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The metamorphosis of Dental Press Implantology

The best publishing houses in the world are continuously rethinking their business and seeking new ways to reach their readers. Additionally, publication of scientific literature is nowadays mainly in English language.

Dental Press Journal of Periodontology and Implantology came into existence in 2007, and has taken part in this process of rethinking: in 2012, the journal not only had its title changed into Dental Press Implantology, but also began to be officially published in English, despite keeping its Brazilian Portuguese version in order to meet the expectations of its former readers. At the head of its editorial board is Prof. Dr. Alberto Consolaro, with his experience and scientific charm, his desirable eagerness and love for scientific dissemination. Prof. Dr. Consolaro was invited to be the editor of this journal together with Prof. Dr. Carlos Eduardo Francischone.

In the company of these two editors, we are continuously encouraged by new challenges to create projects in order to solidify Dental Press Implantology. The journal is currently indexed in Ulrichs (2013), EBSCO (2012), LILACS (2007) and BBO (2007), and we hope that the articles published in Dental Press Implantology have their visibility as well as their impact increased, which will contribute to the indexation of the journal in internationally recognized databases — similarly to what happened with the Dental Press Journal of Orthodontics (Dental Press' first periodical) which, 17 years after being released, became part of the MEDLINE/PubMed collection, the most important database in the Health Sciences field.

Prof. Dr. Carlos Eduardo Francischone has been the editor of this journal since it was firstly published. In the present issue, besides the articles selected for publication, we are delighted to have a propitious interview with such an important icon of the Dentistry field, whose personal trajectory is inspiring to all of us. It is a privilege to read not only about his accomplishments and the lessons he has compiled from great masters and researchers, but also about the course of national and international science and research.

To the delight of our eyes and to induce further reflection, the present issue also presents the photograph in the Image and Science section and the select group of abstracts in the Observatory section.

Furthermore, given that Biology, associated with technology, increasingly offers more options for Implantodontics to advance in terms of techniques and possibilities that provide proper oral rehabilitation to patients, every issue of Dental Press Implantology presents new approaches to biomaterials and rehabilitation techniques. The technical possibilities increase and, for this reason, systemically reading the articles becomes a compulsory task for clinicians, as well as Implantodontics researchers and professors, to constantly update their practice.

In modern society, there is no place for professionals who are highly specialized in one field of knowledge, only. Thus, interacting with other specialties and the possibilities that they offer is a demand of the way Implantodontics has advanced: by overlapping with other specialties. Bone biology gives support to the clinical practice and the implants are constantly being improved in order to optimize their relation with tissues, cells and molecules.

Dental Press Implantology is, therefore, offered on the basis of such a practice, by means of which it has significantly matured. Moreover, we believe that this journal is now able to prove that its goals and objectives have been fulfilled not only due to the efforts made by its staff, but also due to the receptiveness of those who fight for this field of knowledge — which has brought indispensable help in the increasingly intense and responsible development of this important mean of disclosing the dental literature.

Enjoy your reading!
Dario Miranda — assistant editor

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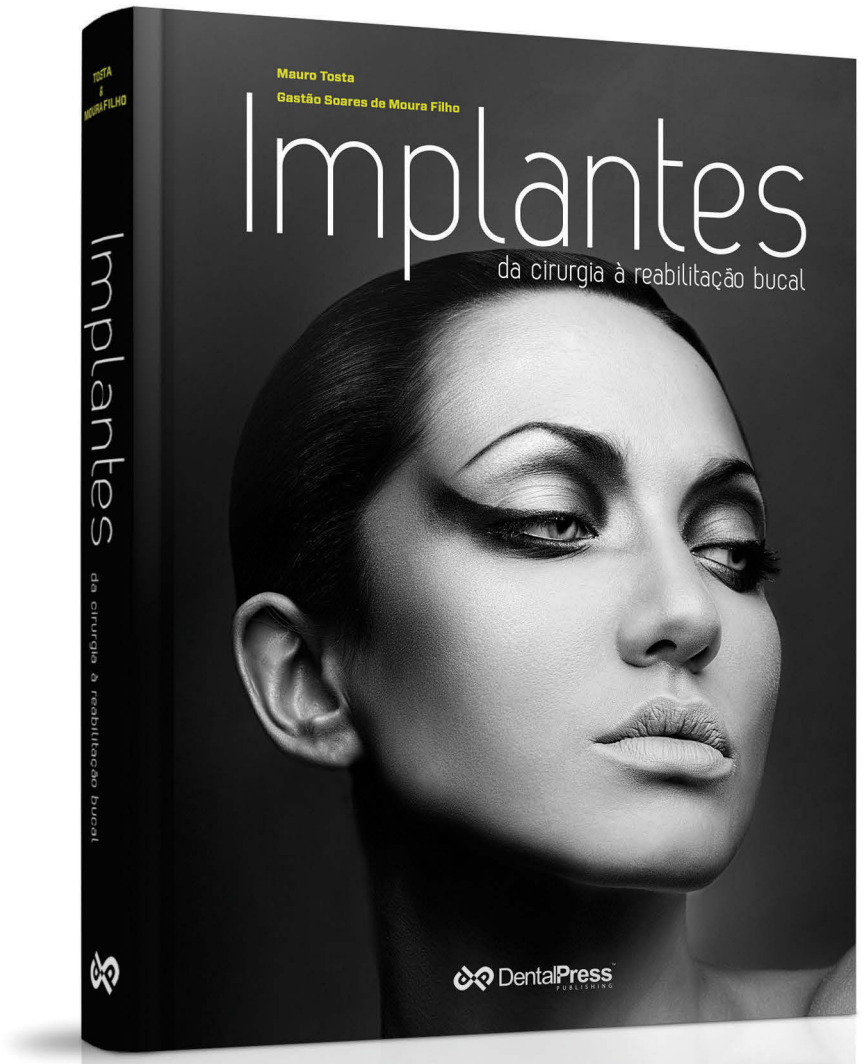

