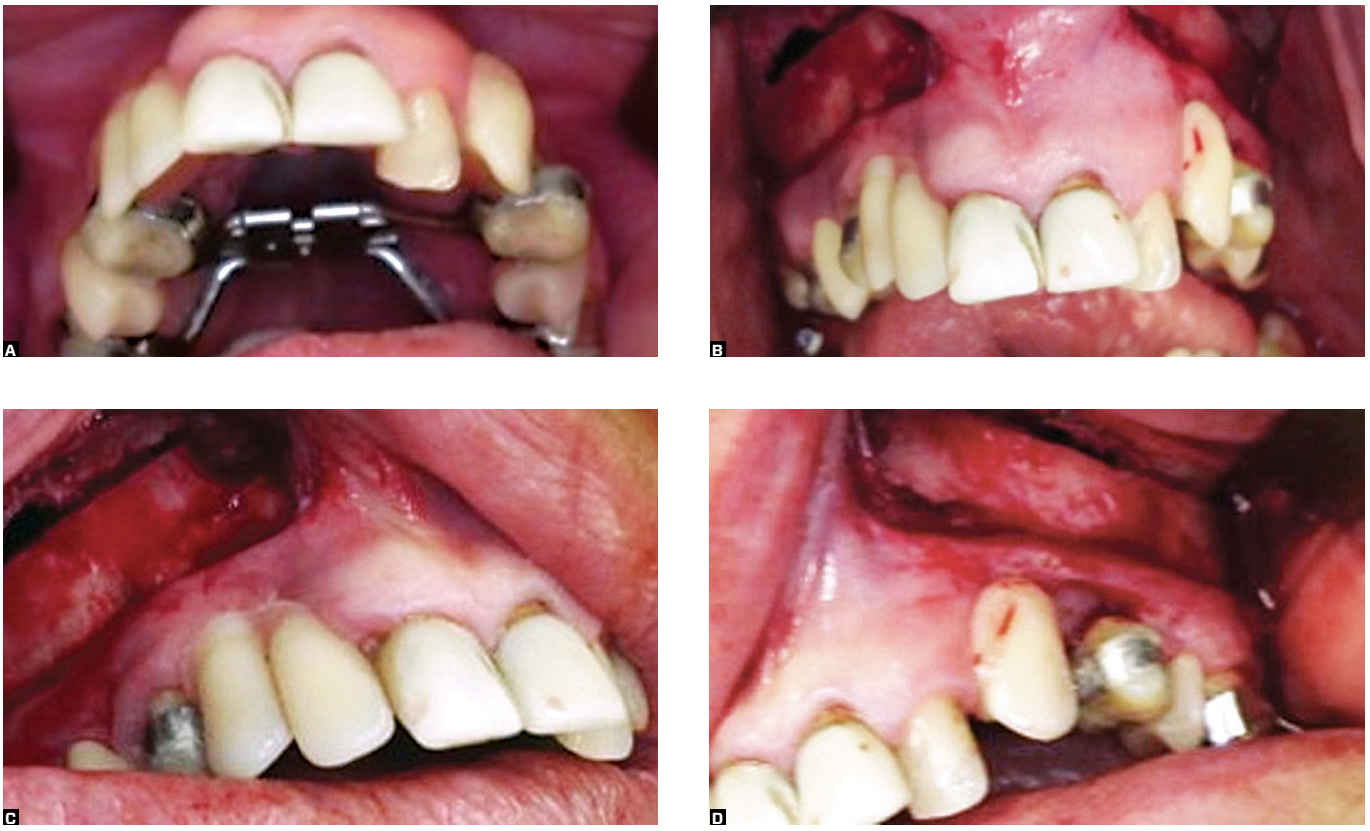

Figure 5 - Osteotomies in the maxillary expansion surgery.

After 14 days of expansion, the screw was locked and remained in the mouth as a passive retainer for another four months, the time necessary for new bone formation in the midpalatal suture. The expected expansion of 12 mm was achieved. The implants did not move and there was no pain.

The comparison of clinical findings and photographs confirmed the success of maxillary expansion using implant and tooth anchorage (Figs 7 and 8).

Orthodontic treatment with fixed appliances

The Hyrax expander was removed four months after the screw was locked, and the orthodontic treatment was completed using a fixed appliance in both maxilla and mandible. Maxillary teeth were moved using anchorage on the two implants, which remained stable and osseointegrated. Twenty months later, the fixed appliance was removed, and the patient received a removable maxillary retainer (Fig 9).

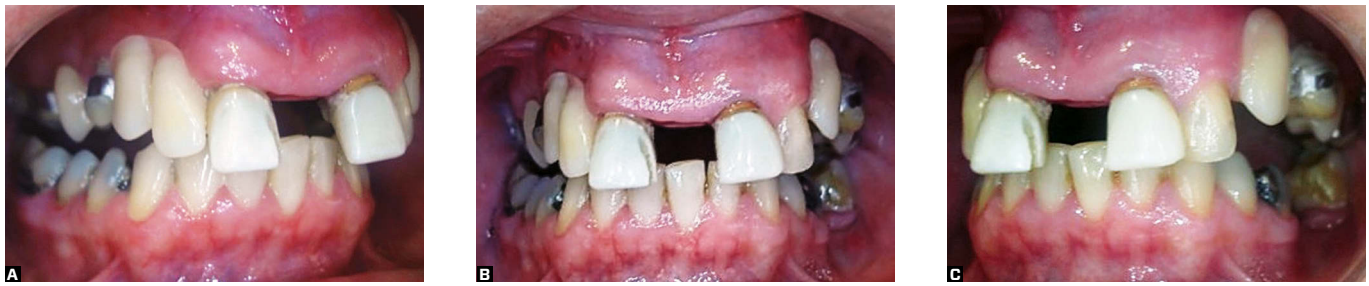

Figure 6 - Expanded maxilla, 30 days after surgery.

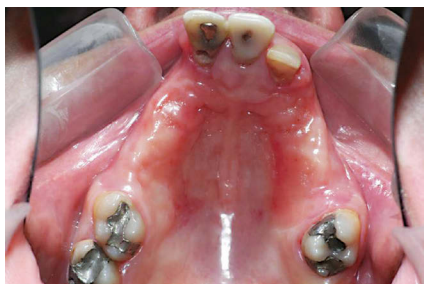

Figure 7 - Initial occlusal photograph.

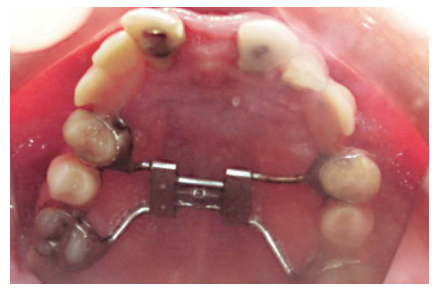

Figure 8 - Occlusal photograph after expansion.

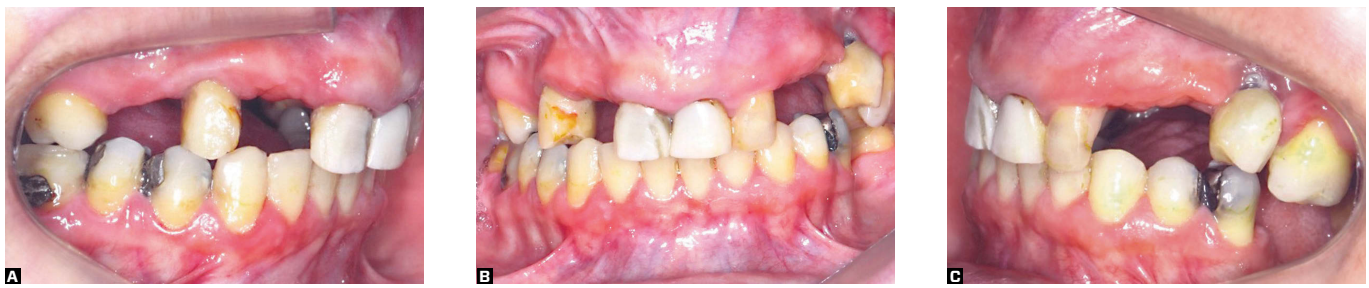

Figure 9 - Finished orthodontic treatment.

Placement of implants in edentulous regions and definitive restorations in remaining spaces

Implants (Alvim Cone Morse, Neodent) 3.5 mm in diameter and 10 mm long were placed in the region of teeth #12 and #23. Biomaterials (BoneCeramic™, Straumann, Andover, MA) were placed in the buccal areas of the ridge and covered with resorbable membranes (Gen Derm™, Baumer).

Healing caps were used for three months to allow for osseointegration.

After that time, the definitive ceramic crowns were manufactured.

At treatment completion, radiographs were obtained to confirm results and, mainly, to check whether implant osseointegration was satisfactory (Figs 10 and 11).

Figure 10 - Final intraoral photographs.

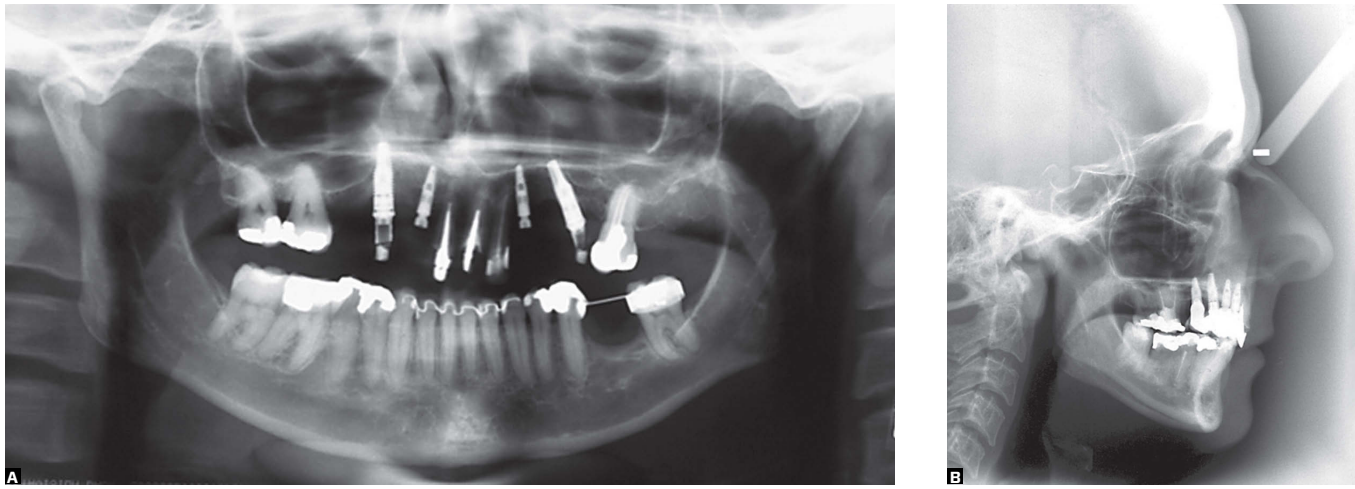

Figure 11 - Final radiographs.

Discussion

The excellent integration between bone and titanium implants provides suitable stability for the anchorage of an expander in orthodontic treatments. One of the main advantages of implants is their performance in conditions that require maximum anchorage, particularly in cases of patients with posterior edentulous segments.[5,16] Implants are also indicated when, in addition to serving as anchorage, they can later be used as abutments during the final stage of the orthodontic treatment.[11] In this case, the implant site should be carefully planned by the prosthetist. The implantologist and the orthodontist should share information to achieve a satisfactory result.

Dental implants ensure patient comfort, better esthetic results, faster treatment (because forces are applied for a shorter time), easy placement, great stability and the use of different activation rates.[6,19]

The clinical case described here confirmed what previous publications had already demonstrated, that is, that implants may be used as orthodontic anchorage without any peri-implant bone loss or loss of osseointegration. Implants in edentulous posterior segments can be used for fixed intraoral anchorage, and the orthodontic forces applied on them are directly transmitted to the peri-implant bone.[7,8,15]

Several types of implants and materials have been used by numerous authors, but most studies have been conducted with titanium implants: Orthosystem, Onplant, Sas, Gips, mini-implants, miniscrews, microimplants, titanium abutments, bicortical screws and osseointegrated implants currently used for prosthetic rehabilitation.[1,5,10]

Higuchi and Slack[14] and Ödman[18] studied the use of implants in human beings and found that there should be a time interval after implant placement to achieve ideal clinical and histological results. In their studies, orthodontic movements were always achieved and osseointegration was preserved until the treatment was complete.

A clinical pilot study[20] with six patients used endosseous implants as anchorage and a three-month interval before the beginning of the active phase of the treatment. During the nine months of the active phase, there were no signs of mobility or inflammation. Our study confirmed those findings.

The treatment of transverse maxillary deficiency using rapid maxillary expansion (RME) has been evaluated in several clinical and experimental studies, and RME has become a routine method for growing patients. In addition to increasing the maxilla transversely, RME also increase the nasal cavity width, which results in better air flow.

In adults, RME has limitations and complications, such as the resistance to expansion, little or no opening of the midpalatal suture, predominance of dentoalveolar expansion over transverse bone gains, excessive buccal tipping and extrusion of posterior maxillary teeth, absorption of buccal cortical bone, gingival recession, pain, edema, ulcers and ischemia of the palatal mucosa, besides a high relapse rate.[3] To avoid such complications, the treatment of choice is the surgically assisted maxillary expansion.

Expander anchorage using rigid implants has a number of advantages, such as preventing tipping of the teeth used as anchorage for the expander. Also, all the forces released by the activation of the screw are transferred to the separation of the intermaxillary suture. Other advantages, in addition to greater orthopedic effect, are the transverse increase of the maxilla, the reduction of relapses, and a consequent long-term stability.[2,9]

Maxillary expansion anchored on teeth results in a certain amount of buccal bone resorption, as well as greater risk of gingival recession. The teeth that anchor the expander move along the alveolar bone, and not together with it. These unwanted side effects may be avoided with the use of implant anchorage. Posterior teeth remain centralized in the alveolar ridge, and the periodontal anatomy is preserved, which promotes the health of the anchorage system and protects teeth in the long term.

No sign of mobility or inflammation around the implants was found during and after the treatment of this clinical case. The patient was very happy with the results achieved by the multidisciplinary team, and her esthetic, functional and respiratory conditions improved.

Conclusions

The description and analysis of this clinical case, together with our review of the literature, suggest that:

1) The benefits for the patient may be significant when the orthodontist coordinates tooth movements and implants, orthognathic surgery and prosthetic treatment to achieve all the treatment objectives.
2) The high degree of integration between bone and the titanium implants provides adequate stability for anchorage in orthodontics.
3) Basic conditions, such as the selection of implant placement site, bone quality, adjacent anatomic structures, implant size and the time necessary for osseointegration, should be considered in the analysis of demands for stability and effectiveness in receiving the forces that are applied to the implants.
4) The technique described in this study for maxillary expansion using dental implant anchorage led to a high degree of success for the treatment planned.
5) Osseointegrated titanium implants may be used as abutments for prosthetic rehabilitation after orthodontic treatment.

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Root coverage with laterally positioned flap

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Abstract

Gingival recession is a common clinical condition that brings esthetic discomfort, sensitivity, among other problems. Looking for a satisfactory outcomes both esthetically and functionally, several techniques have been proposed to root coverage, including the laterally positioned flap — which is a pedicle graft technique that, despite some limitations and a few indications, may achieve good outcomes in some cases. Due to the lack of predictability, the treatment of class III gingival recession is considered a major challenge for dental professionals; thus in the case reported in this paper, we aimed the root coverage in a class III by means of the laterally positioned flap technique.

Keywords: Gingival recession. Periodontics. Dentin sensitivity.

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Introduction

Gingival recession is defined as an apical migration of the gingival margin in relation to the cementoenamel junction (CEJ). Gingival recession may cause the patient to feel esthetic discomfort and dentin hipersensitivity.[1]

There are several techniques with the purpose of achieve the coverage of exposed root surfaces.[2] The main indications to mucogingival procedures for root protection are: Increase of keratinized tissue,[3] root coverage,[2] correction of edentulous ridges,[4] peri-implant correction,[5] biological dressing,[5] aid to maxillofacial surgery,[6] adjunctive frenulectomy[7] and to increase keratinized tissue and prevent gingival recessions in orthodontic movements.[8] The presence of an alveolar bone dehiscence is considered a prerequisite for the development of a marginal tissue recession.[8]

The choice of a repositioned flap may lead to improved esthetic conditions, gingiva rearrangement, reduced root sensitivity, but also may present limitations, such as: shallow vestibule, little attached gingiva and wide recessions, with prominent roots.[9]

The elimination of some likely etiological factors — as traumatic brushing, local irritants such as calculus, improperly adapted restorations, misplaced orthodontic bands — and the adoption of a strict and proper plaque control, with adjustments on the brushing technique, may stabilize a gingival recession in the long-term.[10]

However, when the desired increase of attached gingiva is not obtained, it may be necessary to perform an additional surgery,[11] such as the lateral positioning of the flap. Thus, this paper objective was to describe a case where root coverage was achieved with laterally positioned flap.

Case report

In this case report, a 27-years-old female patient, with good general health, searched for assistance complaining of esthetic dissatisfaction. On clinical examination it was found chronic periodontal disease in a few sites and the presence of an isolated gingival recession in tooth #23, classified as Müller class III[12] (Figs 1 and 2). According to the patient's report, it was performed a periodontal surgery in the area about a year before, which certainly

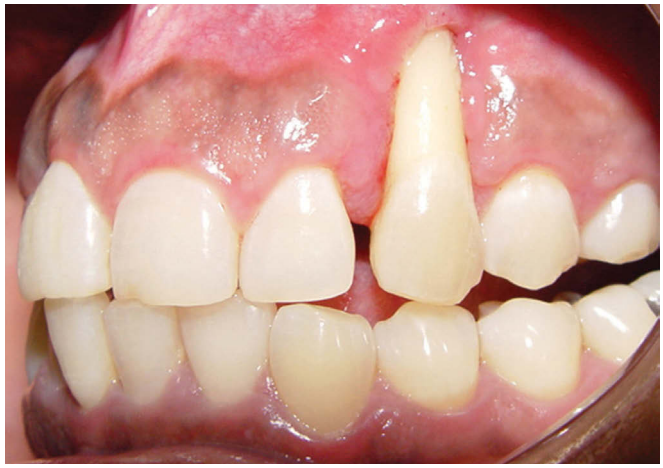

Figure 1 - Initial clinical aspect. Note deep gingival recession in #23 tooth.

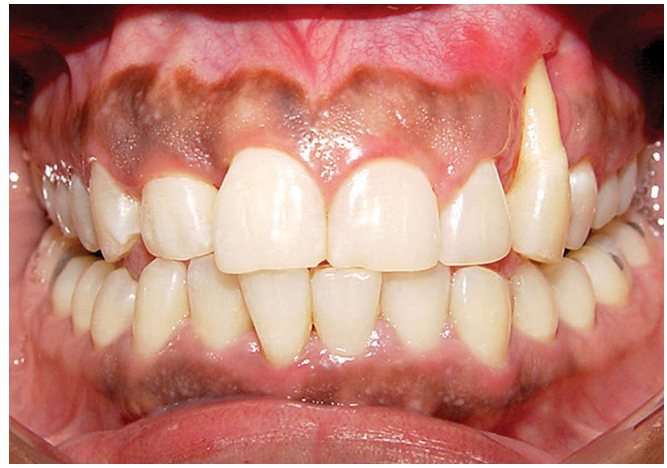

Figure 2 - Initial frontal photograph showing gingival Müller class III gingival recession.

contributed to this recession. Endodontic treatment of tooth #23 was also performed prior to this surgery.

Due to the extent of root surface exposed and the lack of attached gingiva in the buccal area, surgical planning was directed to the laterally positioned flap, in order to obtain tissue to cover the root and, hence, connective tissue graft (Fig 4).

Previously to the surgery, the patient received basic periodontal therapy. At the receiving area, it was performed infiltrative anesthesia, intra-sulcular incision in the tooth #23, while maintaining a strip of attached gingiva[13] in the teeth #24 and #25, associated to relaxing incisions with detachment of a partial flap. The root of the tooth #23 was carefully scraped using Gracey curette 5-6 (Hu-Friedy).

In the donor area, anesthesia was performed and then removed a full-thickness graft. This area was calculated in millimeters with a periodontal probe. The donor tissue was removed from the region of the palate with an extension from the canine to the mesial area of the first molar (Fig 3). The removed graft was compressed in the receiving area for about 3 minutes and then stabilized with interrupted sutures of 6.0 Vicryl wire. The flap was stabilized with continuous sling sutures in the element #23 and with simple suture with Vicryl 6.0 and Silk 4.0 on the other areas (Ethicon) (Fig 5). In the donor area simple sutures and the application of surgical cement (Coe-Pack®) was also performed.

Anti-inflammatory and analgesic were prescribed as postoperative care, besides mouthwash with 0.12% chlorhexidine gluconate, twice daily to control plaque up to seven days. The sutures were removed 15 days after surgery.

Clinical follow-up after 21 days (Fig 6) and then after 3, 6 and 12 months (Figs 6, 7, 8 and 9) show maintenance of tissue stability, suggesting the functional and esthetic effectivity of the therapy. In Figure 10, an approximate view of the whole case, which allow us to observe the results over the 12 months of treatment.

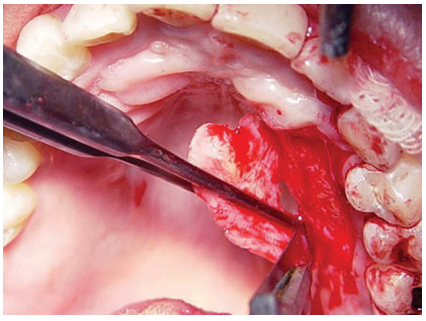

Figure 3 - A 15 mm graft was removed from the palate region.

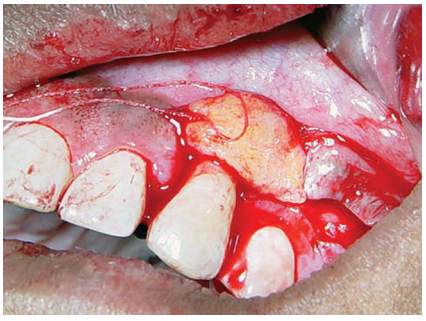

Figure 4 - Graft stabilized in the receiving area with sutures.

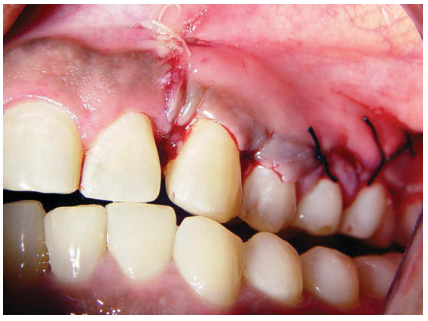

Figure 5 - Sutures performed after laterally positioned flap procedure.

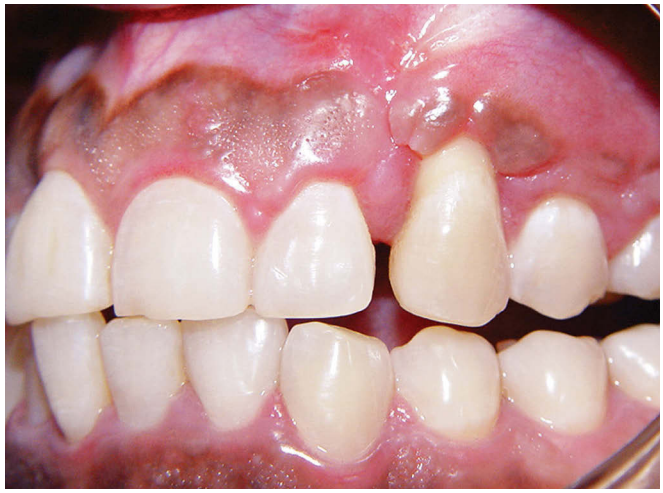

Figure 6 - Aspect of tissue healing after 21 days.

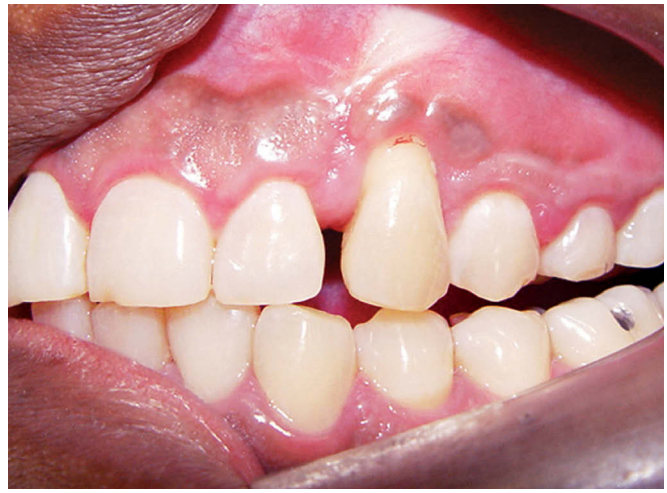

Figure 7 - Aspect after 03 months. Note mild bleeding and plaque accumulation in the element. The patient was instructed to intensify the oral hygiene.

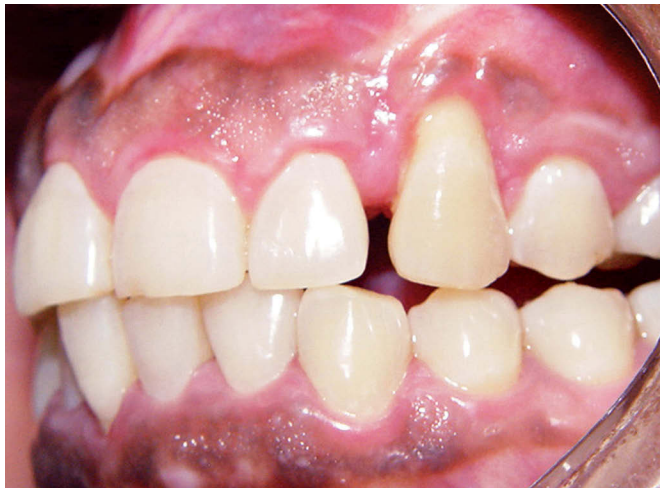

Figure 8 - Aspect after 6 months.

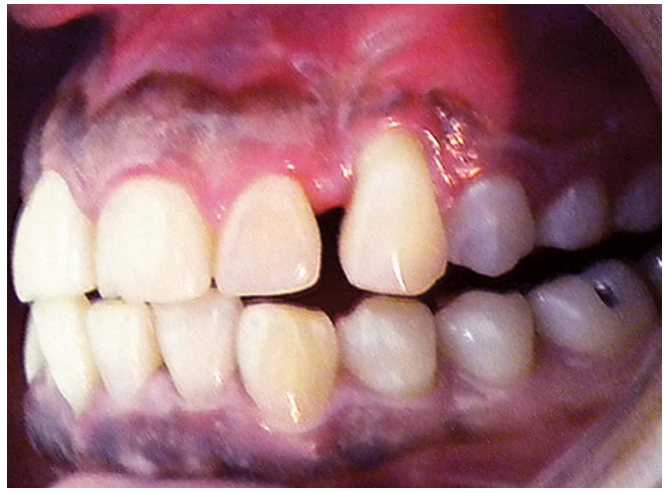

Figure 9 - Final aspect, after 12 months.

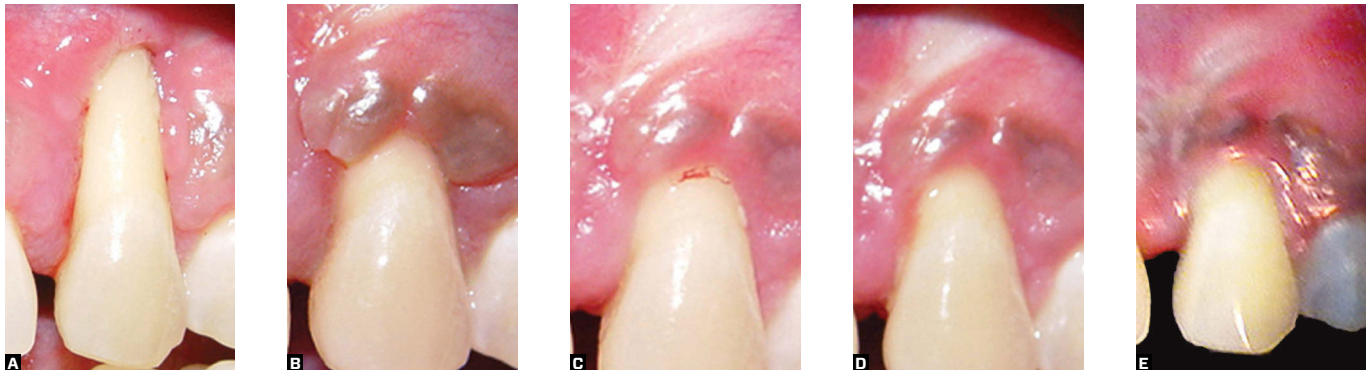

Figure 10 - Close-up views: **A**) Initial, **B**) after 21 days, **C**) after 3 months, **D**) after 6 months and **E**) after 12 months.

Discussion

In this case reported, the patient had a complex recession in the tooth #23 due to loss of keratinized tissue including interproximal loss. It was a class III recession according to Müller classification[12], in which marginal tissue recession occurs, and extends to or beyond the mucogingival junction; and loss of interdental bone or soft tissue is apical in relation to the cementoenamel junction, but coronal to the apical extension of the marginal tissue retraction, thus generating a prediction of partial root coverage. A combination of techniques was indicated as having the best prognosis for this case. The root coverage in this case is in accordance with the literature,[14] where only partial coverage of the recession was achieved in a Müller[12] class III defect, independently of the technique performed.[15]

The type of root coverage performed in this case promote several advantages to the recession as esthetic improvement in the region, greater protection against root abrasion, besides reduction of dentin hypersensitivity reported by the patient. However, only classes I and II recessions have predictability of covering 100% of the root by means of surgical techniques. Class III recessions have predictability of partial coverage and Class IV has no predictability for covering.

In many cases, more than one procedure is necessary for the treatment of gingival recession, as in this case reported. Consequently, the combination of two or more procedures have been increasingly used to provide best results.[16,17] According to the literature,[18] several factors can influence the level of success of each procedure, and the most important to be considered are the interproximal bone level and the selection of the most suitable technique for each particular case.

This case report is in accordance with a recent case report[19] of a Müller class III, where the authors describe the simultaneous application of a combination of three techniques, including: A connective tissue graft and a laterally positioned flap to treat a Müller class III recession located in the anterior inferior region. Twelve months after the surgical procedures, there was partial root coverage with favorable esthetic results and a gain in clinical attachment level, without any periodontal pockets and bleeding on probing.

In two other cases of gingival recession[20] in the area of central incisors, with absence of keratinized mucosa, the authors reported that the use of free gingival graft — despite its limited use in esthetic conditions and generating postoperative discomfort by exposing an open wound in the donor area — provided excellent functional results, promoted efficient attached gingiva and allowed, with the aid of creeping attachment, root coverage that generated esthetic improvement and reduction of tooth sensitivity. In the present case, it was decided for the subepithelial connective tissue graft because it allows a very good final esthetic result, predictability of root coverage, reduction of probing depth, clinical attachment gain and gain in keratinized tissue.[10]

Among the places most suitable for obtaining connective tissues are: The palate, the tuberosity and the edentulous ridge, but no doubt, the most commonly used as a donor area is the hard palate, as in this case.[13,16] In this case it was applied the subepithelial connective tissue graft technique,[21] which is considered a usual technique for the removal of palatal tissue, where the removed graft is placed on the exposed roots.

One study evaluating 28 patients over 8 years observed possible clinical changes that occur in the buccal gingival wall of donors teeth in the treatment of localized gingival recessions with laterally positioned flap. The authors noted that donors teeth had small and predictable undesirable results, with decreased range of keratinized gingiva, increased recession in a few teeth,

and clinical attachment loss even smaller without interfering plaque and gingival indexes. The authors emphasize that the technique should be properly indicated and performed, and if possible it should be kept a small strip of gingiva in the cervical region of the donor tooth,[13] which was performed in the present case in the vestibular region of teeth #24 and #25.

The free gingival graft is still considered the most appropriate technique when the aim is to increase the width of attached gingiva.[22] However, the technique of connective tissue graft, despite needing more than one surgical site, proves to be quite efficient and advantageous because of its high predictability, the absence of keloid, double blood supply and healing by first intention.[16] Thus, choosing the technique is a crucial moment and it should takes into account all aspects of the recession — as the width, height and thickness of adjacent gingiva, and depth of the vestibule on the region — as well as patients expectation, and even their financial condition.[19] In this case, the choice was influenced by the absence of attached gingiva on the buccal region and because it was a very extensive recession.

According to the recent literature,[3,8,23] for root coverage, the connective tissue graft technique with coronal repositioning is the most appropriate and with greater predictability, generating less strain on the flap. However in this case it was observed that the technique of laterally positioned flap generated a satisfactory result. This result corroborates findings in the classic scientific literature,[24-29] where the authors found better results using the laterally moved flap.

Conclusion

As it can be noted in the reported case, class III gingival recession may alternatively be treated by means of a surgical intervention to achieve root coverage. It should be emphasized the importance of evaluating the extent of the recession and the patient expectation before selecting the most suitable technique for the case, pointing out the importance of taking into account the indications, contraindications and limitations of each technique. Still, it should be emphasized that early diagnosis and instructions on oral hygiene may favor non-surgical conservative procedures, and prevent the progression of gingival recession.

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Switching platform on esthetic area: Case report

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Guilherme da Gama **RAMOS*****
Danilo Lazzari **CIOTTI******
Leonardo **BUSO*******

Abstract

The cervical bone remodeling around implants with conventional platform, known as saucerization, may compromise the maintenance of peri-implant hard and soft tissues, leading to esthetic impairments such as recessions and/or loss of papillae. The concept of platform switching with an inner placement of the implant-abutment junction, increasing the distance between bone and prosthetic platform, seems to minimize and/or block this bone resorption. The present paper has the purpose of presenting a clinical case report of previous esthetic rehabilitation using a platform switching implant associated to peri-implant plastic resources and peri-implants prosthesis that would maximize the final result. The clinical and radiographic results show preservation of proximal bone crest and papillae, maintenance of the soft tissue thickness and appropriate final esthetic result. Choosing implants with these characteristics of platform switching may be favorable in esthetic areas.

Keywords: Implants. Tooth structure. Prosthesis. Supporting tooth. Bone resorption.

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Introduction

The implants with conventional platform, where the diameter of the implant is the same as of the prosthetic platform, were widely used in dentistry. Unfortunately it was found a cervical bone remodeling around these implants, between 1.5 and 2 mm vertically and 1.3 and 1.4 mm horizontally, on the first year of exposition to oral environment, placement of healer or abutment. This remodeling received the name of saucerization.[7,11,14,16,17] Many studies were done to find out how this saucerization occurs and if these factors could be present at the same time. Among them it is found the establishment of the peri-implant biological space,[6,14,15] stress forces generated by the abutment movimentation[6,11,15] establishment of the inflammatory infiltrate, bacterial colonization of the microgap existing on the implant-abutment junction[6,14] and the bacterial colonization of the peri-implant sulcus.[6]

A new concept or approach on the placement of prosthetic platform in relation to the implant trying to overcome these problems appeared and became known as Platform Switching. It uses the horizontal displacement of the bone abutment-implant junction through the use of abutments with smaller diameter than the implant diameter,[9,11,13,16,17] occurring the separation of the cervical bone in relation to the inflammatory infiltrate and microgap of contamination of the implant-abutment junction. There is great discussion about which are the necessary parameters to obtain good peri-implant esthetics, either in cases of unitary or adjacent implants. The correct placement and the presence of enough volumes of hard and soft tissues must allow the stability of soft tissues in harmony for a long time, so that there is presence of interproximal papilla and maintenance of the stable gingival magin,[17] ensuring the harmony of peri-implant tissues in relation to natural adjacent teeth, besides an adequate rehabilitation observing the anatomic aspects of adjacent teeth as for shape, texture, contour, position, color and also characteristics of the gingival architecture.[2]

The objective of this paper is to report a clinical case in which it was used an implant with platform switching approach and cone morse prosthetic connection in anterior superior esthetic region.

Clinical case report

Female patient sought the Specialization Course in Implantology of APCD/Piracicaba complaining about fracture and loss of tooth #11, extracted about 3 weeks before (Figs 1 and 2). During anamnesis it was not found any type of history of preexisting systemic disease, the patient was non-smoking and had an adequate plaque control.

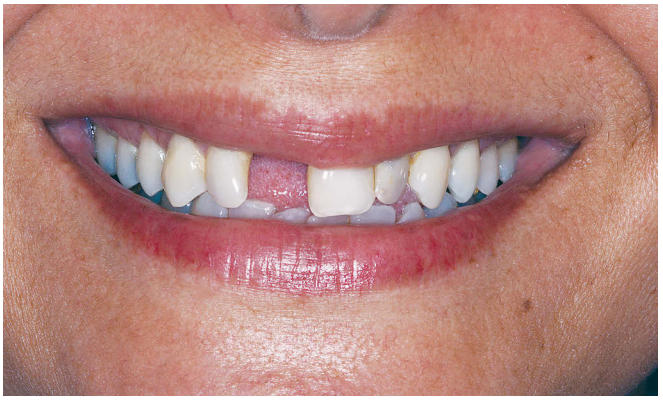

Figure 1 - Initial photograph of the patient smiling.

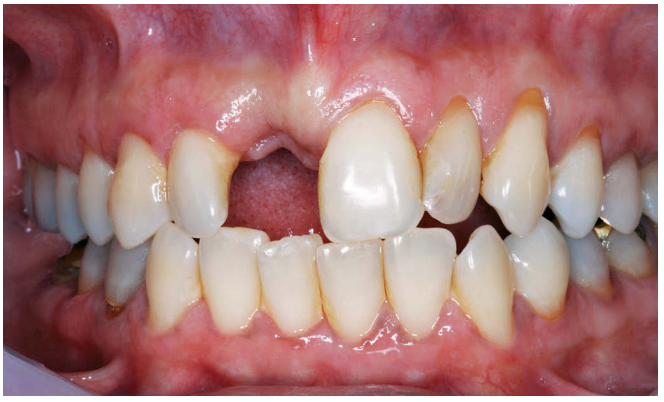

Figure 2 - Frontal photograph of the patient in occlusion.

The clinical examination suggested that the ridge presented enough thickness for the installation of an implant of reduced diameter and that the periodontal biotype was intermediate with a slight depression on the buccal face of the ridge (Figs 3 and 4). Through panoramic and periapical radiographic exam it was found that even with slight bone remodeling in height and little loss of proximal bone crests, there was enough mesiodistal and cervico-occlusal space for installation of an implant in an early approach (Fig 5).

The surgery for implant installation was performed under local infiltrative anesthesia (lidocaine with epinephrine 1:100000). A supra-crystal incision slightly turned to palatine and intrasulcular extensions on the proximal and buccal faces of the adjacent teeth were performed, followed by total detachment of the buccal fold until all the bone wall could be seen. It was verified that the alveolus was partially healed. Then, it was installed an implant Ankylos® with 3.5 mm in diameter and 9.5 mm in height. It was placed 3 mm apical in relation to the cementoenamel junction of adjacent teeth (Figs 6, 7 and 8).