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Carlos Eduardo Francischone

The current issue of Dental Press Implantology presents to its readers an interview with one of the most highly respected and important Brazilian professors in the Dentistry field. Due to his restrained behavior — especially for having been one of the editors-in-chief of this journal for many years — he resisted as much as he could to his colleagues' recurrent requests as well as to the continuous attempts of this journal editorial board to highlight him in this section.

After participating in the 1st Meeting of Prof. Dr. Carlos Eduardo Francischone's students and former students, held in the city of Campinas/SP — Brazil — in April of 2013, during which Dr. Francischone was interviewed by his former students at an auditorium for about an hour and a half, he finally agreed on having his interview, which was recorded upon his own authorization, used by this journal. It brings curious as well as valuable information of general interest related to the history of Brazilian Dentistry.

Born in the city of Dois Córregos, located in the countryside of São Paulo, Prof. Francischone — as he is widely known — has reported details of his academic success, revealing the trajectory of a humble Brazilian who is persistent in his aims and endowed with a strong personality, an acknowledged career and numerous gifts.

He has received a degree in Dentistry from the School of Dentistry — University of São Paulo/ Bauru, where he is a full professor due to his own merits, acknowledgement and competence. He has become a member of the Brazilian Dentistry Academy as a result of his achievements as a researcher and author of many books. He has advised more than 80 masters and doctors coming from many different states in Brazil as well as from different Latin American, European and African countries.

He is a dental surgeon in the very true sense of the term. He is considered a remarkable professor within the Dentistry field not only for teaching how things should be done, but mainly for practicing to the utmost degree what he teaches, with neither restriction nor omission of details, but for the pleasure of teaching. In addition, he is regarded as a professor endowed with desirable creativity and manual abilities to solve potential problems, complications or incidents occurring in daily clinical practice. Due to his wide experience in clinical practice and teaching, Dr. Francischone is able to perfectly reconcile theory and practice — always with the admirable humbleness of those who know all shortcuts and the best alternatives very well; in addition to knowing the most appropriate paths which have been presented to him by knowledge and experience acquired during 42 years of hard work.

With more than 200 articles published in scientific journals and more than 700 lectures and courses given inside and outside Brazil, he often goes around the world from one scientific event to another, being acknowledged worldwide as a respectful researcher.

Those who are privileged to have a close relationship with Dr. Carlos Eduardo Francischone can easily notice his indefatigable enthusiasm, peculiar to those who love their occupation. An extremely honest, sincere and righteous man who is absolutely fair with everyone around him, acknowledging those who deserve it.

Additionally, this interview presents his special interest in different sports as well as his passion for music — a hobby he has had for most of his life. Graduated in music at the Jauense Conservatory of Music, in 1967, he is the author of his city's anthem, written in partnership with Heusner Grael Tablas and Carlos Nascimento (a well-known Brazilian journalist). His family is definitely his greatest source of renewing positive energy, giving him emotional stability. He is married to Ana Luiza, father of Carlos Eduardo Júnior (dentist), Ana Carolina (dentist) and Fabricio (physician). He is also happy and proud to be little Lucca's grandfather.

Hereinbelow, we present a written record of what has just been mentioned in this brief introduction.

Franklin Moreira Leahy

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Prof. Carlos Eduardo Francischone at his clinic, flanked with some scientific books written by him.

The band "*Os Gatos*" (The cats).