A graft of palatal conjunctive tissue was removed and stabilized under the buccal fold through simple sutures (Fig 9). Even with good stability, the cervical screws of the implant on buccal face were exposed after milling, needing guided bone regeneration using Bio-Oss and a collagen membrane over the biomaterial (Fig 10). The implant was immersed and the fold was replaced and sutured with simple sutures (Fig 11).

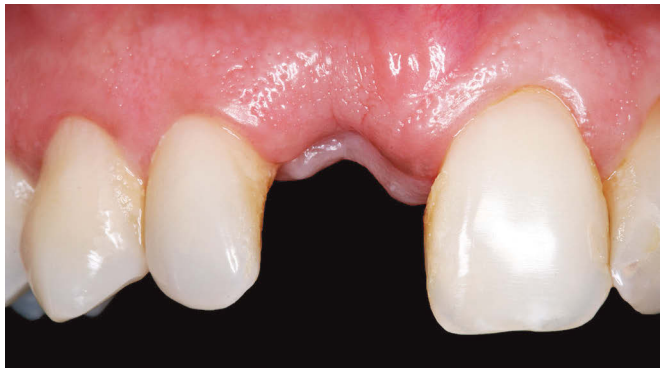

Figure 3 - Absence of the proximal papillae.

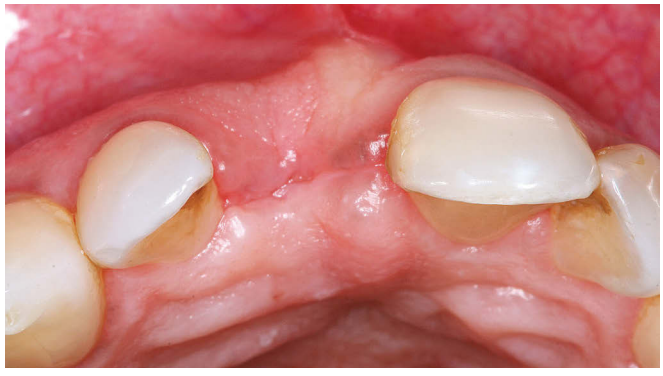

Figure 4 - Occlusal view, tissue depression in thickness.

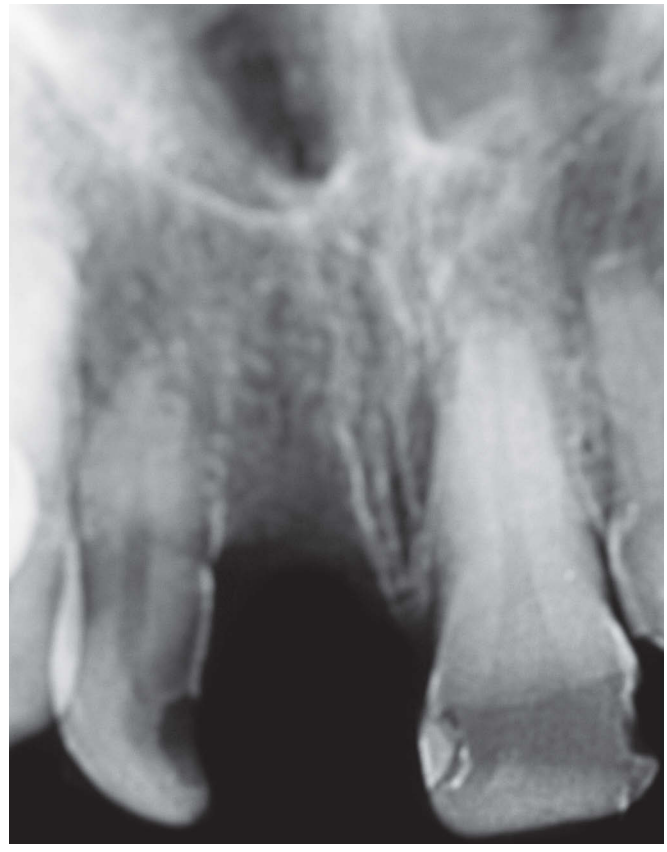

Figure 5 - Initial radiograph.

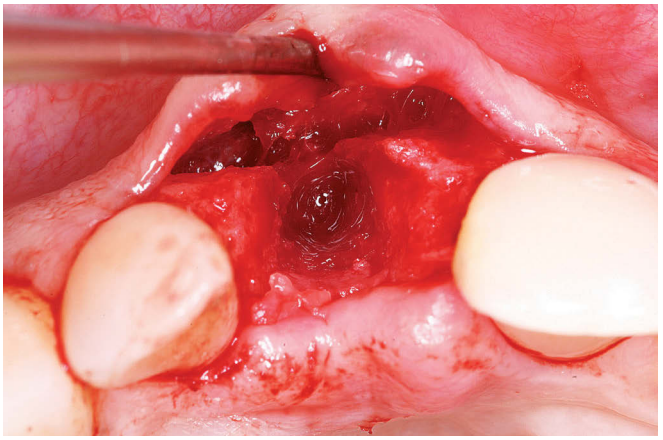

Figure 6 - Inspection of the ridge after lifting of the fold.

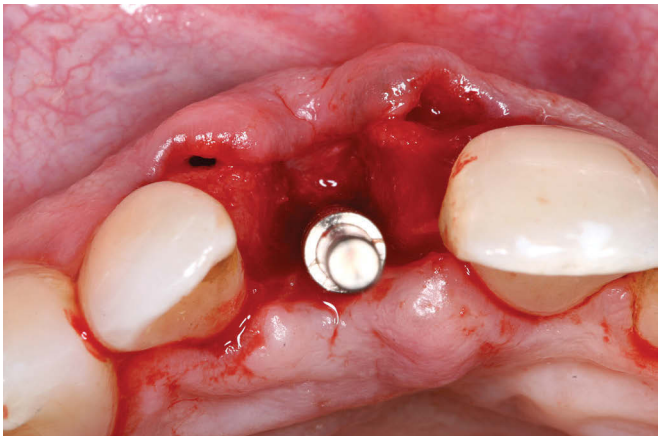

Figure 7 - Parallel pin in position.

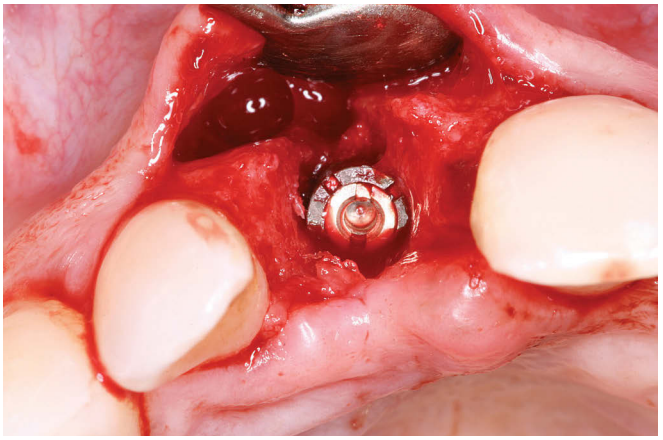

Figure 8 - Implant already installed and buccal bone dehiscence.

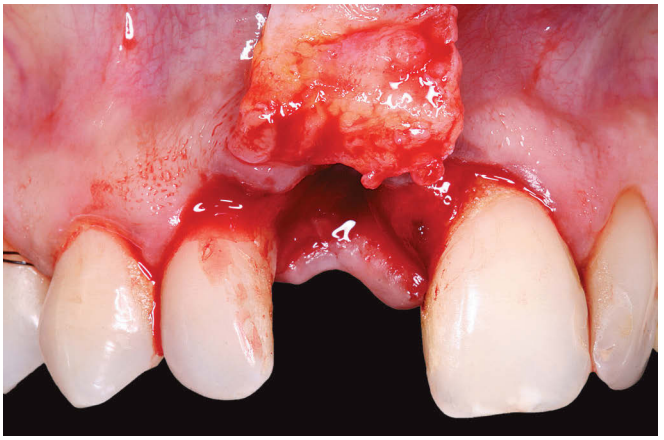

Figure 9 - Test of the placement of subepithelial graft.

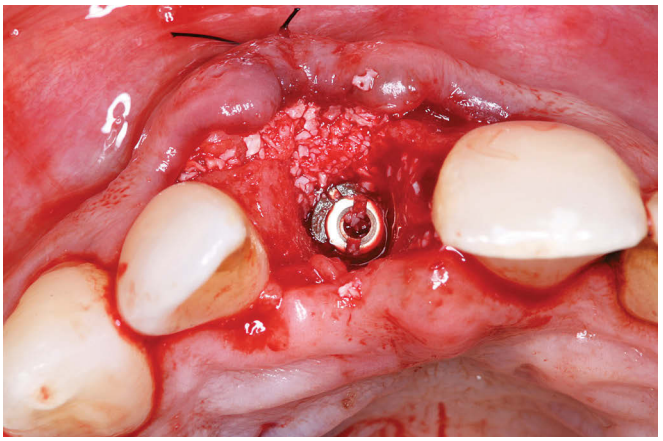

Figure 10 - Placement of Bio-Oss on the buccal bone dehiscence.

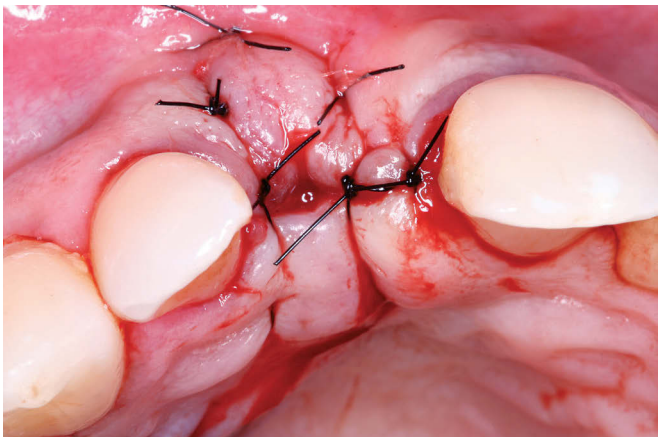

Figure 11 - Replacement of the fold and sutures.

Four months after implantation, it was done the reopening of the implant with a discrete semilunar excision, without touching the proximal faces of adjacent teeth. On the same session it was captured, right in the mouth, the temporary abutment of 3 mm in height, for beginning of tissue conditioning through temporary crown (Figs 12 to 15). Two months after the temporization it was done the personalized transfer of the emergency profile and of the tissue conditioning obtained with the temporary (Figs 16 to 21). Thus, a zirconia abutment Balance Ankylos® was prepared in laboratory and tested in mouth with the aid of a placement guide made in red acrylic resin that guaranteed the reproduction of its exact position (Figs 22 and 23).

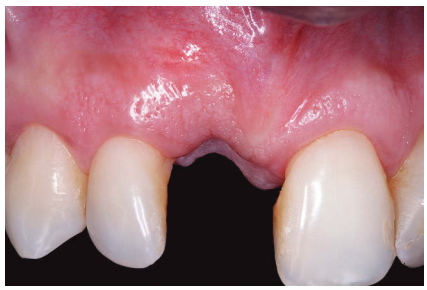

Figure 12 - Tissue condition before the reopening.

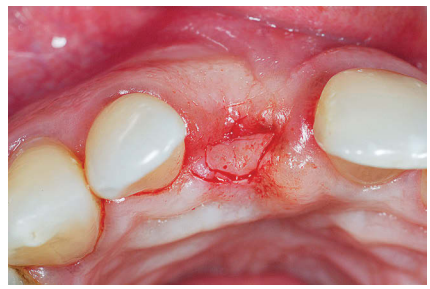

Figure 13 - Semilunar supra-crystal incision.

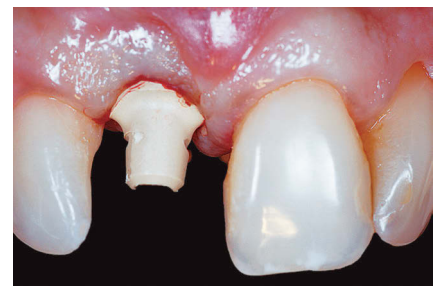

Figure 14 - Test and adjustment of temporary pillar.

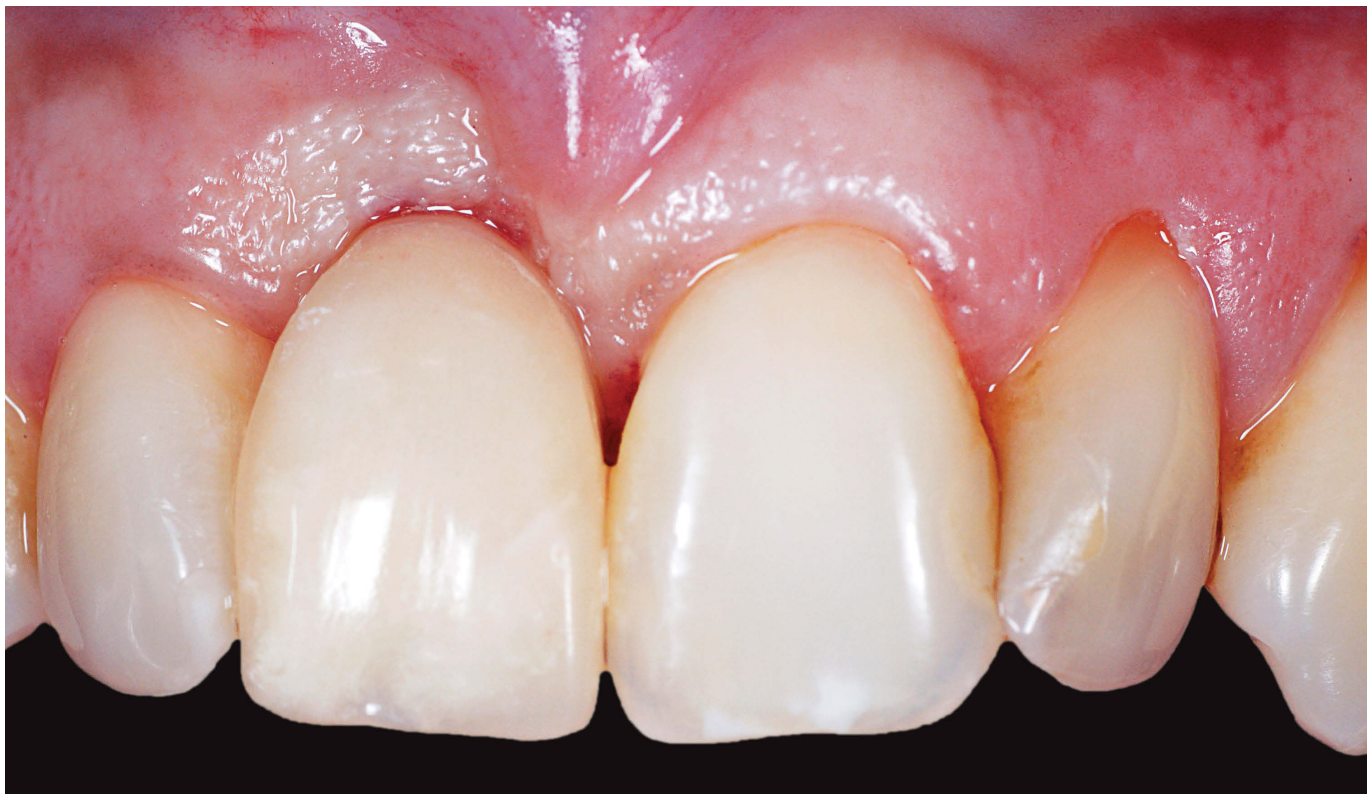

Figure 15 - Temporary crown installed.

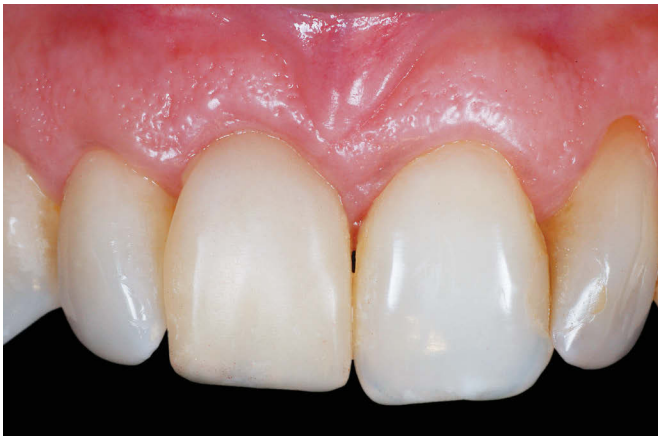

Figure 16 - Tissue conditioning obtained after 2 months.

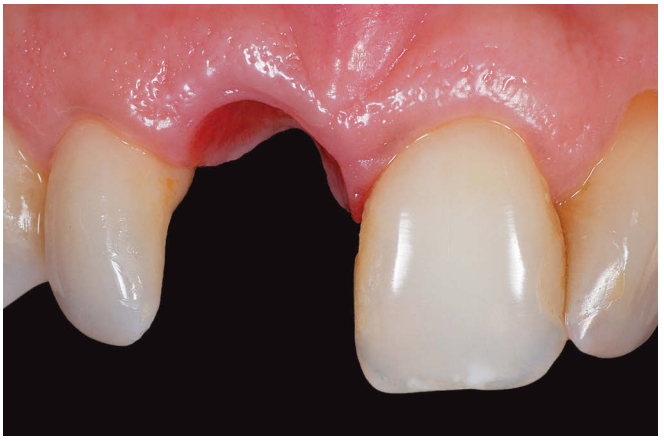

Figure 17 - Emergency profile obtained with the temporary.

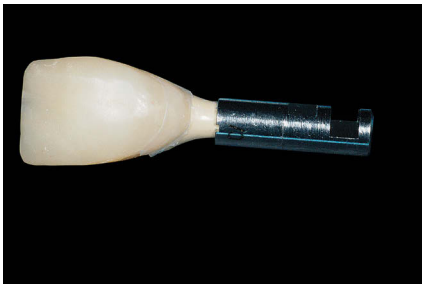

Figure 18 - Temporary crown joint to analogous.

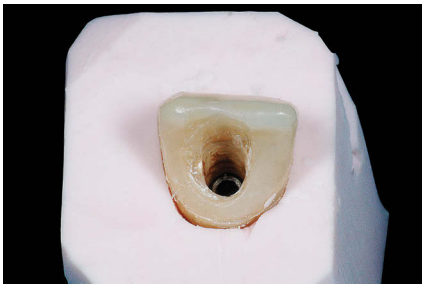

Figure 19 - Casting of emergency profile of temporary crown.

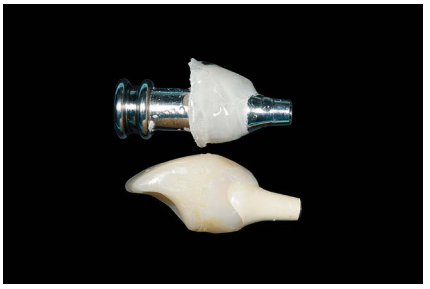

Figure 20 - Personalized transfer and temporary crown joint to temporary pillar.

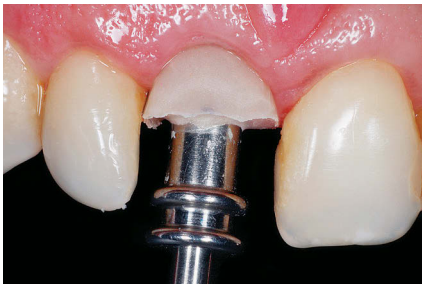

Figure 21 - Transfer personalized in mouth at the moment of transfer of implant.

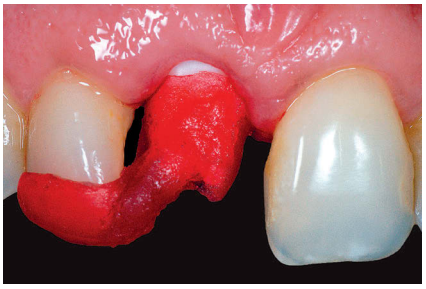

Figure 22 - Test of the zirconia pillar with assistance of a guide in acrylic resin.

Figure 23 - Zirconia pillar, ceramic coping and acrylic resin guide.

The test and adjustment of the crown were performed followed by its installation (Figs 24 and 25). Clinically it was possible to observe the presence of proximal papillae, good thickness of buccal peri-implant mucosa, absence of recession of mucosa and good integration of the prosthesis with the peri-implant tissues (Figs 26 to 29). The final periapical radiograph showed good adaptation of the crown and of the abutment and permanence of bone above the shoulder of the implant preserving the proximal bone crests (Fig 30). The maintenance of clinical and radiographic results can be observed one year after finalization of the case with acceptable maintenance of esthetic with good integration to peri-implant tissues and maintenance of interproximal bone levels (Figs 31 to 33).

Figure 24 - Test and adjustment of ceramic crown.

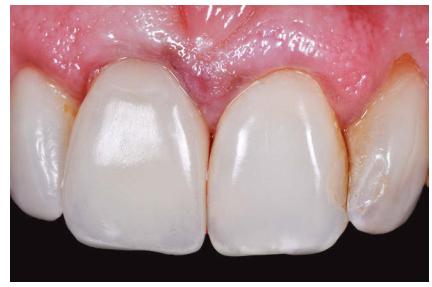

Figure 25 - Installation of ceramic crown.

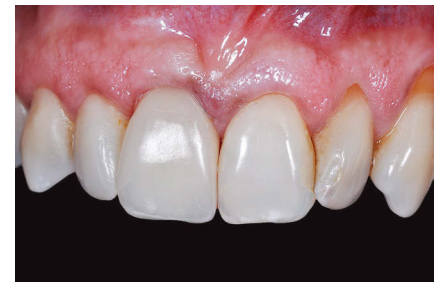

Figure 26 - Good integration of the crown with adjacent teeth.

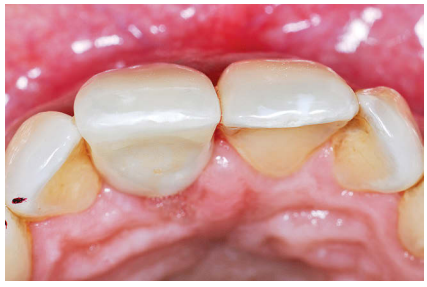

Figure 27 - Occlusal view of the installed ceramic crown.

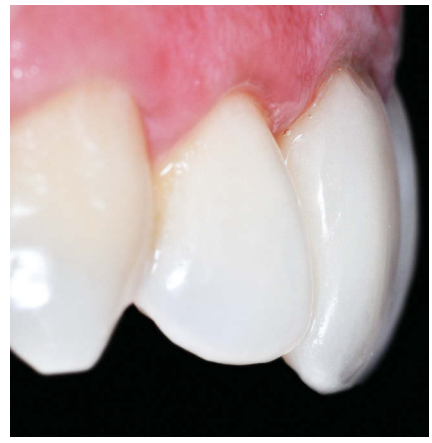

Figure 28 - Right side view.

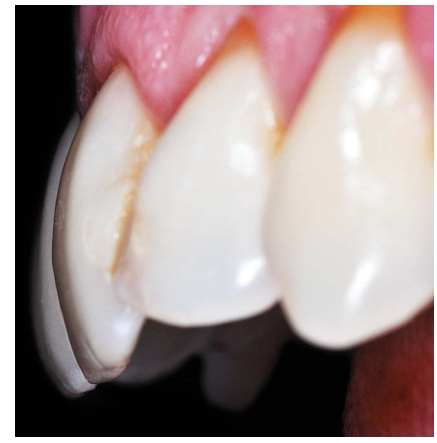

Figure 29 - Left side view.

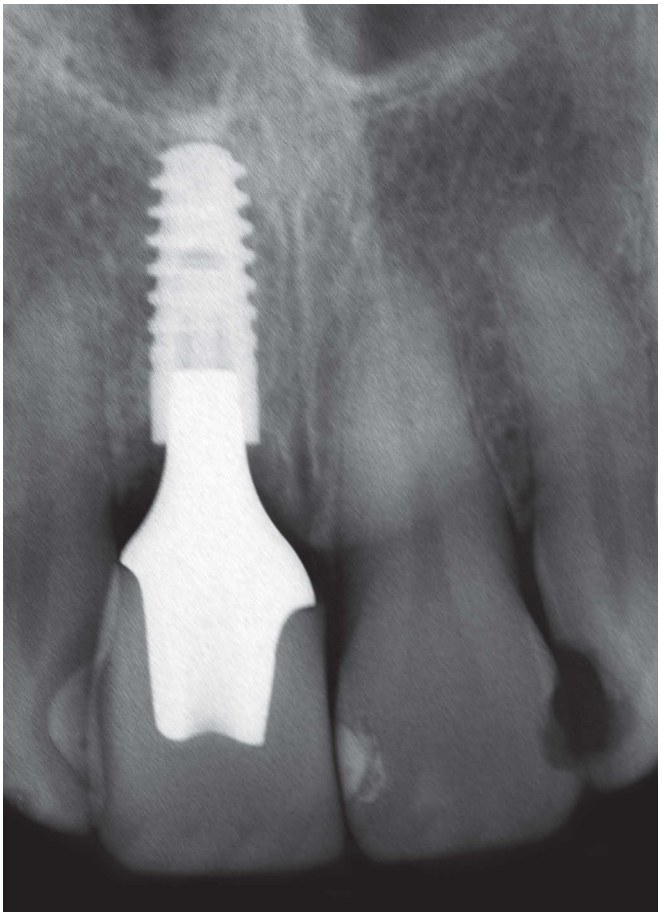

Figure 30 - Radiograph taken after installation of the ceramic crown.

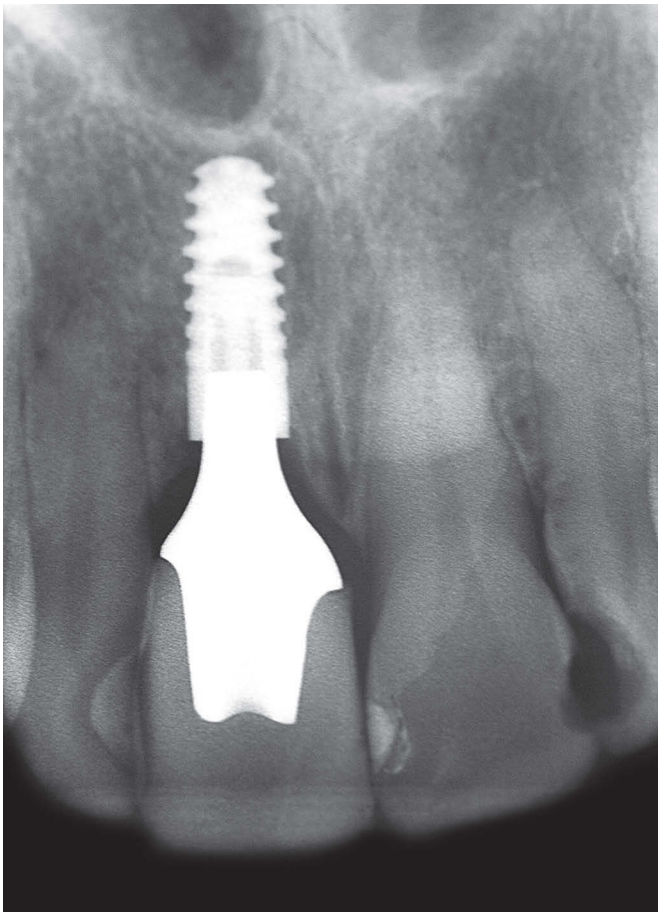

Figure 31 - Observation of 1 year after installation of ceramic crown.

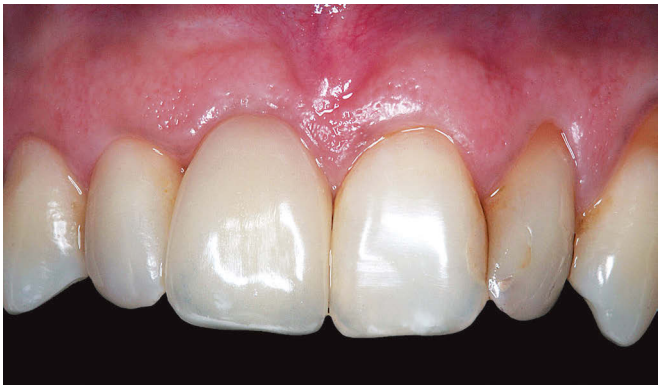

Figure 32 - Observation radiograph of 1 year after prosthetic finalization.

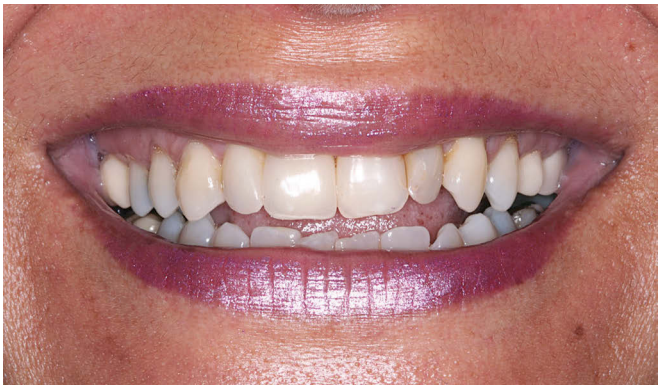

Figure 33 - Final photo of the patient smiling.

Discussion

The clinical case presented in esthetic region had a ridge with alveolus in stage of early remodeling, with slight buccal depression, but that appeared to have enough thickness for installation of an implant with reduced diameter. The periodontal biotype was from intermediate to thin, and radiographically there was a slight remodeling of bone and proximal bone crest. The main objectives were adequate esthetic solution and satisfaction of the patient. For such, the necessity of using a graft of conjunctive tissue to increase the tissue thickness and, of guided bone regeneration to rebuild and keep the soft and hard tissues stable for a long time, besides the criteria for choice of platform pattern and prosthetic connection of the used implant.

The implants of conventional platform, where the diameter of implant is the same as of the prosthetic platform or abutment, were and still are widely used in Dentistry. Unfortunately it was found that it occurs a cervical bone remodeling around these implants, between 1,5 mm and 2 mm vertically and between 1,3 and 1,4 mm horizontally, on the first year where there is exposition to the oral environment- placement of healer or abutment. This remodeling received the name of saucerization.[7,11,14,16,17] Countless attempts to explain the causes and how the saucerization occurs were done: establishment of peri-implant biological space,[6,14,15] stress forces generated by the abutment movimentation,[6,11,15] establishment of the inflammatory infiltrate and of the peri-implant conjunctive tissue,[1,6,7,9] bacterial colonization of the microgap[6,14] and bacterial colonization of the peri-implant sulcus.[6]

On the attempt to solve this problem, a new approach on the placement of the implant platform in relation to the implant emerged, known as platform switching. In it there is the horizontal displacement of the implant-abutment connection in relation to the bone through the use of abutment of smaller diameter than the diameter of the implant.[9,11,13,16,17] It occurs the separation of the cervical bone in relation to the inflammatory infiltrate and microgap of contamination of the implant-abutment connection. Georg-Hubertus Nentwig[13] and Walter Moser developed the first system of implants that uses this approach, Ankylos by Dentsply, in 1985. In 1987 this system began to be clinically used. Richard J. Lazzara was one of the first to mention the existence of this concept and his study is widely mentioned in literature.[11] His clinical case report described radiographic observations done within 13 years, when it were used healers and abutments of smaller diameters than of the conventional platform of implants, in 2 hexagonal implants by Implant Innovations (3i), where the prosthetic components available on the market, in 1991, had smaller diameter than the diameter of implants. It was analyzed that in case of horizontal alteration on the placement of the implant margin and its platform, the installation of abutments seemed to reduce or eliminate the remodeling of the vertical bone crest common on the use of conventional platform.

The inner replacement of the implant-abutment junction of the implant shoulder and of the adjacent bone would reduce the bone resorption or remodeling for keeping the inflammatory infiltrate in an area of exposition smaller than 90°, different from the 180° observed in implants of conventional platform.[10,11] Another consequence observed was the increase on the area of surface for settlement of implant, with exposition of its surface, having more space for conjunctive insertion to insert and less necessity of bone crest resorption to occur this insertion.[11]

The clinical results (of bleeding absence or peri-implant inflammation and maintenance of soft tissues and papillae) and radiographic results (with the reduction or elimination of remodeling of the vertical bone crest) obtained in mentioned studies, gave support to choose an

implant with the pattern or approach of platform switching on the performance of this clinical case instead of the conventional platform. It were mentioned[4,9,12,16] the following recommendations for the use of the concept platform switching: Esthetic area, where it is necessary the preservation of hard tissues and consequently soft tissues, and region where there has been certain bone remodeling, after exodontia and when the ridge already is limited or atrophic. All these characteristics were present in this reported clinical case.

The implant selected for solution of the presented clinical case was the Ankylos® by Dentsply, which has surface treatment and platform switching approach with cone morse prosthetic connection. It was obtained a good prosthetic emergency profile on the clinical case because it was done the installation of the infraosseous implant and for the tissue conditioning done with the use of temporary prosthesis, since it was possible the permanence of a collar around the interface implant-cervical bone.[13] The best performance of cone morse implants when submitted to stress, in relation to other patterns of prosthetic connection, minimizing the risks of overloading the cervical, allows the installation of the infraosseous implant.[1]

At the moment of installation of the implant it was performed periapical radiograph, where it was verified a good adaptation of the crown and abutment and permanence of bone above the shoulder of the implant preserving the proximal bone crests. Clinically, there was formation of proximal papillae, good thickness of buccal peri-implant mucosa, absence of recession of mucosa and good integration of the prosthesis with the peri-implant tissues. The obtained results are similar to the presented in most studies in literature with implants of platform switching approach and/or cone morse connection.[1,2,4-7,9-17]

More studies are necessary to prove which are the physical and/or biological events resulting from change on the placement of the implant platform associated to cone morse connection. Also, lack studies that show the maintenance of stable soft and hard tissues over time in case of unitary and multiple adjacent implants in these approaches.

Conclusion

It is concluded that the use of implants with platform switching concept associated to cone morse prosthetic connection may help to prevent or minimize the peri-implant bone loss and consequently alterations on adjacent soft tissues, associated to the correct surgical and prosthetic planning ensuring an excellent functional and esthetic stability of the result.

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Peri-implant tissues health and its association to the gingival phenotype

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Abstract

Peri-implant tissue is an adaptation of the masticatory mucosa to the different implant systems placed in the oral cavity. The lack of root cement to anchor gingival fibers to the surface of the implant is responsible for the parallel direction of the fibers around it. The absence of connective attachment between the mucosa and the implant may suggest a deficiency of the structural defenses in the region and may be associated with the more rapid progression of peri-implantitis than of periodontitis. Several studies have evaluated the importance of epithelial connections to form an adequate seal around implants. Other discussions have focused on the evaluation of whether peri-implant gingival health may be correlated with the presence of a specific amount (height and thickness) of keratinized mucosa. This study evaluated the association of the structural role of the soft tissue and the effect of gingiva phenotype on peri-implant health. The studies that were reviewed stressed the importance of a good biological seal around the implant system, the protective function that the structures of this tissue provide to the bone-implant interface, and the discussion about the need to have a band of keratinized mucosa around tooth implants to ensure a better prognosis. Current studies point to the need to conduct further investigations to evaluate the effect of the clinical characteristics of soft peri-implant tissues so that peri-implant health may be ensured and preserved.

Keywords: Mucositis. Peri-implantitis. Keratinized mucosa.

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Introduction

Some factors associated with amount and quality of bones, soft tissues (keratinized mucosa), host response, type of treatment applied to implant surface and biomechanical events (occlusal overload) are very important and directly associated with implant success or failure.[1]

The masticatory mucosa, composed of gingiva and palate mucosa, is covered by keratinized squamous epithelium and dense fibrous connective tissues (lamina propria). In the gingiva, the lamina propria is attached directly to the alveolar bone through the periosteum and, in the supracrestal portion, to the tooth root.[2] In implants, the connective tissue fibers run parallel to the implant surface and form a collar.

Although the soft tissues around teeth and implant have aspects in common, the direction of their connective tissue fibers is different. The string of soft tissue around the implants is a critical barrier that ensures the protection of bone adjacent to the implant.[3] The preservation and stability of the bone walls around the implant depend on the formation of a functional barrier on the abutment/implant interface (transmucosal), important for implant protection against bacterial invasion.[4]

In contrast, some authors report that the keratinized mucosa around implants is not necessary in patients that have a good oral hygiene.[3,5,6]

Although not conclusive, some authors have suggested that the lack of an adequate zone of masticatory mucosa may be a barrier to good hygiene and may provide poor protection to the support teeth and the implant against injuries caused by frictional forces during mastication and brushing and against the accumulation of bacterial plaque.

This study compared findings in the literature about the actual effect of peri-implant phenotype and its correlation which gingival health and long-term implant prognosis in relation to inflammation.

Literature review

The effect of bacterial plaque on inflammation

For several years, periodontal disease (PD) was believed to be the only entity caused by the accumulation of bacterial plaque that led to gingivitis, which, if not treated, may lead to bone loss and, consequently, periodontitis. Dentistry students underwent a model of experimental gingivitis that included an initial period of intensive plaque control, a period of plaque induction, with controlled onset and progression of the disease, and a final period of new plaque control. All individuals had rapid plaque accumulation and different changes in microbiota, followed by gingival inflammation. The study clearly demonstrated that gingivitis in human beings may be produced by bacterial plaque and may be controlled after plaque removal.[7]

The literature about this topic shows a correlation between the presence of bacterial plaque and periodontal disease (PD), although plaque does not necessarily result in PD. Longitudinal studies showed that individuals without good oral hygiene standards had different patterns of bone loss, or no bone loss.[8] This demonstrated that, for the development of PD, other factors must be present in addition to bacterial plaque.

Some individuals have intrinsic characteristics that trigger the most severe form of the disease, such as environmental factors, smoking, systemic diseases or genetic changes.