We know that as a young man and an adult you have enjoyed incorporating all sorts of activities into your life. Such activities include not only your interest in carefully watching your father operate Santo Antônio Drugstore — located in the city of Dois Córregos, countryside of São Paulo — with which he was able to keep up The Francischones; but also your eclectic passion for studying music and setting up a band called "*Os Gatos*" (The cats) which remains until these days. In addition, you are also fond of indoor sports, such as table tennis, indoor soccer and chess, as well as other sports, for instance, basketball, soccer and sport fishing. Thus, what encouraged and influenced you, more than 40 years ago, to choose Dentistry as a profession?

Two were the factors that influenced me to choose Dentistry: The first one was the fact that I had a close relationship with my father at the drugstore where he kindly took care of patients, dedicating himself for more than 70 years to such an honorable profession. I used to go along with my father on his "Ford Model A" when he went to his patients' houses to medicate them. At that time, I would repeat to myself how important and good it was to see a person being cured. And that influenced me to go for the health field.

The second factor was my passion for soccer. In my city, there was an excellent soccer player whose name was Estevinho (Dr. Wilson Esteves); he used to play in a Brazilian professional soccer team. I remember reading a newspaper headline that said: "People went to see Pelé playing, but saw Estevinho instead." He studied Dentistry in the city of Araraquara and set up his own office in Dois Córregos. He was an excellent dentist. I still have an amalgam applied to my teeth by Dr. Wilson Esteves when I was 10 or 12 years old...I miss amalgams so much!

In addition, when I was in high school, I used to hate studying Exact Sciences and Drawing, but I loved Biology. There was an interesting episode when I first started at

USP/Bauru School of Dentistry soccer team, 1969.

the University of São Paulo School of Dentistry — Bauru (FOB). On my first day as a student, Professor Noracilde Lima, who used to teach a discipline on Tooth Sculpture, asked each one of us to draw a tooth. The outcome was: my drawing was the worst out of 50. That terrified me, but warned me that I should improve. How could I become a dentist otherwise?

With determination, endeavor, devotion and lots of training, anyone is capable of overcoming difficulties and practicing the proposed aim with excellence. Perseverance is necessary!

These were the two factors that influenced me to choose Dentistry.

Within this same train of thoughts, do you believe that your interest in teaching arose while you were at college, as a vocation? Did it emerge because your colleagues and professors encouraged you to do so? Or did it come out as an opportunity carefully prepared by fate?

First of all, I believe it happened because I see professors as examples, quite unattainable admirable people whose hands guide those who are and will be professionals — on whose hands the future of our nation depends. I must mention two professors, among many others, who exerted great influence in my life. Prof. José Mondelli and Prof. Waldyr Janson are great examples of excellence in teaching, in addition to being skillful and perfectionist dental practitioners. They are real icons.

By chance, when I was in my second year at college, I was invited to teach Biology in a preparatory course for students taking university entrance exams. I took on the challenge and enjoyed that new experience.

That is the reason why I was invited to teach Biology at a college in the city of Bauru when I was in my last year of the undergraduate course. During my last few months as a student, I was invited to teach four different subjects: Pharmacology, Anatomy, Prosthesis and Cosmetic Dentistry. At first, I was an assistant professor, but later on, I became a full professor.

That is when fate began to play its role: I was about to finish an amalgam restoration on a left maxillary first molar when Prof. Mondelli entered my box by chance and asked for an oral mirror so that he could check the restoration I was doing. It was "by chance" because Prof. Aquira Ishikiriane was the one liable for my box. After I had finished the procedure, Prof. Mondelli gave me the oral mirror back and said with a strong tone of voice: "Finish your work and go to my room." I began to shiver as I thought something wrong had happened. When I arrived at his room, I asked: "What is wrong, professor?" He replied: "Starting tomorrow, you will attend the Cosmetic Dentistry Department and soon you will be hired as a professor."

With his mentor, professor and friend Dr. José Mondelli.

Accompanied by Prof. Waldyr Janson, after the Tiradentes medal had been handed in by the APCD (Association of Dental Surgeons from São Paulo).

That was the deepest emotion I had ever experienced, as I felt that one of my ideals was approaching me. That is how I began my career at the University of São Paulo, where I have been teaching for 42 years.

Not a long time ago, Brazilian Dentistry experienced a period when Restorative and Operative Dentistry were the backbone of dental procedures. Many professionals were interested in practicing, studying, teaching and researching within this field, among whom you are, as a full professor of the Cosmetic Dentistry Department at University of São Paulo School of Dentistry, Bauru. Such focus also swung from Cosmetic Dentistry to Periodontology, Prosthesis and Endodontics. At that time, the Orthodontics field stood out as an independent and selective specialty aimed at elective and specific therapeutic procedures. Despite the importance of the specialties mentioned, don't you believe that the emergence of osseointegration and, as a result, Implantodontics, has caused the different specialties to interact within the Dentistry field, allowing planning and treatment to be interdisciplinary?

The osseointegration phenomenon yielded new prosthesis retention methods which provide safety, predictability and longevity. Implantodontics itself has existed since the Etruscan civilization, but with discouraging results.

Today, it has enabled different methods of prosthetic resolution for complete, partial or single edentulous patients, as well as for the rehabilitation of maxillectomy and face-mutilated patients. Thus, dental planning and treatment have become more complex, requiring deep knowledge of Dentistry as a whole. Moreover, Implantodontics has been inserted within interdisciplinary and multidisciplinary contexts, involved with both medical and paramedical fields. I claim that Implantodontics is

the most dependent specialty. Alone, it does not offer neither the best functional nor esthetic results.

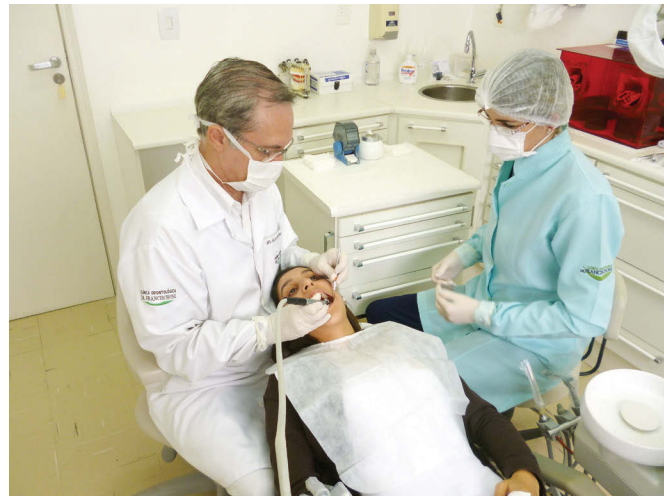
Therefore, the question is: How can we teach Implantodontics for undergraduate and postgraduate students?

Taking into account that you are a professor who originally worked with Cosmetic Dentistry, how did you deal with the changes resulting from osseointegration? When did you become interested in osseointegrated implants?

Implantodontics became part of my professional and academic life thanks to Prof. Mondelli's view and intuition. He once told me: "Ado, investigate this implant thing. It will soon be a success." That happened around 1988. He was right once more.

I should tell another story which demonstrates Prof. Mondelli's unique way of thinking. When I first started in the Cosmetic Dentistry field, he came to me and said: "You are going to have a masters and doctorate degree in Oral Rehabilitation with Prof. Waldyr Janson", who had recently arrived from the USA with a new interdisciplinary approach integrating Prosthesis and Periodontology. Then, I asked him: "Why shouldn't I go for both masters and doctorate in Cosmetic Dentistry, since this is my area of expertise?" Prof. Mondelli pointed his forefinger at me and piercingly replied: "Cosmetic Dentistry is something you must know. You should learn other things, especially Periodontology which can be applied to Cosmetic Dentistry. Additionally, you will apply Prosthesis and Periodontology to your patients." At that time, I worked part-time and also had my own clinic.

Prof. Mondelli's way of thinking brought into existence a new concept of Cosmetic Dentistry. From cavity preparation and restoration-oriented approach to integrated Cosmetic Dentistry interdisciplinarily associated with Periodontology and Prosthesis. Based on this, Prof. Mondelli and his Cosmetic Dentistry team published the book "Integrative Clinical Treatment" (*Tratamentos Clínicos Integrados*) of which I am one of the authors. In my opinion, that is a landmark in Cosmetic Dentistry. I may be exaggerating, but there is Cosmetic Dentistry before and after Prof. Mondelli.



At his clinic where he has enthusiastically and gladly worked.

As for Implantodontics, he was really right. I had no idea of what Implantodontics was.

As soon as I told Prof. Mondelli that I was interested in Implantodontics, he called a friend of his, Dr. Clóvis dos Reis, from the city of Juiz de Fora, who used to work with implants. A week later, I was at Mr. Reis' office learning about Implantodontics.

Afterwards, Uncle Gastão (Prof. Dr. José Alberto de Souza Freitas) also expressed interest in using osseointegrated implants for rehabilitating cleft patients treated at the university hospital. That was when he sent me to the USA with Dr. Heli Brosco to take a course on the IMZ system and to internship at University of South Carolina, in 1989. In 1990, we took the first Brånemark System course.

It was taught by professors Lars Kristerson and Pelle Petterson through Nobel Pharma, at the School of Dentistry, in Bauru.

Two years after that, in 1992, I met Prof. Brånemark. At that time, he started working at the university hospital and I was invited to join his team whose purpose was to work with prosthesis in the rehabilitation of patients operated by him. That was when everything began to happen.

How relevant was Prof. Brånemark's coming to Brazil? How do you evaluate this phase of Brazilian osseointegration?