One of the causes of osseointegrated implant failure is bacterial infection.[1]

Implantology recognizes the existence of groups of individuals that have increased risks to osseointegration and applies the concepts developed by Periodontics.[9]

The process of infection of the peri-implant sulcus first leads to the formation of peri-implant mucositis, which may be defined as an inflammation of peri-implant soft tissues without bone loss. In some situations, mucositis may progress and turn into peri-implantitis, which is peri-implant inflammation with bone loss. Both processes are associated with bacteria that are pathogenic for the periodontium.[10]

An experimental study with beagles was conducted to evaluate inflammatory changes of the peri-implant mucosa and compare it with periodontal changes. After 3 months of plaque accumulation, clinical examinations showed that the peri-implant gingiva was edematous, red and bleeding at probing, and that the lesion in the peri-implant mucosa grew and extended more apically than in the gingival tissue. This study showed that mucositis may occur due to plaque accumulation, and that the peri-implant mucosa was less efficacious than gingiva in preventing plaque-associated lesions.[11]

In contrast, as study of experimental mucositis in human beings collected biopsies of periodontal and peri-implant gingival tissues of 12 people after a time of plaque control and then after 21 days of no oral hygiene. The authors found that plaque formation was associated with clinical signs of inflammation and more lesions to soft tissues with variable rates of cell markers. However, there were no significant differences in the location of teeth and implants in both the first sample and after 21 days.[6]

A study with monkeys showed that, in the presence of inflammation, peri-implant tissues were more susceptible to probing, and the tip of the probe reached a point closer to the bone than in inflamed periodontal tissues. These results suggest a greater fragility of the peri-implant tissue when associated with marginal inflammation than of periodontal tissues in the same clinical condition.[12]

In a review study that collected clinical, radiographic and biochemical factors to control peri-implant conditions, the parameters used by the authors to evaluate peri-implant health and disease severity were presence of plaque, macroscopic aspect of the mucosa, depth of peri-implant probing, presence and width of keratinized mucosa, analysis of fluid of the peri-implant sulcus, suppuration, mobility, discomfort and radiographic follow-up. The authors showed that, when oral hygiene was satisfactory, the characteristics of the mucosa have little influence on long-term implant success. However, they admitted that inadequate oral hygiene may lead to an increase of tissue loss around the implant in the area of alveolar mucosa when compared with regions of keratinized tissues. The authors also found that oral hygiene procedures are more easily performed when there is an appropriate band of keratinized mucosa.[13]

Biological periodontal and peri-implant distances

The first study about biological distance evaluated the dimensions and associations of the dentogingival junction in autopsies of human specimens. That study established that there is a proportional dimensional association within a region of +2.73 mm, from the level of the alveolar bone crest to the level of the gingival

margin, and including the connective attachment, the junctional epithelium and the sulcus epithelium. In their study, 325 measurements were made in clinically normal specimens. The authors found a great consistency in the dimensions of several components:

a) Sulcus depth was 0.69 mm;
b) Junctional epithelium covered 0.97 mm;
c) Mean connective attachment was 1.07 mm.

The most consistent finding was recorded for connective attachments, whose mean measure was 1.07 mm, ranging from 1.06 to 1.08 mm. The mean combined value of connective attachment and junctional epithelium was 2.04 mm, and this was classified as the "biological distance".[14]

The epithelium in the sulcus has been described as the extension of the oral gingival epithelium whose coronary limit is the height of the free marginal gingiva, and its apical limit, the surface of the junctional epithelium.[15]

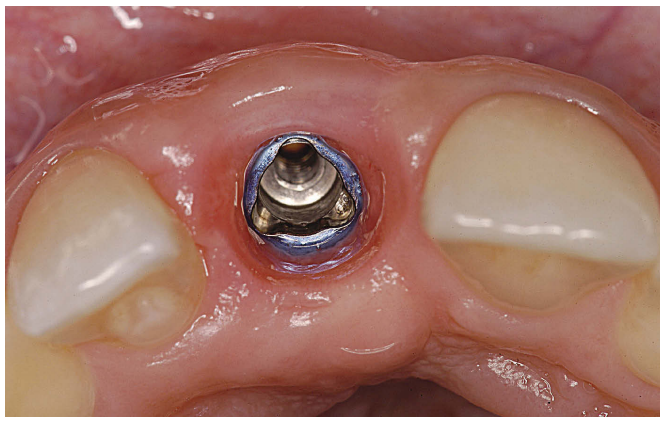

Figure 1 - Peri-implant tissue with pink color, firm consistency and good thickness of keratinized mucosa.

The junctional epithelium is the tissue that joins the tooth in one side and the oral sulcus epithelium or connective tissue in the other, and forms the basis of the clinical gingival sulcus. Its structure and function are significantly different from those of the gingival epithelium. In several aspects, the junctional epithelium clearly seems to be a unique biological system.[16]

The gingival connective tissue may be dense and fibrous, with a complex functional orientation developed gradually during tooth eruption, which is later modified due to functional demands. The structural orientation of this tissue is appropriate to support the physical stresses of mastication and deglutition. The fibers are intertwined, and several are not even attached to the tooth surface. The function of the fibers is to stabilize the gingiva in relation to the alveolar process and the tooth and, secondarily, to stabilize the tooth to the bone. The circumferential distribution of the fibers (circular ligament) keeps the junctional epithelium in close contact with the tooth and helps to keep the epithelium sealed to the tooth, while interdental fibers help to stabilize the teeth.[17]

The evaluation of clinically healthy soft tissues around teeth and implants reveals that both are pink and consistent. The two types of tissue also have several microscopic characteristics in common, such as keratinized oral epithelium in continuation of junctional epithelium in teeth and implants and a measure of about 2 mm. Epithelium is separated from alveolar bone by a high area of connective tissue of about 1 mm.[18]

Therefore, a biological space of 3 to 4 mm above the bone is necessary and defined by about 2 mm of an epithelial component and 1 to 1.5 mm of connective tissue. A 2-year longitudinal analysis of Branemark implants to evaluate changes in the position of the margin of peri-implant soft tissues found that the mean value of recession was greater for implants with a small band of

keratinized mucosa only in the first 6 months, but the examination at 18 months revealed that the regions with little keratinized mucosa at baseline had a lower mean recession value than the regions with a greater amount of keratinized mucosa. According to the authors, this tissue change is not associated with inflammation. Areas with a greater probing depth had greater recession because of remodeling to stabilize the biological dimensions of supraosseous soft tissues. We may conclude that both soft tissues and recession are not significantly affected by the amount or mobility of marginal tissue, which confirms studies that found that the alveolar mucosa has the capacity of protecting the bone surrounding the implant, similarly to the masticatory mucosa.[3]

A study with dogs, whose internal portion of soft tissue surrounding the implant was removed to decrease its biological distance from the implant, demonstrated that there was bone resorption in those areas to ensure adequate fixation of soft tissue around the implants and reestablish the junctional epithelium, which suggests that a certain mucosa thickness is necessary to prevent bone remodeling around implants.[19]

In confirmation of the study described above, the biological distance of 3 different implant systems was histologically evaluated, and results showed that their morphological characteristics were similar. The biological distance was 3.03 to 3.15 mm, the distance of the junctional epithelium from the mucosa margin ranged from 1.6 to 4.3 mm, and the height of the connective tissue ranged from 1 to 1.5 mm. There was dense collagen with lithe vascular structure and dispersed inflammatory cells. Their conclusion was that the mucosa adjacent to the alveolar crest follows the same pattern. Sites with angular bone defects also have a thin mucosa. Therefore, to promote an adequate attachment of epithelial and connective tissue, a minimal amount of peri-implant mucosa is necessary.[21]

In addition, the composition of connective tissue between the mucosa and titanium implants was analyzed by authors that divided it, for analysis, into two portions within the adjacent connective tissue. The one closer to the implant characteristically had few blood vessels and abundant fibroblasts, and the one more lateral, had more vessels and fibers and fewer fibroblasts.

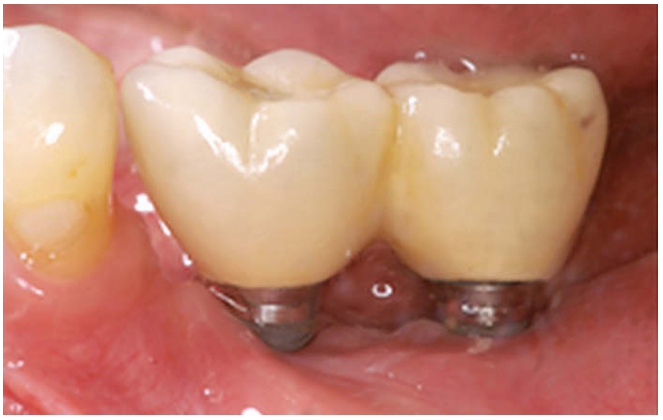

Figure 2 - Illustration of two implants in the left posterior inferior region, showing soft tissue with absence of keratinized mucosa and presenting gingival recession.

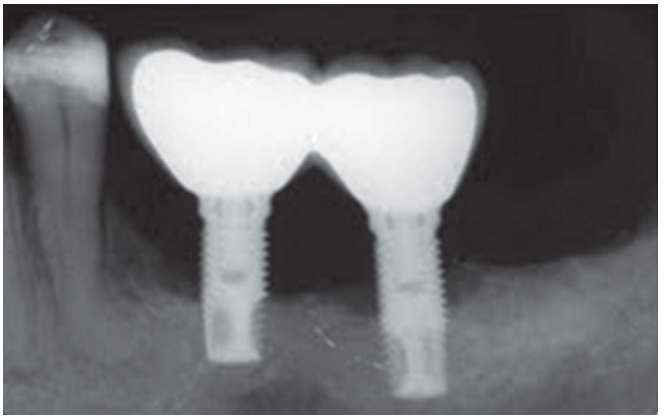

Figure 3 - Radiographic image of Figure 2, showing excessive bone loss to the mid third of implants.

These findings suggest that a barrier rich in fibroblasts close to the titanium surface plays a role in maintaining adequate sealing between the oral environment and the peri-implant bone.[22]

Osseointegrated implants have few functional and anatomic barriers than natural teeth. Adhesion occurs only by means of the junctional epithelium. The presence of keratinized mucosa seems to promote such sealing.[23]

The association between keratinized mucosa and mucositis

Although the masticatory mucosa adjacent to teeth is similar to that around implants, they have structural differences that may affect the health of the marginal tissues. While the final sulcus epithelium (junctional epithelium) seems to end at a similar distance to the bone crest (1 to 1.5 mm) both in teeth and in implants, the orientation of the supracrestal collagen fibers, however, is different. The lack of root cement to anchor gingival fibers to the surface of the implant results in a parallel orientation of the fibers around it, instead of the perpendicular orientation found around teeth.[18]

The formation of tissue defense in the host (granulation tissue) begins in the narrow layer of vascularized connective tissue below the junctional epithelium. If the surface of the implant is contaminated by bacteria, an inflammatory response will be triggered in the connective tissue. The bone on the implant bed cannot organize a defense against infection, in contrast with the periodontal ligament, which is rich in vessels that are found around a natural tooth. Therefore, the apical extension of the inflammatory

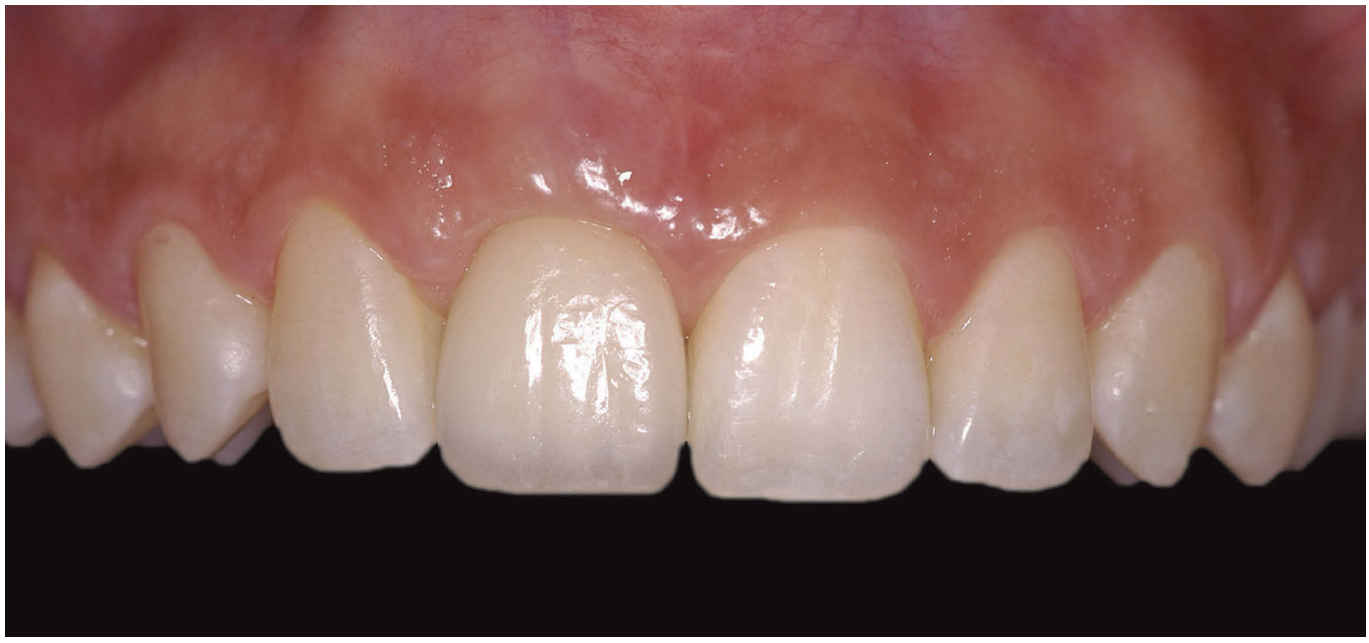

Figure 4 - Illustration of peri-implant tissue with contours, appearance and texture similar to periodontal tissue.

infiltrate around the implants, more significant when found in the periodontium, seems to result from the morphological orientation of the supra-alveolar peri-implant fibers.[34] This is also the opinion of other authors, who found that the great difference between inflammatory response of the peri-implant and periodontal tissues is associated with the organization of the supra-alveolar fibers and the mobility of the gingival margin, which renders the implant more vulnerable to bacterial contamination.[24]

Therefore, although not based on conclusive studies, clinical findings suggest that the lack of an adequate area of masticatory mucosa may prevent the performance of appropriate oral hygiene procedures and grant insufficient protection against peri-implant infection in tissues that support implants.[5]

In teeth, minimal widths of keratinized tissues are compatible with gingival health. However, inflammation persists in areas with less than 2 mm of keratinized mucosa and, therefore, the width of the keratinized mucosa area should be 2 mm or more, and the gingiva should have an attachment of at least 1 mm.[25]

Another longitudinal study with teeth followed up 106 sites with buccal recession and probing depth of 3 mm or less. They concluded that, when there is gingival recession, the elimination of hygiene trauma is usually enough to prevent recession or loss of independent attachment, regardless of the width of the attached gingiva.[26]

However, it is still unclear whether a sufficient amount of keratinized tissue is necessary to preserve, in the long term, periodontal and peri-implant health, as well as how much tissue is sufficient.[27]

Some authors evaluated the association of the width of peri-implant soft tissue in 39 patients that received complete fixed prosthesis about 10 or more years before, or a partial denture at least 5 years before (total of 171 Branemark implants). They found that 24% of the sites did not have masticatory mucosa, and the measure of the keratinized mucosa in 13% of the implants was less than 2 mm. Analyses revealed that neither the width of the masticatory mucosa nor the mobility of the margin tissue had a significant influence on the pattern of bacterial plaque control or the health of the peri-implant mucosa according to the diagnosis made by bleeding at probing.[5]

In contrast, an experimental study evaluated the effect of the presence or absence of keratinized mucosa in the progression of peri-implantitis induced in monkeys. Five monkeys and a total of 30 transmucosal implants in mandibles, with or without keratinized mucosa, were included in the study. After healing for 3 months under optimal plaque control, all implants were submitted to plaque accumulation for 9 months. Loss of attachment was measured clinically and histometrically. Implants placed in areas without keratinized mucosa had a significantly greater loss of attachment and a greater gingival recession than those placed in areas with keratinized mucosa. The results of that study suggest that the absence of keratinized mucosa around endosseous tooth implants increases the susceptibility of the peri-implant region to tissue destruction induced by plaque.[2] These findings were confirmed by other studies, which suggested that the presence of keratinized mucosa around implants is strongly associated with optimal health of soft and hard tissues.[19,20,28]

At the same time, other longitudinal clinical studies have failed to confirm great differences in the progression of lesions around implants placed in sites with or without keratinized mucosa, and suggest that it may mask a health problem of the peri-implant mucosa.[3,5,6]

Other authors, however, conducted clinical studies to investigate the role of presence, or absence, of keratinized mucosa in the preservation of bone integrity around

implants that received different surface treatments (smooth x rough) in human beings. They examined 69 patients that had received implants three or more years before. The following parameters were evaluated: Bone loss, amount of attached gingiva, depth of probing, bleeding index, width of keratinized mucosa and attached mucosa. The implants were divided into 4 subgroups according to the band of keratinized mucosa. They found that gingival inflammation and plaque accumulation were statistically greater in implants with keratinized mucosa smaller than 2 mm. The analysis according to implant locations, divided into posterior and anterior sites, revealed an increase of gingival inflammation in posterior implants with a keratinized gingival band smaller than 2 mm. Bone loss of the anterior and posterior implants with a band of attached gingiva equal to or smaller than 2 mm wide was 0.04 mm and 0.14 mm. These values were statistically significant.[29]

To study the importance of peri-implant keratinized mucosa as a prerequisite for the health of soft tissue in the long term and its stability for 5 years, the following parameters were examined: Plaque accumulation, bleeding index, amount of mucosa margin and width of keratinized mucosa. There was no clear association between plaque accumulation and the width of keratinized mucosa in buccal regions. However, in the lingual region, plaque accumulation increased as the amount of keratinized mucosa decreased. The association of recession with width of keratinized mucosa revealed that recession is greater in areas with a smaller amount of keratinized mucosa.[27]

Another longitudinal study divided 276 implants into two groups. One group had keratinized mucosa equal to or greater than 2 mm, and the other, lower than 2 mm. The parameters evaluated were plaque and gingiva (Löe) index, depth of buccal probing, mucosa recession and marginal bone loss. Ninety implants were in the group that had keratinized mucosa smaller than 2 mm, and the other 186 implants were in the first group. The authors found that the plaque and gingiva indices had only a slight increase in implants with less than 2 mm of keratinized mucosa. In contrast, gingiva recession and marginal bone loss was greater and statistically significant in the group with keratinized mucosa. They concluded that in cases that require tissue maintenance for the long term, particularly in esthetic areas, keratinized mucosa should be present.[30]

To determine whether the width of keratinized mucosa of the implants has a significant effect on the health of soft and hard tissues around it, 200 implants were evaluated to define thickness of gingival tissue, width of keratinized mucosa, plaque index (PI) and gingival index (GI), depth of probing, implant mobility, radiographic bone level (RBL) and smoking. The implants were divided into group A, with 110 implants that had a keratinized mucosa equal to or greater than 2 mm, and group B, with 90 implants with less than 2 mm of keratinized mucosa. As a result, the study showed that the sites with less than 2 mm of keratinized mucosa had a greater accumulation of plaque and clinical signs of inflammation. Moreover, bleeding at probing and mean alveolar bone loss were also greater in areas with a keratinized mucosa smaller than 2 mm. They concluded, therefore, that there is an association between width of the keratinized mucosa and health of peri-implant tissues.[31]

Another study investigated the association of keratinized mucosa and the health of tissues that surrounded implants supporting overdentures. A total of 24 implants in the maxilla and 42 in the mandible were evaluated and divided into two groups: Group A = 36 implants with keratinized mucosa U 2 mm; and group B = 20 implants with keratinized mucosa < 2 mm. There were no statistically significant differences between the two groups in probing depth. The mean values of plaque and gingiva indices, bleeding at probing,

recession and periodontal insertion level were statistically greater in B than in A. Therefore, the study suggested that the absence of keratinized mucosa around implants that support overdentures is associated with a great accumulation of plaque, gingival inflammation, bleeding at probing and recession.[32]

The width of the keratinized mucosa was not significant to maintain health in case of adequate oral hygiene. However, a thin gingiva may be more susceptible to recession when exposed to orthodontic or prosthetic functional demands. The functional need of keratinized gingiva around implants does not seem to have been clearly defined, despite the fact that its esthetic benefit has been widely acknowledged.[33]

Conclusions

- Studies indicate a consensus about the fact that the presence of an adequate band of keratinized mucosa promotes greater stability of peri-implant tissues and, therefore, greater recession in the regions where the gingiva is thin.
- There is no consensus about the effect of gingiva phenotype to maintain peri-implant health in the long term, although studies suggest that a band of keratinized tissue may facilitate oral hygiene and preserve adequate levels of attachment in the long run.
- Further prospective and longitudinal studies should evaluate the effect of the clinical characteristics of peri-implant soft tissues on the different implant systems currently used.