Prof. Brånemark coming to Brazil was very relevant. Uncle Gastão invited him to come to the university hospital via Dr. Laércio Vasconcelos. In 1992, he began treating cleft as well as maxillectomy and face-mutilated patients. He brought many benefits regarding patients' quality of life and self-esteem.

As a positive result of such a work, Prof. Brånemark published the book "The challenge of Bauru" (*O Desafio de Bauru*) of which I was both clinical coordinator and coauthor. Afterwards, he began treating patients at Sacred Heart University (*Universidade Sagrado Coração - USC, Bauru*) where he set up the Brånemark Osseointegration Center which I coordinated until the Brånemark Institute was built. Prof. Brånemark was the head of the Institute which was built on a site donated by the municipality of Bauru.

In addition, it should be noted that Prof. Brånemark contributed to the learning, spreading and prestige of osseointegration among Brazilian dental surgeons.

In the capacity of a renowned and acknowledged professional known not only in Brazil, but around the world for your theoretical and practical work, considered someone who has left a significant literary legacy and who is capable of going from one specialty to another within the Dentistry field without any issues, how do you feel about being one of the pioneers who developed the first course and the first book for teaching Implantodontics in the country and, as a result, for being responsible for shaping great part of the scientific opinion in Dentistry?

In spite of not belonging to the first generation of Brazilians who began working with osseointegration in the country, I believe I have intensely worked in teaching, researching and treating patients with osseointegrated implants. By the way, it should be noted that the pioneer in using and applying osseointegration concepts in Brazil was Dr. Humberto Cerrutti Filho,[1] whose first implant record is dated of the 22nd of March, 1987.

The need for teaching Implantodontics based upon a solid foundation led us to the necessity of having independent courses included in the curriculum framework of our undergraduate and postgraduate courses, since implant training courses were no longer enough to make professionals feel secure in performing the procedure. Moreover, osseointegrated implant science and technology were quickly heading towards improvements and greater applicability. Dr. Laércio Vasconcelos and I had the opportunity to work together in the development of a different training course model in which, in addition to theoretical content and hands-on, we included surgery and prosthesis practice strictly and responsibly performed directly in patients. It was a hazardous teaching method, however valid for the time it was carried out.

Having this in mind, we created the first Implantodontics course in Brazil, maybe in the world, included in the curriculum framework of an undergraduate Dentistry course. It was compulsory and it first happened in August, 1996 at USC. Before that, in 1994, we gave an Implantodontics

course at UNIMAR, however, as an optional course. At the University of São Paulo School of Dentistry — Bauru, the Implantodontics course was first taught in 2006.

With the support of Mrs. Maria Isabel Leite, my sister, who used to coordinate the Biology Center in 1998, we implemented one of the first masters course in Implantodontics at USC. In 2007, we started with the doctorate course in Implantodontics at the same university.

I retired from USC in July of 2011. Nowadays, I coordinate both the masters and doctorate courses in Implantodontics at São Leopoldo Mandic College, in the city of Campinas, state of São Paulo.

I consider text books to be the most appropriate teaching tool. I published the first one about osseointegrated implants in Brazilian Portuguese, in 2000, and in English later on. Thereafter, other text books were published, most of them written in partnership with my students of both the masters and doctorate courses.

Thus, I currently have more than eleven books published in Brazilian Portuguese, English and Arabic.

Within both Cosmetic Dentistry and Integrated Clinic fields led by Prof. Mondelli, our team published more than twenty text books.

In addition to text books, more than two hundred articles were published and more than six hundred courses and conferences were given inside and outside the country. I strongly state my personal pleasure and fulfillment for having contributed to the formal professional and teaching education of many Brazilian and foreign students and colleagues.

As an expert and talented prospector, you have already discovered many young professors during your academic life. How do you see Implantodontics teaching practice in Brazil? Even with plenty of courses set up in many different regions and important cities in the country, do you believe we are in the right track? How can we assess the quality of such courses?

Teaching Implantodontics is a complex task not only with regard to undergraduate, but also postgraduate courses, especially for its inter/multidisciplinary characteristic.

The important thing is that we have well-prepared masters and doctors who were taught by us and our colleagues and who have eagerly and competently devoted themselves to osseointegration teaching and research. We are delighted to have a close relationship as well as to learn with them. All of this is renewed with the opportunity we have to be around professors of unquestionable scientific competence, world-wide respectability, admirably ethical and moral conduct, and who are models that should be followed. Among many professionals who fit such a profile, I would like to highlight two who are closely related to Brazil, for their warming way of welcoming us and our students in Sweden (especially during the Brazilian Day, an event held every three years in Gothenburg. The next one is going to be held in 2014, in Malmö). Professors Drs. Tomas Albrektsson and Ann Wennerberg truly represent and deserve every single word I have said, not only for being honest friends, but also for the scientific exchange and research they strictly develop.

As for the new generation of professors, they are eager to teach. They just have to choose serious institutions and count on a competent team to develop their courses.

So far, my team and I have been given the opportunity to advise 75 masters and 51 doctors. Many of our former students have already got an academic career, with interesting scientific and didactic researches

Prof. Francischone's students in Gothenburg, Sweden, in front of the School of Dentistry, accompanied by Prof. Tomas Albrektsson during the second Brazilian Day.

Prof. Carlos Eduardo Francischone and Prof. Tomas Albrektsson during the second Brazilian Day meeting.

published in different universities, teaching at state, federal and private universities, coordinating masters, doctorate and specialization courses, working as editors and peer-reviewers of scientific journals as well as in consultancy and technology boards. They have already published more than two hundred articles, nationally and internationally. Additionally, they have published an average of 30 text books in Brazil and more than 50 book chapters.

Having qualified professors provides us with high-quality Implantodontics teaching, and Brazil occupies an outstanding and respectful position in this field around the world.

The great number of courses set up in Brazil, many of them at inadequate institutions, should be dealt with care.

There should be stricter and more frequent inspection carried out by government agencies. In my opinion, only authorized higher education institutions, such as colleges and universities under the approval of CAPES (Coordination for the Improvement of Higher Education Personnel) and MEC (Ministry of Education), should develop and offer postgraduate courses.

Our former students' initiative of organizing biannual* meetings aiming to study and discuss different issues concerning not only scientific-didactic matters, but also those regarding the future of Implantodontics, may be an important channel through which they shall contribute to assess the quality of Brazilian courses.

Dental-surgeons themselves who are interested in taking a specialization, masters or doctorate course in Implantodontics should consistently and directly search for such courses in order to choose the best one for them.

You were involved in coordinating and teaching in *stricto sensu* masters and doctorate programs for 15 years. Is there any remarkable episode or any important incident which surprised you

Prof. Francischone and the chairman of the Brazilian Dentistry Academy, Dr. Brigagão, during the Academy induction ceremony.

"Advising and teaching professionals, masters, doctors, researchers and professors is not enough. The commitment goes beyond that, as they will always have to be scientifically and didactically productive and up-to-date, never forgetting their social view."

(Prof. Carlos Eduardo Francischone's speech during the 1st Meeting of Prof. Dr. Carlos Eduardo Francischone's students and former students, April, 2013).

in a positive or negative sense and which do you consider important to tell us?

Reporting remarkable episodes concerning our academic life is always difficult, especially because there have been so many of them, good and bad ones. I will talk about three.

The first one happened in 1996, when my sister, Maria Isabel Leite, a former coordinator of the Biology Center at Sacred Heart University (USC), gave us the opportunity to implement a course in Implantodontics in the curriculum framework of the undergraduate course. That was the first Implantodontics course implemented in Brazil, maybe in the world.

She also authorized us to start a masters course in Implantodontics — one of the first ones implemented in Brazil as well. It all started when I had a meeting with her on a Holy Thursday. That was how everything began...

We were able to give classes, prepare students for the Implantodontics field and advise masters and doctors, as we have already mentioned.

The second episode refers to the fact that we have to deal with a research and teaching system which oftentimes does not go the way we would like to. In 2011, the Dean of USC proposed amendments in the postgraduate program to which I disagreed. In order to give total freedom to the Dean, I decided to retire. I had already worked enough time

** Interviewer note: The 1st Meeting was held in the Royal Palm Plaza & Resorts Hotel in the city of Campinas/SP on the 5th and 6th of April, 2013. The results were highly satisfactory and originated from discussions regarding the following issues: Alveolar preservation: clinical and histomorphometryc studies, with Prof. Dr. Arthur Belém Novaes Júnior, Techniques on how to speak in public or how to speak extemporaneously in order to catch the audience's attention and curiosity, with Carlos Nascimento, a well-known Brazilian anchorman; among other issues such as Implantodontics teaching models, reduction in price of implants and other components, among others.*

which allowed me to apply for retirement, and I did in July, 2011. Nearly immediately, the Dean of São Leopoldo Mandic College, in Campinas, Professor Dr. José Luiz Cintra Junqueira, invited me to take up the coordination of two postgraduate programs: a masters and a doctorate one.

I was honored to be invited by him and I promptly accepted that new challenge. In October of 2011, we started working on those programs. Following our steps, demonstrating a surprising prove of friendship, professional trust and loyalty, 26 out of 33 students who used to go to USC spontaneously decided to transfer to SLMandic, entering the postgraduate course under our coordination.

That was a remarkable episode in the postgraduate program, maybe the only one happening in Brazil. Those students made a very difficult decision which involved many different consequences regarding logistics — moving to another city, going from one university to the other, formal and financial issues, transportation, rescheduling and trips, accommodation, adaptation to a new course, among other factors. They demonstrated the most legitimate and expressive form of respect, care and credibility that any professor, even the most experienced ones, could ever wish for. Even though I always tried to be idealistic, dedicated, hard-working and participative in all teaching and researching activities in undergraduate and postgraduate programs, that was one of the greatest demonstrations of recognition, prestige and personal emotion that I could have ever experienced.