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Zirconia dental implants: An alternative for today or for the future? (Part II)

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Abstract

Introduction: Recent research suggests that titanium (Ti) dental implants may have more side effects than previously believed. In addition to the fact that metals compromise esthetics, emerging technologies involving zirconia (Zr) ceramics were recently introduced in dentistry, which are proving as effective as Ti, but in metal-free rehabilitation. The clinical/histological outcomes of ceramics (ZrO_2), driven by the awareness of patients seeking esthetics without metals, have increased their demand. **Objective:** To find a viable alternative to Ti implants and identify the ceramic systems amenable to use by humans, taking into account biocompatibility and longevity, while pointing out their advantages and disadvantages. **Methods:** Extensive and detailed literature review. **Conclusions:** Although ISO standards need to be reviewed, it has been found that zirconia (Y-TZP) dental implants show a promising future. Zirconia increases the longevity of oral rehabilitation given its diminished bacterial adhesion. The following Zr implant systems were found in the studies: CeraRoot, Sigma, Z-Systems, Ziterion Zit-Z, Easy-Kon, Zeramex, White Sky, Denti Circon Implants, Zimplant-Biosyr, Omnis-Creamed, White Implants and Ziraldent. Among the disadvantages are a high production cost, the need for protectors during healing, and potential hydrothermal degradation of the material. Based on international scientific publications, it was concluded that Zr (Y-TZP) dental implants are now a viable substitute for Ti, although not yet recommended for routine clinical practice.

Keywords: Osseointegration. Allergy and immunology. Biomedical materials. Materials test. Dental Implants. Experimental implants.

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Introduction

Extensive studies have been conducted on the chemical stability of biomaterials used in Dentistry.[1-5] Among these, certain metals have been found to induce nonspecific immunomodulation and autoimmune diseases (multiple sclerosis, rheumatoid arthritis, amyotrophic lateral amyotrophic).[2,3] It is believed that even titanium (Ti), which is considered inert, is a likely inducer of toxicity and type I or IV allergic reactions[2] due to metal ions released into the bone-implant interface, and via the systemic route over time.[3,4] Studies focusing on hypersensitivity and accumulation of Ti particles and gold in the lymph nodes of chronically exposed patients demonstrate that these metals should not be considered biologically inert.[2]

Allergy to Ti may be the cause of dental implant failure in some patients.[2,5] These factors, combined with the galvanic effect of Ti in saliva, and fluorides,in addition to the fact that metals on the oral mucosa can be unsightly - especially in thin gingival phenotypes -has sped up the search for metal-free materials.[4,6,7]

Y-TZP (tetragonal poly crystalline zirconium stabilized with yttrium) ceramics, called here zirconia (Zr), may be an alternative given its excellent chemical stability, biomechanical properties, radiopacity and high osseointegration potential.[6,7,8] Used for more than three decades in orthopedic surgery to replace metals, or combined with these,[6] Zr has also been tested in terms of desirable properties for Dental Implantology.[7,8,9] Several studies confirm excellent results with Y-TZP implants, whose osseointegration proved equal to or better than that of Ti, with superior esthetics and soft tissue response.[7-16] However, few systematic reviews of the literature have been published investigating the possibility of using Y-TZP as an alternative material for Ti dental implants.[9]

In light of all the scientific knowledge available today and the demands regarding the use of metal-free reconstructions by patients with high esthetic expectations and/or a history of allergy to Ti and its by products released into the body, rehabilitation with metals should be reviewed.[6]

After evaluating the physicochemical properties of Zr ceramics and the clinical data with respect to the bone-implant contact area (BIC) *in vitro* and animal *in vivo* studies,[9] this second article sought to identify the Zr dental implant systems available in the international literature, taking into account biocompatibility and longevity through clinical trials in humans, while also pinpointing their downsides and market outlook.

Clinical trials in humans

Among others, Ulrik Volz spearheaded the use of zirconia dental implants (Y-TZP) in humans with intolerance to metals. Following the principles of holistic medicine for over 10 years, this author has succeeded in carrying out totally metal-free reconstructions, achieving complete osseointegration, biocompatibility and incomparable esthetics (Fig 1 and 2).[10] However, Kohal and Klaus were the first to publish a case in the literature involving the technique of immediate replacement on an upper incisor with a Z-Look3 implant (Z-Systems AG, Oensingen, Switzerland).[17]

Figure 1 - Surgical kit Z-Systems, with FSZ (fully stabilized zirconia) ceramic tools.

Figure 2 - Z-Systems, Z-Look3 and LockBall (at right) implants.

Clinical survival is the most widely accepted measure of success in the research on human implants. In 2006, 189 Zr implants (Z-L3) with a mean load time of 8.2 months were assessed after 1 year. The parameters for success in clinical/radiographic evaluations stood at 93%. Compared with Ti implants, Zr had a good performance, and esthetic benefits. In view of the encouraging sampling results, Zr was indicated to replace Ti in future dental Implantology, while encouraging further long-term studies.[11]

Another study compared the survival rates of Zr and Ti implants for a period of up to 45 months using 237 two-piece Ti implants (3i/Osseotite) and 139 one-piece Zr implants (Z-L3) (Fig 3). The non-selected patients, mean age 51, received implants and esthetic protectors. The transmucosal abutments were loaded onto the mandible after 3 months, and 6 months on the maxilla. Ti survival rate was 95.23% in the maxilla and 94.44%

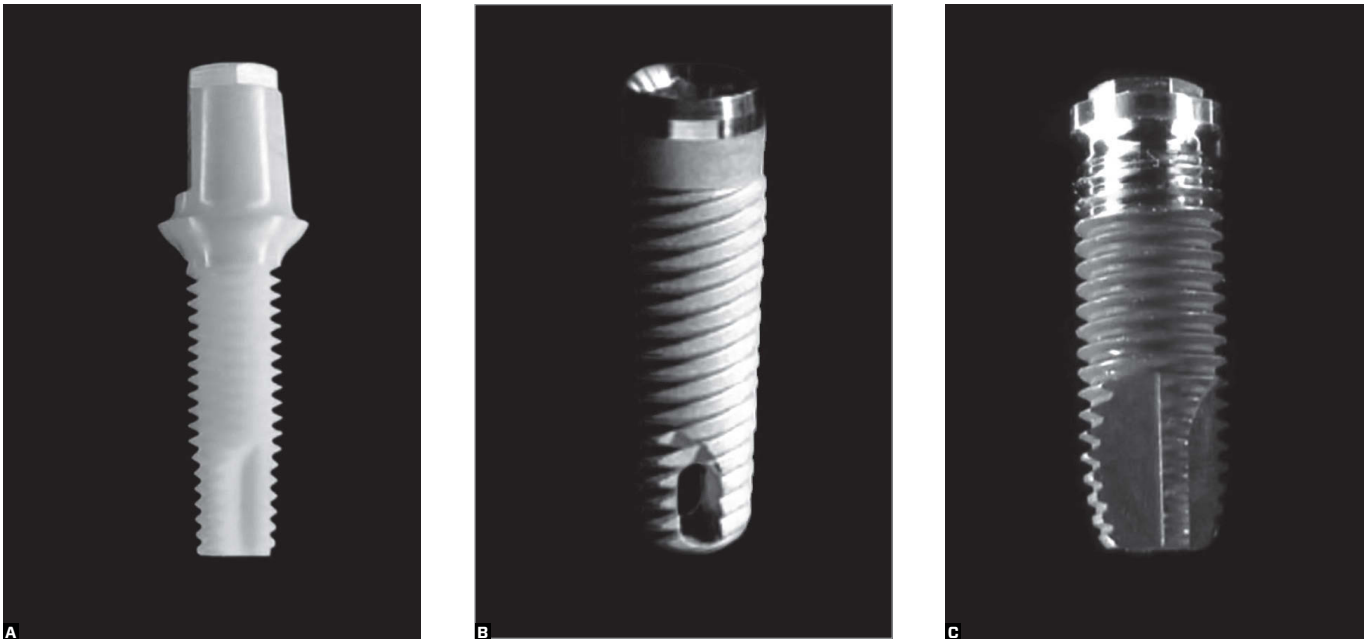

Figure 3 - Zr and Ti implants used in the study of Lambrich.[12] (Source: Lambrich,[12] 2006).

in the mandible. Survival of Zr implants was 84.37% in the maxilla and 98.41% in the mandible. Protection of Zr implants with a prosthetic device during the healing period was crucial for osseointegration.[12]

A retrospective study compared the survival rates of 361 implants (234, Ti and 127, Zr) in 124 unselected patients. One-piece Zr implants (Z-L3) were protected from premature loading. Survival of Ti implants was 98.4% in the maxilla and 97.2% in the mandible, while Zr reached 84.4% in the maxilla and 98.4% in the mandible. The difference of 14.0% for Zr implants in the maxilla was attributed to low stability (torque <35Ncm^2), post-graft placement, premature loading or the poor protection afforded by mucosa-supported dentures (Fig 4). In cases of low primary stability, it was recommended to protect Zr with prosthetic devices, preferably supported on stable proximal teeth (Fig 5).[13]

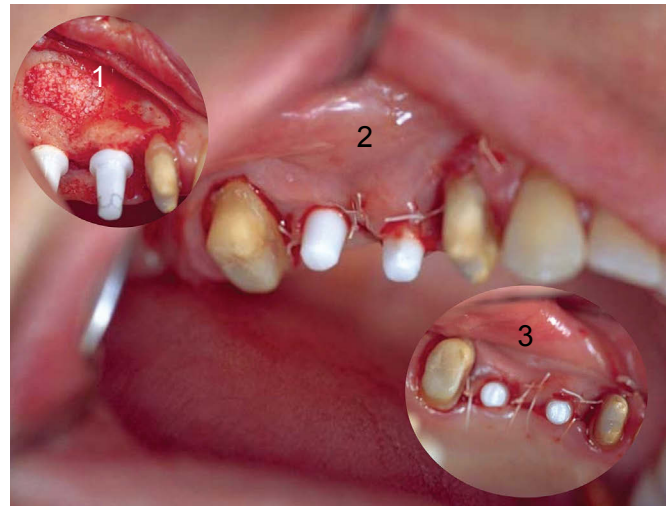

Figure 4 - Z-Look 3 (Z-Systems) implants insertion with graft. (Source: Lambrich and Iglhaut,[13] 2008).

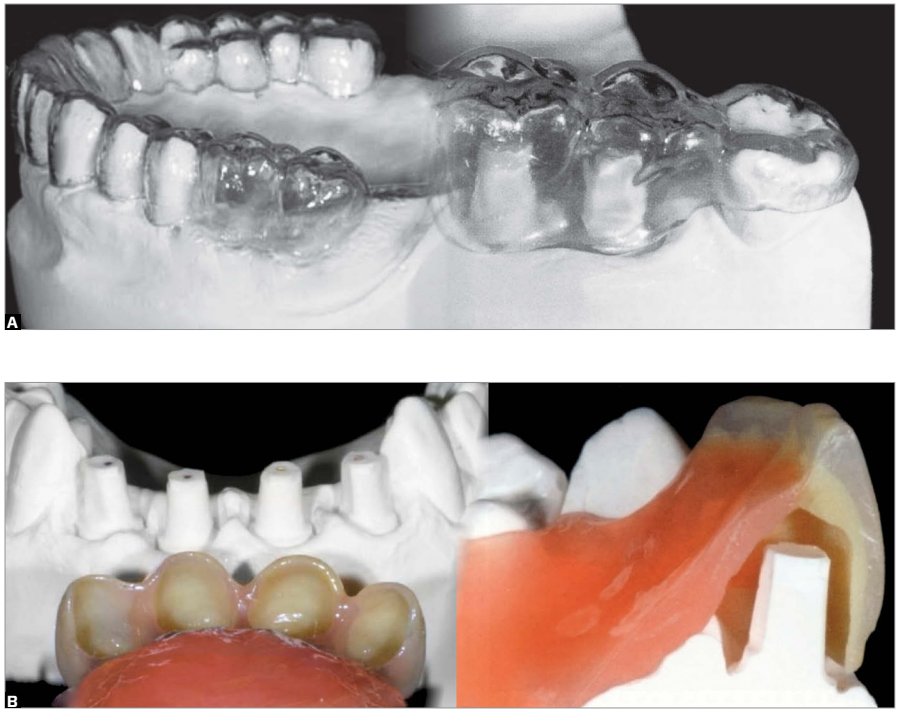

Figure 5 - Protectors for one piece Zr implants in the posterior region, made with acetate and acrylic plates in the anterior region (observe the inner relief zones). (Source: Lambrich and Iglhaut[12,13]).

In a 5-year follow-up, 378 patients with an average age of 48 years, were instructed to avoid chewing in the implant region during the first two months. The 831 one-piece Zr implants (CeraRoot, Barcelona, Spain) with three different surfaces, received restorations after 4 to 8 months or more, concurrently with bone regeneration. All were left in infra-occlusion and adjusted for lateral/protrusive excursions. The subjects were followed-up at 1, 3, 6 and 12 months and annually, with implants being documented in terms of mobility, pain and sulcus depth, with panoramic and/or periapical radiographs. The mean survival rate was 95% (Tables 1 and 2). The implants with acid etched surface were more successful than the other two groups, and peri-implant probing depth was between 2 and 3 mm. Based on this study, the authors concluded that the Zr implants with rough surfaces can be a viable alternative for tooth replacement, but suggest a long-term follow-up.[14] Insertion quality of peri-implant soft tissues related to Zr implants and abutments was investigated in a systematic review which compared the clinical results within a five-year period. Sixty-five Z-L3 implants were inserted in 34 patients, who were evaluated after complete healing and with prosthetic structure in function. Throughout 22 months of use, adhesion of plaque, type of bacterial colonization, and its influence on peri-implant tissues were evaluated in histological examinations. Compared with Ti implants, all Zr implant and abutment data were equally good, or better. In clinical evaluations, the probing depth was 2-3 mm. Regarding the presence of plaque and bleeding, Zr averages were above what is considered good. Even in difficult cases, the protective periodontium appeared esthetically appealing, with encouraging results.[15]

Table 1 - Zirconia implants distribution in surface types, in a 5-year period of use in humans.[14]

Implant surface	N° insert.	Segment	Gender		Smoker	Regeneration		Implant location				Flap	Immediate prov.
			Male.	Fem.		Bone graft	Sinus elev.	Maxilla		Mandible			
								Ant.	Post.	Ant.	Post.		
No treat.	249	2-5 a.	99	150	33	55	11	59	93	25	73	95	32
Treated	249	2-5 a.	91	158	42	42	15	51	99	12	87	102	35
Acid et.	**333**	**1-4 a.**	**128**	**205**	**53**	**65**	**21**	**82**	**113**	**22**	**115**	**126**	**70**
Total	831	1-5 a.	318	513	128	162	47	192	305	59	275	323	137

In bold, the implants with acid etched surface.

Table 2 - Failure proportion on Zr implants, according to the surface type, in a 5-year period in humans.[14]

Implant surface	N° insert.	Fail number	% failure	Gender		Smoker	Regeneration		Implant location				Flap	Period/ failure			Immediate prov.
				M.	F.		Bone regen.	Sinus elev.	Maxilla		Mandible			< 1y	≤ 2y	> 2y	
									Ant.	Post.	Ant.	Post.					
No treat.	249	18	7,23	9	9	11	4	3	2	7	1	8	2	17	2	0	32
Treated	249	16	6,43	6	8	12	2	4	2	7	1	6	2	13	2	0	35
Acid et.	**333**	**8**	**2,40**	**3**	**5**	**6**	**2**	**2**	**2**	**2**	**1**	**3**	**1**	**8**	**0**	**0**	**70**
Total	831	42	5,05	18	22	29	8	9	6	16	3	17	4	38	4	0	137

In bold, the implants with acid etched surface.

Dental Implantology's achievement: From Europe to the world

Extensive research on Y-TZP ceramics has yielded positive results and recommends it as a new biomaterial for dental implants thanks to its fracture toughness, excellent osseointegration and periointegration, surface dimensioning and conditioning.[7-15] Some histological results with zirconium showed new bone formation at the interfaces, or a "biofunctional-composite-osteogenesis."[16]

Despite scarce clinical/histological and biomechanical data in the international literature,[17,18] Zr implants are booming in Europe. The main systems found to be commercially available are: Z-Systems (Oensingen, Switzerland, Fig 2),[11-13] White Sky (Bredent Medical, Germany),[18] Sigma (Incermed, Switzerland),[19] CeraRoot System (Barcelona, Spain, Fig 6),[14,20] Zeramex (DentalPoint, Switzerland),[21] Easy-Kon (General Implants, Liechtenstein),[16] Ziterion Zit-Z (Uffenheim, Germany, Fig 7),[22] Denti Circonium Root (Budapest, Hungary, Fig 8)[23] and Zimplant-Biosyr (Bucharest,Romania).[24] Besides the European (EC) certifications, some systems also obtained authorizations from FDA/Canada[14,20] and ANVISA, Brazil.[11-13]

Studies of these Zr implants in humans are still scarce. Table 3 shows a summary of some of these products surveyed between 2004-2012, compared to Ti samples and results.

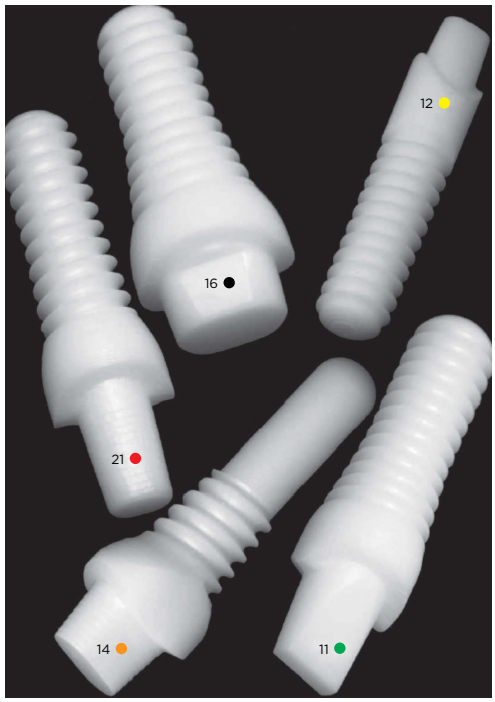

Figure 6 - CeraRoot implant for different indications (incisors, canines, pre-molars and molars). (Source: Oliva J, Oliva X, Oliva D[14,20]).

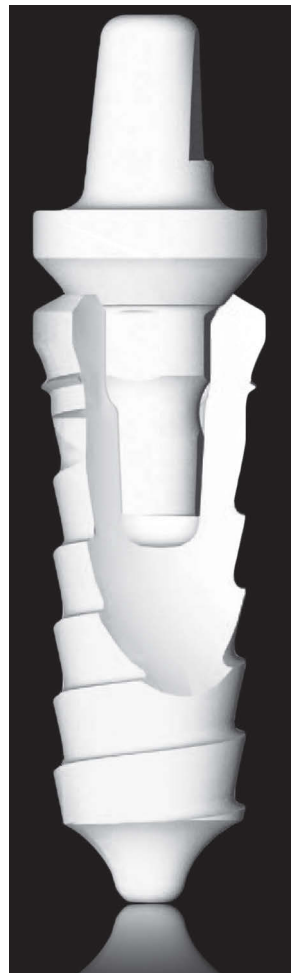

Figure 7 - Zit-Z (Ziterion) implant in 2 pieces. (Source: Özkurt e, Kazazoğlu[30]).