Due to personal principles, behavior and character, I am deeply thankful to those 26 special students.

And the third meaningful episode that was remarkable to me during these 15 years in which I was involved with *stricto sensu* programs was our former students' initiative of organizing the 1st Meeting of Prof. Dr. Carlos Eduardo Francischone's students and former students. I really take it as an extremely important episode which deserves to be mentioned.

Franklin Leahy, Angelo Menucci, Carlos Eduardo Francischone Júnior and Mauricio Rigolizzo advised these former students who were able to perceive that a postgraduate course is not finished when students receive a masters or doctorate title. It goes far beyond teaching and researching. It is necessary to re-evaluate whether our teaching and researching methods are up-to-date and if new tools are being created. Additionally, we need to discuss controversial issues related to teaching and researching as well as the possibility of extending such practice to the community. Thus, having meetings every two years, as proposed by my former students, is essential. By the way, the next meeting is going to be held in the city of Salvador, state of Bahia. The date has not been set yet.

Surely, their initiative demonstrates that they wish to be and are already becoming real professors. Certainly, they are going to be successful people. Quoting Tom Jobim: "In Brazil, being successful is an insult." It is a pity that many people think and act as so.

What is your opinion about the current market of dental implant companies? Is imported implant better than the national one? Has this industry created new jobs and contributed to the growth of the country? Has it been beneficial to patients?

The Brazilian market of implants is already broad and tends to expand even more in the next few years. It is one of the most growing markets in the country and around the world as well. This is due to many reasons, such as: more information has been provided to patients via means of communication and dentists; a higher number of products has been offered and more dentists

Official examination for the post of full professor at USP, with the board of examiners.

have been qualified to place implants and prosthesis onto implants; people are living longer and, as a result, the number of partial edentulous people is increasing with time. According to information provided by the Ministry of Health, 30 million Brazilians are complete edentulous. This research did not include any dental extraction cases, which certainly would increase the number of complete edentulous patients. According to information provided by the United Nations, more than 390 million people older than 65 are edentulous. In 2025, this amount will increase to 800 million. This means we will need a great number of implants, dentists, public health services and projects developed by the government available in order to treat all interested patients! This will be an issue not only for the Brazilian, but for the international community as well. Furthermore, we must take into account that the costs have gone down due to the fact that implants have become more available and affordable. Thus, more implants have been placed.

With regard to quality, both national and international implants have been considered appropriate and of good quality, thus, being beneficial to patients.

Nowadays, there are more than 1,500 implant systems registered and approved by the competent agencies.

The number of companies working with implants tends to increase, especially at this moment when the eastern ones are strongly investing in this market.

The Brazilian industry has developed a new segment, which has introduced technological development in the country — respected world-wide — and created new job opportunities. The demand for products has been so great that Brazil may not be totally prepared to provide the necessary workforce which is required to be highly specialized. Additionally, there may be lack of qualified elements used in the manufacture of implants and derivative products necessary to meet such demand.

With regard to research, we know that the public universities have given birth to the majority of new findings and technological advancements. Can we claim that this situation has begun to change with companies effectively participating in this field? Is it possible to believe that Brazilian doctors can consider the private sector as a new field of work?

Undoubtedly, not a long time ago, the majority of findings and technological advancements originated from projects idealized and developed by researches and professors working at universities, especially the public ones. We could highlight the names of innumerable Brazilian scientists who have come out with new inventions and findings in many different scientific segments. It is not different in the Dentistry field.

It is constantly moving forward, in an intermittent and voracious movement in which new equipment and new products are being developed in order to help us in many different and abounding treatment approaches.

Many doctors have been graduating from private universities which have been equipped with modern apparatus for developing researches and technology, similarly to what happens in public universities.

The participation of companies in this field is very clear and concurrent in different areas such as Engineering (CAPES — Coordination for the Improvement of Higher Education Personnel; CNPq — National Council for Scientific and Technological Development; FINEP — Ministry of Science and Technology's Research and Projects Financing institution and FAPESP — Research Support Foundation of the State of São Paulo); Medicine (INCOR–USP — Heart Institute and FAPESP — Research Support Foundation of the State of São Paulo), Aeronautics (Embraer — Brazilian Aerospace Conglomerate and USP — University of São Paulo, CTA — Aerospace Technology Center of São José dos Campos with FAPESP), among others. On the 7th of June, 2013, the governor of São Paulo, Dr. Geraldo Alckmin, stated that he would make 17 Science and Technology Centers available, under the leadership of FAPESP in the state of São Paulo. More than 600 researchers will be participating in order to contribute to the development of Brazilian science and technology.