Figure 8 - Denti Circonium root one piece and two pieces implant. (Source: Nevins et al[22]).

Table 3 - Studies of zirconia dental implants in humans - 2004 to 2012 (Zr =Zirconia, Ti=Titanium, w=with,pc=piece, m =month, y =year, BIC = bone implant contact).

Study	Implants used	Sampling / Time	Survival/Result
8	Zr (Y-TZP) and Ti	Systematic Review of literature	Ti = Zr orZr> BIC > 60%
11	Zr (Z-Look 3/Z-Systems)	71 pat./189 impl. Zr/ 12 m	93% survival
12	Ti w/ 2 pc / Zr (Z-Look3 w/1 pc)	237 Ti (3i+TSV) / 3 m 139 Zr / 3 m and 6 m	Ti w/ 95.23% load Zr 84.37 to 98.41%
13	Ti (2 pc)/ Z-Look3 (1 pc)	234 Ti / 127 Zr / 21.4 m	Ti 97.2 to 98.4% Zr 84.4 to 98.4%
14	Zr (CeraRoot) 1 pc	831 cases/load 4-5 y	95% survival
15	Zr (Z-Look 3) / Ti	65 cases / 22 m	>Zr or ≈ Ti
17	Zr (Y-TZP) with load	119 (65 w/1pc+27 w/2 pc.) /12 m	96.6 % survival
20	Zr (CeraRoot) 2 ± surf.	100 impl. Zr/ 36 pat/ 12 m	98% survival
21	Zr: Z-Look3 + Zeramex (2pc)	60% w/immed. exod./imed./load 6 m or +	100% survival
25	Zr (Y-TPS) and Ti (SLA)	surface treatment Zr	> removal torque
26	Zr/Ti abutments+ metal/ceram. crown	40 implants / 6 - 12 - 36 m	100% survival / esthetic Ti = Zr
27	Zr implants w/ roughness, blasted	6 + 12 (prepared) / 1 to 33 m	6 failures / 12 = 92% surv.
28	Y-TZP-ZiUniteTM(Nobel Biocare)	65 cases w/immed. load / 12 m	3 failed = 95.4% surv.
29	Z-Look3 Evo (Z-Systems)	51 w/load 8,4 m	100% survival

Discussion

Technological development has undoubtedly made strides in the search for dental materials that offer the benefits of biomechanical metals while keeping the naturalness of peri-implant tissues. Achievements were driven by advances in medical orthopedics in the last three decades.[9,29] The development of Zr ceramics has fulfilled the criteria for fracture strength, with biocompatibility and esthetics.[9,19,20,21,24,25]

The literature makes it evident that zirconium can be considered the best ceramics for dental use given its physical and chemical properties.[4,6-21] Results from *in vitro* and *in vivo* studies on Y-TZP ceramics corroborate zirconia's excellent biocompatibility and define it as a material of choice for applications in prosthetics or dental implants.[2-5,8,10,21,22,24-30]

Similarly to Ti osseointegration, the clinical success of Zr implants is related to surface properties.[14,20] Changes made with CO_2 lasers and several complex treatment systems impart to Zr a roughness comparable to that of Ti implants.[22,29] Depending on the surface treatment process, biointegration can act chemically or by mechanical irregularities, a determining factor in cell differentiation and maturation.[7-9,12-16,20-22,24-28]

The other advantage of Zr ceramic materials is its low bacterial adhesion.[25] A significant reduction in pathogenic bacteria has been observed, as well as low plaque adsorption and depolarization, with decreased bone resorption. These are key factors in preserving peri-implant health, and are directly related to restoration longevity.[15,20,23,27,29-33]

However, certain disadvantages are attributed to Zr implants, such as higher cost and more limited scientific documentation given its short clinical experience in terms of longevity.[17,18,28]

The vast majority of Zr implants is manufactured in one piece to impart increased strength to the material. These implants therefore require a three-dimensional positioning in the dental arch, with very accurate planning and professional skill, while not allowing reversibility and requiring a protector.[17] Used correctly, protective devices are a decisive factor in osseointegration, especially in cases where no primary stability is achieved, i.e., insertion torque ≤35 Ncm.[2,7, 8,10-14] However, ceramic implants are now available in two pieces, such as Zit-Varioz (Zeterion, Fig 7),[20,30] Denti Circonium Root (Fig 8), Zeramex[24] (Fig 9),[21] Omnis-Creamed (Marburg, Germany)[34] White Implants (Amsterdam, Holland),[35,38] which render planning more versatile and similar to traditional Ti implant systems. However, few studies are cited in the literature regarding the strength of these systems.[14,17,18]

As yet, the ideal surface condition for Zr implants has not been well established, and their osseointegration speed is lower than that of Ti.[36] Since healing takes longer, the failure rate of ceramic implants in general is higher than Ti (grade 4) with an Sand-blasted, Large grit, Acid-etched (SLA) surface, considered standard in the international literature.[36]

Another problem with respect to Zr, since it started being used as biomedical material, is related to potential degradation at low temperatures.[8,37] A severely inadequate preparation of ceramic implants can cause micro or macro-cracks on its surface (Figs 10 to 12).[7,18] The resulting stresses can reduce some physical properties of the biomaterial.[14,18,20,36] Preparation made with fine diamond burs at high speed and with abundant irrigation seems to be the safest procedure.[38]

New concepts in the milling of grain and stabilizing agents such as yttria (Y-TZP), or in combination with alumina, such as Ziraldent-MetoxitAG (Thayngen, Switzerland) with Zircapore® surface, promise to speed up osseointegration and improve hydrothermal stability.[39] However, given that ZrO_2 is supplied by different vendors, it is necessary to use advanced, accurate techniques to assess their microstructure and their aging. A review of ISO standards is also necessary.[40]

Figure 9 - Zeramex two pieces implant. (Source: Andys[21]).

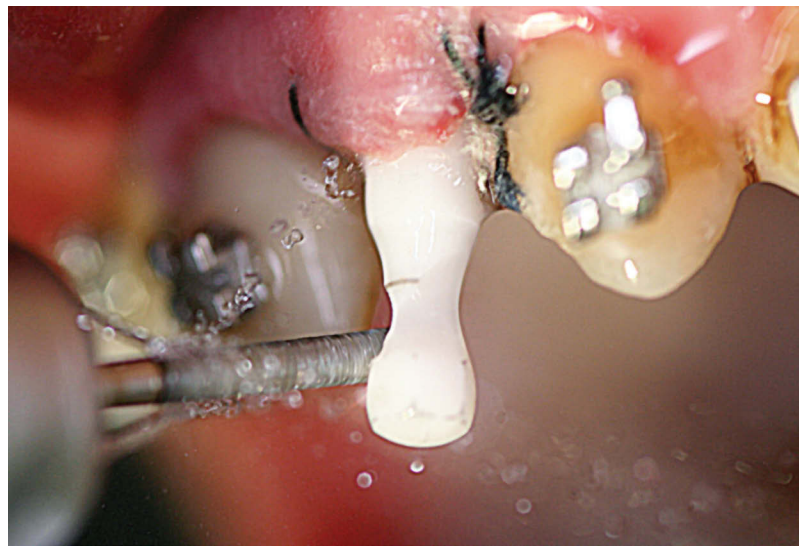

Figure 10 - Z-Look3 (Z-Systems) one piece implant, just inserted in the tooth #22 region.

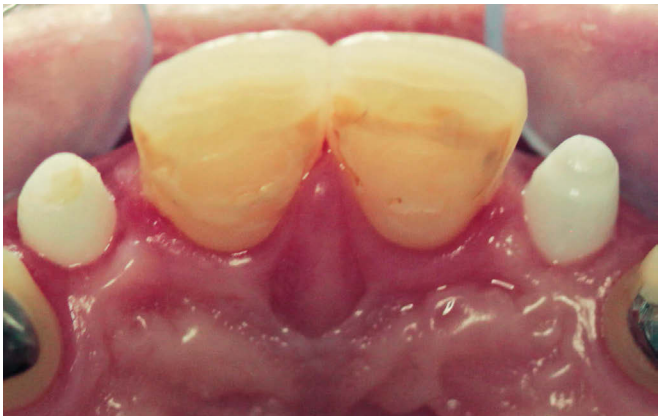

Figure 11 - Occlusal view of Z-Look3 prepared implants, replacing the adhesive fixed prosthesis, in case of maxillary lateral incisor agenesis.

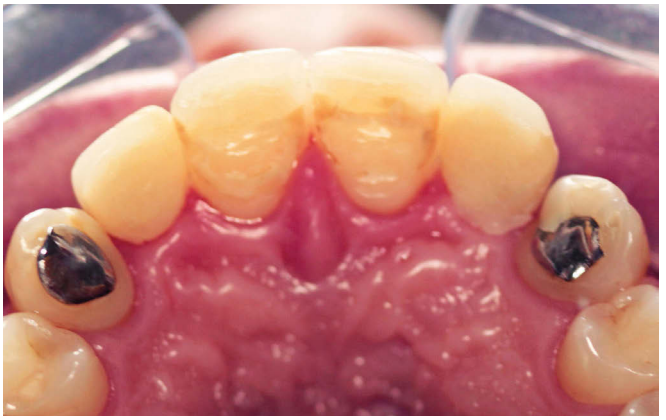

Figure 12 - Immediate provisional of ceramic implant with acrylic crowns.

With more than 100,000 clinical cases in Europe, Zr implants constitute a highly competitive and profitable market driven by an aging population and the growing awareness of patients who do not want metal to be used in their rehabilitation.[41] Soon, the demands and growing maturity of patients will be a key determinant in choosing the material from which their dental implants are manufactured.[6,41]

Computerized systems with advanced technology such as CAD/CAN enable the production of stronger abutments and restorations faster and at a lower cost, thereby improving manufacturing processes of ceramics, with greater precision and mechanical durability. These are mandatory requirements in future metal-free rehabilitations.[14,23,24,37,38,41] Zirconium/titanium in combination[25] with poly-crystalline glass-alumina, sintered by emerging nanotechnologies and new surface treatments, will decrease the diameter and osseointegration time of these new materials, raising the therapeutic possibilities for increasingly demanding audiences.[41,42]

Most studies in this review adopted the indication of Zr as a substitute for Ti in future Dental Implantology, but pointed out the need to ground their decision in further prospective clinical trials and long-term retrospective studies. Therefore, the authors of this study do not yet recommend its use in routine clinical practice.[3,4,6-23,25-30,36,38,41]

Conclusions

- Currently, Zr dental implants are a viable alternative to replace Ti implants in selected cases. However, clinical data regarding ceramic systems are still insufficient to recommend them in routine clinical practice.
- Compared with Ti, Zr ceramics features less bacterial adhesion, enabling an increased longevity.
- The Zr implant systems found in this review were: InCerMed, Cera Root, White Sky, Z-Systems, Easy-Kon, Zit-Z Ceramic, Zeramex, Denti Circon Implants, Zimplant-Biosyr, Omnis-Creamed, White Implants and Ziraldent.
- Besides the high cost and the need for protectors during healing, some ZrO2 ceramics may suffer early hydrothermal degradation. Given a lack of standardization of the materials surveyed in this study, new ISO standards are warranted.
- Finally, it is a very promising market due to technological advances and the increased awareness of patients, who seek metal-free healthcare and beauty treatments.

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Abstracts of articles published in important Implantology, Prosthodontics and Periodontics journals from around the world

Dario Augusto Oliveira **MIRANDA***

Are marginal bone levels and implant stability/mobility affected by single-stage platform switched dental implants? A comparative clinical study

Dursun E, Tulunoglu I, Canpınar P, Uysal S, Akalın FA, Tözüm TF.

Clin Oral Implants Res. 2012 Oct;23(10):1161-7.

Objectives: The aim of this study was to evaluate short-term bone level and stability/mobility measurement alterations at platform switched (PS) and standard platform (SP) implants placed in mandibular premolar/molar regions using a single-stage protocol. **Material and methods:** Sixteen PS and 16 SP implants restorated with fixed prosthesis were included. Standard implant dimensions were used for both implant systems. After 3 months of osseointegration, implants were connected to abutments and final restorations were performed. Marginal bone loss was measured by standardized periapical radiographs. Implant stability/mobility was determined by resonance frequency analysis (RFA) and mobility measuring (MM) device values. Peri-implant parameters were evaluated with clinical periodontal indices and all parameters were assessed at baseline, 1, 3, and 6 months after the surgery. **Results**: After 6 months, all implants showed uneventful healing. Radiographic evaluation showed a mean bone loss of 0.72 mm for PS and 0.56 mm for SP implants, and there were no significant differences between implant types. At 6 months, mean implant stability quotient (ISQ) values were 73.38 and 77 for PS and SP implants, respectively. Mean MM values were -4.75 for PS and -6.38 for SP implants. Mean MM values were lower for SP implants compared to PS implants at all time points. No significant differences were detected between implant types according to clinical peri-implant parameters. **Conclusions:** The micro-gap at crestal level which immediately exposed to the oral cavity in non-submerged two part implants seems to have adverse influence on the marginal bone level.

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Platform switching and marginal bone-level alterations: The results of a randomized-controlled trial

Canullo L, Fedele GR, Iannello G, Jepsen S.

Clin Oral Implants Res. 2010 Jan;21(1)115-21.

Objectives: This randomized-controlled trial aimed to evaluate marginal bone level alterations at implants restored according to the platform-switching concept, using different implant/abutment mismatching. **Material and methods:** Eighty implants were divided according to the platform diameter in four groups: 3.8 mm (control), 4.3 mm (test group(1)), 4.8 mm (test group(2)) and 5.5 mm (test group(3)), and randomly placed in the posterior maxilla of 31 patients. After 3 months, implants were connected to a 3.8-mm-diameter abutment and final restorations were performed. Radiographic bone height was measured by two independent examiners at the time of implant placement (baseline), and after 9, 15, 21 and 33 months. **Results:** After 21 months, all 80 implants were clinically osseointegrated in the 31 patients treated. A total of 69 implants were available for analysis, as 11 implants had to be excluded from the study due to early unintentional cover screw exposure. Radiographic evaluation showed a mean bone loss of 0.99 mm (SD = 0.42 mm) for test group(1), 0.82 mm (SD = 0.36 mm) for test group(2) and 0.56 mm (SD = 0.31 mm) for test group(3). These values were statistically significantly lower (P<0.005) compared with control (1.49 mm, SD = 0.54 mm). After 33 months, five patients were lost to follow-up. Evaluation of the remaining 60 implants showed no difference compared with 21 months data except for test group(2) (0.87 mm) and test group(3) (0.64 mm). There was an inverse correlation between the extent of mismatching and the amount of bone loss. **Conclusions:** This study suggested that marginal bone level alterations could be related to the extent of implant/abutment mismatching. Marginal bone levels were better maintained at implants restored according to the platform-switching concept.

Immediate rehabilitation of the edentulous mandible with screw type implants: Results after up to 10 years of clinical function

Heschl A, Payer M, Platzer S,

Wegscheider W, Pertl C, Lorenzoni M.

Oral Implants Res. 2012 Oct;23(10):1217-23.

Objectives: The aim of this prospective case series was to evaluate the results of an immediate loading concept using four Xi VE S plus implants in the edentulous mandible, after a period of up to 10 years of clinical function. **Material and methods:** Thirty patients were treated with four implants each placed interforaminally and provisionally restored within 1 week. Radiographic bone levels, condition of the peri-implant mucosa, implant survival and success were recorded annually from implant insertion (baseline) up to 10 years after final restoration. **Results**: A total of 120 Xi VE S plus implants were placed in the interforaminal region. A significant coronal bone loss of 1.80 mm (SD 4 0.65) was recorded within the first 8 years of function (P < 0.001). Within the next years no further significant increase of bone resorption was observed. The mean values of the plaque, calculus, bleeding and mucosal indices and probing depth remained low throughout this period. All implants were inserted with an insertion torque of more than 32 N cm. Two losses (1.7%) occurred prior to permanent restoration (1 and 3 months post-insertion), resulting in a survival rate of 98.3% over the entire observation period. Four implants were recorded as failures due to excessive bone resorption, resulting in an overall success rate of 95%. **Conclusions:** The results

of this study indicate that in selected patients immediate restoration of dental implants in the edentulous mandible will achieve a clinically predictable outcome.

Biological complications and peri-implant clinical and radiographic changes at immediately placed dental implants. A prospective 5-year cohort study

Rodrigo D, Martin C, Sanz M.

Clin Oral Implants Res. 2012 Oct;23(10):1224-31.

Objectives: To evaluate clinically and radiographically immediate implants 5 years after insertion and to compare them with delayed-placed implants in the same subjects. Material and methods: Twenty-two consecutive patients that needed at least two implants for replacing hopeless teeth, one immediately upon extraction and the other in a delayed fashion (at least 4 months post-extraction) were selected in this prospective cohort study. Post-extraction immediate implants (II) and delayed implants (DI) groups were defined. One and 5 years after implant loading, clinical and radiographical outcome variables were recorded and analyzed both at site and at implant level. Intragroup and inter-group comparisons were performed. Results: The intergroup comparison did not show significant differences for plaque index, bleeding on probing and suppuration. These parameters worsen in both groups along the study. This trend was stronger for the plaque index in the group II, which increased from 15.6% at 1 year to 25.9% at 5 years ($P < 0.04$). One year after loading, the sites with probing depth U5 mm were higher for the group II compared to DI (2.5% vs. 0%; $P = 0.049$). At the end of the study, no significant statistical differences were found. Radiographically, bone crestal changes did not yield significant differences. During the follow-up period, 25% of the implants (26.4% in group II and 23.5% in DI) showed biological complications: Mucositis (20%) and/or peri-implantitis (5.8%). No differences between groups were found. Conclusions: Within the same patients, the implants placed with the immediate protocol demonstrated a higher tendency to crestal bone loss and to peri-implantitis, although these differences were not statistically significant.

Influence of bone augmentation procedures on the short-term prognosis of simultaneously placed implants

Rammelsberg P, Schmitter M, Gabbert O, Lorenzo Bermejo J, Eiffler C, Schwarz S.

Clin Oral Implants Res. 2012 Oct;23(10):1232-7.

Objectives: The purpose of this study was to investigate the effect of simultaneous bone-augmentation procedures, and their combination, on the survival of dental implants and on the incidence of complications. Material and methods: Within a retrospective analysis, 958 implants placed in 404 patients (mean age 58.18) were selected from a prospective clinical study. In 304 cases of reduced bone width, bone spreading (n = 217) with hand osteotome, or bone splitting (n = 15), or guided bone regeneration (n = 72) combined with autogenous bone grafts were also performed. Eighty-eight implants were placed in combination with simultaneous internal sinus floor elevation without using graft material. For 194 additional implants, several augmentation procedures were combined because of extensive bone deficits. Three-hundred and seventy-two conventionally placed implants served as controls. Implant failures and complications were recorded after a mean observation period of 2.1 years (maximum 6.9 years). Results: Seventeen

failures and nine additional implant-related complications were observed. After 4 years, Kaplan-Meier curves revealed a probability of survival without complication of 97.5% for conventionally placed implants, and 95.8% for implants placed in combination with a single augmentation technique. If several augmentation techniques were combined, success decreased to 94.1%. Complication-free survival differences between combined augmentation techniques and conventionally placed implants were significant (P = 0.004). Age, gender, and location showed no effect on implant survival. **Conclusions:** It can be concluded that simultaneous bone-augmentation techniques slightly reduce short-term prognosis for dental implants. This effect was more pronounced when advanced defects required the combination of several augmentation procedures.

Quantitative biomechanical analysis of the influence of the cortical bone and implant length on primary stability

Hong J, Lim YJ, Park SO.

Clin Oral Implants Res. 2012 Oct;23(10):1193-7.

Objectives: The aim of the study was to investigate the influence of cortical bone and increasing implant fixture length on primary stability. Further investigation considered the correlation between the presence of cortical bone at the marginal bone and implant stability measured by insertion torque (IT) and resonance frequency analysis (RFA), as well as implant length, were determined. **Materials and methods:** Two different types of polyurethane bone models were compared. (Group 1: With cortical and cancellous bone; Group 2: With cancellous bone only). A total of 60 external type implants (∅ 4.1, OSSTEM(®), US II(®)) with different lengths (7, 10, and 13 mm) were used. IT was recorded automatically by a computer which was connected to the Implant fixture installation device during the placement. RFA was conducted to quantify the primary implant stability quotient (ISQ). All two measurements were repeated 10 times for each group. **Results:** All these differences were statistically significant between the two groups (P < 0.001) and intragroups (P < 0.001). Upon comparing the IT, cortical bone appears to have a greater influence on implant stability than implant lengths, whereas the RFA value strongly affects implant length rather than the presence of the crestal cortical bone. **Conclusions**: The quantitative biomechanical evaluations clearly demonstrated that primary implant stability seems to be influenced by the presence of a cortical plate and total surface area of the implant fixture appears to be the decisive determinant for ISQ value.

Dynamics of soft tissue healing around implants and teeth after flap surgery. A study in a dog model

Sukekava F, Lima LAPA, Araujo MG, Liljenberg B, Lindhe J. Dynamics of soft tissue healing around implants and teeth after flap surgery. A study in a dog model

Aim: The aim of this study was to describe and to compare some characteristics of the soft tissue healing process around teeth and implants after flap surgery. Material and **Methods:** Five beagle dogs had their mandible third and fourth premolars extracted in both quadrants. After three months, two titanium fixtures (Osseospeed™) were installed and abutments were connected at each side of the mandible. After 3 months, four regions characterized by one implant and the adjacent tooth were identified in each dog. One region was randomly selected and soft tissue resective flap surgery was performed at its buccal aspect. The lingual soft tissues were not elevated and were regarded as control sites. The remaining three regions were randomly treated in an identical manner and the dogs were sacrificed to provide biopsies representing healing intervals of 1, 2, 4 and 12 weeks. The biopsies were prepared for histological and morphological analyses. Mean values and standard deviation was calculated using the dog as a statistical unit. Student's t test was used ($p<0.05$) **Results:** Morphometric and histometric analyses have shown that the hard and soft tissues surrounding teeth were completely healed in 4-week interval. However, it took from 4 to 12 weeks for the peri-implant mucosa to heal completely. **Conclusion:** The healing process around teeth and implants follows a similar sequence of events. Nevertheless, the complete process of healing and maturation of the peri-implant tissues takes longer than around teeth.

Tooth Loss in quitters and continuing smokers

Gomes EF, Corraini P, Pannuti CM, Romito GA, Rosa EF, De Micheli G, Inoue G, Guglielmetti MR, Sanda SR. Tooth loss in quitters and continuing smokers

Aim: The aim of this study was to evaluate tooth loss in quitters and continuing smokers with chronic periodontal disease who attended a smoking cessation clinic. **Material and Methods:** Subjects willing to quit smoking enrolled in the service offered at the Smoking Cessation Clinic at the University Hospital in São Paulo, Brazil. They received non-surgical periodontal treatment and concomitant smoking cessation therapy. Periodontal maintenance was performed every 3 months until 12 months of maintenance. A single, calibrated blinded examiner to smoking status conducted full mouth periodontal examination at the baseline, after 3, 6 and 12 months after periodontal treatment. The same examiner verified tooth loss during maintenance program. Within the 12 months the necessity of tooth extraction was discussed by at least three periodontists after clinical and radiographic analysis. **Results:** Of 201 enrolled

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patients, 93 met the eligibility criteria and 52 remained in the study for one year. Of these, 17 quit smoking and 35 continued to smoke or oscillated. After one year, the mean tooth loss was of 0.12 (+0.6) in quitters and 0.51 (+ 1.0) in continuing smokers (p = 0.16). Six quitters lost their teeth (33.3%), while 7 (70%) smokers lost their teeth (p = 0.39). Quitters lost 18 teeth and continuing smokers lost 10 teeth. **Conclusion:** There was no significant difference in tooth loss between subjects who quit smoking compared to those who continued to smoke.

The effectiveness of semilunar technique for the treatment of gingival recessions

Dias AT, Kahn S, Imperial R, Menezes CCD, Santana RBD. The effectiveness of semilunar technique for the treatment of gingival recessions

Gingival recession and dental hipersensibility are constant and daily complaints. More than 90% of the population between the ages of 20 and 40 have at least one root exposure. With this in mind, the object of the present study was to compare the results of root coverage in localized bilateral gingival recession, Miller class I, with semilunar flap technique (Tarnow, 1086) using microsurgery (test side) and macro surgery (control side). Fourteen patients, who were being treated at the Veiga de Almeida University Health Center, between the ages of 25 and 41, non-smokers, without systemic diseases, without any history of periodontal disease and who weren't using any medicines that would compromise their periodontal health or healing, were included in this study. Upper canine and premolars with localized gingival recession up to 3 mm were treated. The study followed the split mouth design and choosing the test side or control side was done randomly. All the surgical procedures were done by the same operator to assure optimum standardization levels. The patients were followed up on for six months, where the percentage of root coverage was compared between the test side and the control side of each patient, along with assessing the degree of esthetic satisfaction and post operative discomfort. The mean age was 31.36 (45.08) and 57.14% were female. Six canine, 14 first-premolars and eight second premolars were treated. The average root coverage of the control side (macrosurgery) was 42.40% (416.98). The total coverage was reached in 4 of the 28 procedures (14.28%), two on the test side and two on the control side. Regarding the esthetic evaluation, four surgeries reached the maximum permitted degree (10) and the mean was 6.73%. In one site only was there registered average (5) post operative pain and in 19 (67.86%) sites there was no pain.

Protease-activated receptor-1 expression is increased in chronic periodontitis patients after non-surgical periodontal treatment

Alves VTE, Eichler R, Silva HAB, Brito CAT, Viera PVA, Carvalho MHC, Holzhausen M. Gingipain from Porphyromonas gingivalis is associated to Protease-activated receptor-2 expression in chronic periodontitis patients

Objective: Protease activated receptor 1 (PAR-1) seems to play a role in vascular matrix deposition after injury, bone repair and homeostasis of periodontal tissues, as well as proliferation of gingival fibroblasts. The objectives of this study were to investigate the PAR-1 mRNA expression in human chronic periodontitis and to evaluate whether periodontal treatment affects its expression. Material and **Methods:** Gingival crevicular fluid (GCF) samples and clinical parameters consisting of measuring probing depths (PD), clinical attachment loss (CAL), bleeding on probing (BOP), and gingival (GI) and plaque index (PI) were collected from periodontally healthy (control) and moderate chronic periodontitis patients before and 45 days after periodontal non-surgical treatment. PAR-1 mRNA at the GCF was evalu-

ated by real time-PCR (qPCR). **Results:** Clinical parameters (PD, CAL, BOP, GI, and PI) were significantly improved after periodontal therapy ($p<0.01$). The q-PCR analysis showed that before periodontal therapy, PAR-1 mRNA levels in chronic periodontitis were not statistically ($p<0.05$) different from controls. Periodontal treatment led to a substantially increase of PAR-1 expression in chronic periodontitis ($p<0.05$). **Conclusion:** PAR-1 mRNA levels in chronic periodontitis are not different from control patients. Non-surgical periodontal treatment resulted in increased expression of PAR-1 in chronic periodontitis patients, therefore suggesting its role in periodontal tissue repair.

The effect of non-surgical periodontal treatment on C-Reactive Protein (CRP) levels in patients with chronic periodontitis: a controlled clinical trial

De Souza AB, Okawa RTP, Silva CO, Sukekava F, Araujo MG. The effect of non-surgical periodontal treatment on C-Reactive Protein (CRP) levels in patients with chronic periodontitis: a controlled clinical trial

Aim: The aim of the present study was to evaluate serum C-reactive protein (CRP) levels in chronic periodontitis patients and periodontally healthy individuals and to assess the effect of non-surgical periodontal treatment on the CRP levels. **Material and Methods:** Twenty two patients with chronic periodontitis (Test Group) and 22 periodontally healthy individuals without any systemic disorder (Control Group) were included in the study. At baseline, periodontal clinical variables and CRP levels were obtained in both groups. In the Test Group, oral hygiene instruction and scaling and root planning were carried out and after 60 days periodontal clinical variables and CRP levels were re-evaluated. **Results:** The baseline CRP level in the Test Group was significantly higher than the corresponding values in the Control Group (1.97±1.55 mg/L vs. 1.26±1.05 mg/L; $p<0.05$). After periodontal treatment in the Test Group, there were improvements in all periodontal clinical variables ($p<0.05$). In addition, the CRP level decreased significantly only in those patients with higher baseline levels of CRP (>3 mg/L). **Conclusion:** Chronic periodontitis seemed to promote elevated levels of CRP. Furthermore, non-surgical periodontal treatment significantly decreased the levels of CRP in patients with high baseline levels of such pro-inflammatory cytokine.

Microbiological diversity of localized aggressive periodontitis by 16S rRNA clonal analysis

Faveri M, Ribas TRC, Silva ESC, Figueiredo LC, Feres M, Mayer MPA. Microbiological diversity of localized aggressive periodontitis by 16S rRNA clonal analysis

Aim: The purpose of this study was to determine the bacterial diversity in the subgingival plaque of subjects with localized aggressive periodontitis (LAgP) by using capillary-based Sanger sequencing on 16S rRNA gene. **Material and Methods:** Thirty subjects were assigned into two groups: LAgP (n=15), consisting of subjects with LAgP; and PH (n = 15), consisting of subjects with periodontal healthy (PH). Two subgingival samples were taken in the LAgP group [probing depth (PD) >5mm and PD<3mm] and one in the PH group. DNA was extracted and 16SrRNA bacterial genomic libraries were constructed and sequenced. Bacterial diversity was estimated and a phylogenetic tree was built. **Results:** A total of 2.041 clones were analyzed (mean, 45.4 4 4.5 clones per sample) and 164 phylotypes were identified. Of these, 42% were represented by not-yet cultivated phylotypes. Associations with LAgP were observed for several uncommon species or phylotypes, such as Selenomonas

sputigena, Filifactor alocis, Pseudoramibacter alactolyticus, Dialister pneumosintes, Dialister invisus, Synergistes sp BH007/OT359, Prevotella sp. AH125/OT292, Desulfobulbus sp. R004/OT041 and Selenomonas sp. DS051/OT137. Species or phylotypes more prevalent in periodontal health included species of Streptococcus, Actinomyces sp. BL008/OT171 and Actinomyces sp. IP073/OT448. Species or phylotypes from the genus Parvimonas, Pseudoramibacter, Synergites, Dialister and Filifactor was found in higher prevalence in shallow sites from LAgP subjects when compared with PH. **Conclusion:** Species or phylotypes not previously associated with LAgP may be involved with the disease. In addition, there are differences between the microbial diversity present at shallow sites of subjects with PAgL and PH.

Comparison of subgingival microbial profiles of chronic periodontitis and periodontal health using the RNA-oligonucleotide quantification technique

Mestnik MJ, Oliveira ACG, Feres M, Teles F, Mayer MPA, Faveri M. Comparison of subgingival microbial profiles of chronic periodontitis and periodontal health using the RNA-oligonucleotide quantification technique.

Aim: To assess the prevalence, levels and proportions of uncultivated/unrecognized bacterial taxa, as well as "unusual" bacterial species in chronic periodontitis patients (ChP) and periodontally healthy individuals (PH) using RNA-oligonucleotide quantification technique (ROQT). **Material and Methods:** ChP patients (n=19) and PH subjects (n=15) were selected and their clinical periodontal parameters were evaluated. Subgingival plaque samples were collected and analyzed for the prevalence, levels and proportions of 39 bacterial taxa, including cultivated and uncultivated/unrecognized microorganisms using ROQT. **Results:** ChP subjects showed significantly higher mean counts, prevalence and proportion of Tannerella forsythia, Treponema denticola, Porphyromonas gingivalis, Selenomonas sputigena, Filifactor alocis, Prevotella sp. oral clone AH125 (Oral Taxon 292), TM7 sp. oral clone AH040 (OT 346), Tannerella sp. oral clone BU063 (OT 286), Peptostreptococcus sp. oral clone DA014 (OT 113) e Selenomonas sp. oral clone EW084 (OT 146), while Actinomyces gerencseriae, Veillonella parvula, Atopobium rimae, Rothia dentocariosa/mucilagionsa and Actinomyces naeslundii were found in higher mean counts and proportion in PH ($p<0.01$). Regarding "unusual" bacterial species, S. sputigena and F. alocis were positively correlated ($r>0.5$; $p<0.05$) and they both were correlated with PD increase ($p<0.05$). Peptostreptococcus sp. OT 113 was the only uncultivated bacterial taxon that showed a positive correlation with PD increase ($r> 0.5$, $p<0.05$). Uncultivated/unrecognized taxa accounted for 42.8% and 44.1% of the subgingival microbiota in ChP and PH subjects, respectively. **Conclusion:** The microbial profiles of uncultivated/unrecognized bacterial species and "unusual" bacterial species in subjects with ChP differs markedly from that observed in subjects with PH.

Levels of Selenomonas sputigena and not-yet-cultivated Selenomonas phylotypes in subgingival biofilms of generalized aggressive periodontitis

Fermiano D, Gonçalves LFH, Feres M, Figueiredo LC, Teles F, Faveri M. Levels of Selenomonas sputigena and not-yet-cultivated Selenomonas phylotypes in subgingival biofilms of generalized aggressive periodontitis

Aim: To compare the levels of Selenomonas sputigena and uncultivated/unrecognized Selenomonas species in subgingival biofilms from generalized aggressive periodontitis subjects (GAgP) and periodontaly healthy individuals (PH). **Material and Methods:** GAgP (n=15) and PH (n=15)

subjects were recruited and their clinical periodontal parameters were evaluated. Subgingival plaque samples were collected (9 samples/subject) and analyzed for the levels of 10 bacterial taxa, including cultivated and uncultivated/unrecognized microorganisms using the RNA-oligonucleotide quantification technique (ROQT). Differences in the levels of the test taxa between groups were sought using the Mann-Whitney test. **Results:** GAgP subjects showed significantly higher mean counts of Porphyromonas gingivalis, Selenomonas sputigena and Selenomonas oral clone CS002 (Mitsuokella sp. Oral Taxon 131), while Actinomyces gerencseriae and Streptococcus sanguinis were found in higher mean counts in PH subjects ($p<0.01$). Selenomonas sp. oral clone EW084 (Selenomonas sp. OT 146) was only detected in the GAgP group. In the GAgP group, levels of P. gingivalis and S. sputigena were higher in sites with probing depth (PD) >5mm than in shallow sites (PD <3mm) ($p<0.01$). Furthermore, sites with PD<3mm in GAgP subjects harbored higher levels of these two species than sites in PH subjects. There were positive correlations between PD and levels of P. gingivalis ($r=0.77$; $p<0.01$), S. sputigena ($r=0.60$; $p<0.01$) and Selenomonas dianae (oral clone EW076) ($r=042$, $p<0.05$). **Conclusion:** S. sputigena, Selenomonas sp. oral CS002 (OT 131) and Selenomonas sp. oral clone EW084 (OT 146) may be associated with the pathogenesis of GAgP, and their role in the onset and progression of this infection should be further investigated.

Impact of different dosages and duration of systemic antibiotic therapy in the treatment of generalized chronic periodontitis: a double-blinded, placebo-controlled, RCT- preliminary results

Borges J, Faveri M, Figueiredo LC, Duarte PM, Feres M. Impact of different dosages and duration of systemic antibiotic therapy in the treatment of generalized chronic periodontitis: a double-blinded, placebo-controlled, RCT- preliminary results.

Aim: Although metronidazole (MTZ) + amoxicillin (AMX) has been constantly used as an adjunct to the periodontal treatment, the optimal dosage and duration of this antibiotic protocol is still unclear. Therefore, the aim of this study was to compare the clinical outcomes of different doses of MTZ as well as of the duration of the systemic administration of MTZ+AMX in the treatment of generalized chronic periodontitis (ChP). **Material and Methods:** Sixty subjects were randomly assigned to receive scaling and root planning (SRP)-only (control group) or combined with 250 mg or 400 mg of MTZ, plus AMX (500 mg), for either 7 or 14 days (four test groups). Subjects were clinically monitored at baseline and at 3 months post-therapy. **Results**: The four antibiotic groups exhibited overall better clinical results in comparison with the control group. However, subjects receiving MTZ (250mg or 400 mg) + AMX during 14 days presented the deepest reduction in the full-mouth mean probing depth (PD) and gain in clinical attachment (CA) in comparison with those treated with SRP-only ($p<0.05$). These two test groups also exhibited a greater mean gain in CA in initially deep sites and a lower percentage of sites with PD>5 mm at 3 months post-treatment, in comparison with the control group ($p<0.05$). **Conclusion:** The adjunctive use of MTZ+AMX during 14 days, independently of the MTZ dosage used, offers short-term clinical benefits, over SRP alone, in the treatment of subjects with generalized ChP. The added benefits of the 7-days antibiotic regimen were less evident.

MTZ alone or with AMX in the treatment of chronic periodontitis: a 1-year double-blinded, placebo-controlled, RCT. Part I: Clinical results

Feres M, Soares GM, Mendes JA, Faveri M, Socransky SS, Teles R, Figueiredo LC. MTZ alone or with AMX in the treatment of chronic periodontitis: a 1-year double-blinded, placebo-controlled, RCT. Part I: Clinical results

Aim: Previous studies have suggested that the adjunctive use of metronidazole (MTZ) or MTZ+amoxicillin (AMX) is beneficial in the periodontal treatment. However, data from double-blinded placebo-controlled RCTs beyond 6 months for the MTZ+AMX therapy or for comparisons between these two antibiotic protocols are still lacking. Therefore, the aim of this study was to evaluate the effects of the adjunctive use of MTZ or MTZ+AMX in the treatment of generalized chronic periodontitis (ChP). **Material and Methods:** 118 subjects were randomly assigned to receive scaling and root planing (SRP)-only or combined with MTZ (400 mg/TID) or MTZ+AMX (500 mg/TID) for 14 days. Subjects were clinically monitored at baseline, 3, 6 and 12 months post-therapy. **Results**: The two antibiotic groups showed lower mean number of sites with probing depth (PD)>5 mm (SRP+MTZ+AMX=4.7, SRP+MTZ=6.3, SRP=16, $p<0.05$), and fewer subjects exhibiting nine or more of these residual sites (SRP+MTZ+AMX=9, SRP+MTZ=11, SRP=25, $p<0.05$) at 1 year post-treatment. Logistic regression analysis showed that MTZ and MTZ+AMX were the only significant predictors of subjects presenting M 4 sites with PD³5 mm at 1 year (MTZ+AMX: OR, 13.33; 95% CI, 3.75-47.39; P=0.0000; MTZ: OR, 7.26; 95% CI, 2.26-23.30; P=0.0004). The frequency of adverse events did not differ between the two antibiotic treatments ($p>0.05$). **Conclusion:** The adjunctive use of MTZ or MTZ+AMX significantly improved the outcome of mechanical treatment of generalized ChP. MTZ+AMX should be considered the first-line treatment because it increased de odds of a subject converting to "low risk" of disease progression, with similar tolerability to the MTZ therapy.

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