However, with regard to Dentistry, particularly in Implantodontics, such practice is immature, since it is a new specialty. Undoubtedly, doctors graduating in Brazil are within a new, fine field of work. Some of them have already been hired by respectful foreign universities and are highly respected and successful.

They need to value themselves in order to be valued by the companies. Such companies should invest part of their profit in serious, consistent and competent scientific departments (investigative and clinical) which would help not only in science and technology development, but also in the publication of journals internationally recognized, thus, accrediting, supporting and contributing to build a fine history of trust and credibility. We can mention, for instance, the case of ITI (International Team for Implantology).

That may be achieved if the officers of such companies interact with their target audience more often, listening to them and accepting their suggestions in terms of improvement and adjustment of products available for sale, which should be more frequently examined and tested. The results should be carefully analyzed in order to bring the expected contributions necessary to improve the products, so that they may be safely and naturally accepted by professionals — who use and recommend them — as well as by patients to whom the effort is aimed.

It is important to have every research published, regardless of their results and without being subject to market, business or industry pressure. This shall contribute not only to build an image of frankness, transparency, nobility and credibility for the companies, but also will give dentists, in general, the guarantee they need to make the best choice regarding the most appropriate implant systems they are going to be using in their patients who will have the implant inserted into their organisms, hoping that they remain there for a lifetime.

When a product is available for sale, it is known that two different situations may occur: entering market competition against similar products or disputing the preference of consumers — in which case the consumers are us, dentists. Therefore, it is understandable and acceptable that parallel studies be carried out by serious and accredited research and teaching institutions without strong businesses links, in order to assess and confirm (or not) the features and advantages highlighted by the companies and their marketing campaigns. Research results which clearly aim at improving or adjusting products that are already of good quality are the basic and essential differential between serious and frivolous proposals.

Quoting Mário Quintana: "Research is the mother of progress. If men had not been lazy to walk, they would not have invented the wheel."

I also work in Cosmetic Dentistry, a specialty that is much older than Implantodontics. In the Cosmetic Dentistry field, the research results are naturally accepted in spite of disagreeing with the companies' interests. These companies use such results for their benefit, improving their products, spreading and reaching new business territories. We can see how much the dental whitening strips, compound and ceramic resins have developed — to mention only a few products.

According to one of the greatest renowned scientists in the world, Isaac Newton, "What we know is a drop, what we do not know is an ocean." It is important that we reflect upon this thought.

Changing subject a little, we know that you are a family person. How did you manage to conciliate 40 years of academic activity with your family obligations? Have they always supported you?

It is very difficult to express any demonstration of care, love and understanding involving our families. For those who are minimally recognized and thankful, their family will always be a source of renewing energy and, at the same time, their emotional "Achilles' heel". My wife Ana Luiza and my three children Carlos Eduardo, Ana Carolina and Fabricio have always given me unlimited support. Despite the fact that I over studied, over worked and was absent when giving courses, my family never highlighted my well-intentioned absences. Somehow, that is what hurts the most because I know that I missed many beautiful moments which I could have lived with my family. When I was with them, I tried to give as much attention as I could. But those are times that are not coming back. Nowadays, I try to compensate that with my 4-year-old grandson Lucca.

Nevertheless, I feel comforted to know that my family was happy — that they are happy — for my motivation and happiness to teach, passing on to my students and my colleagues the knowledge acquired during these 42 years of experience.

Prof. Francischone's siblings, Leda Francischone and Paulo César Francischone, and their parents Mrs. Mirtes and Mr. Sebastião.

The Francischones (from left to right): Carlos Eduardo Francischone Junior (dentist), Ana Luiza (wife), Prof. Francischone, Ana Carolina (dentist) and Fabricio (physician).

Prof. Francischone with his grandson Lucca during a show of the band "*Os Gatos*" (The cats).

At home, besides a genuine Steinway grand piano in which he can practice one of his favorite hobbies: music. On the wall, an oil painting by the Spanish artist Chema Rodriguez. It was given by his students during the 1st Meeting of Prof. Dr. Carlos Eduardo Francischone's students and former students, held in Campinas.

I am sure that if it were not for my family and some of my closest friends who have always believed, trusted and encouraged me, I would have quit these activities.

While I am given the opportunity to have family, friends, colleagues and students around, people who are eager to listen to me, I will be teaching. All I need is health. I like it.

When you look back and you see many of your former students teaching and multiplying knowledge, can you say it was worth it?

Of course it was and it is worth it! I still work and I always try to contribute to the education of good professionals, professors and researchers, passing on the pleasure of teaching and showing everything I have had the chance to learn. Above all, I always aim at acting in an honest, professional, humble and human way. Knowledge that is acquired, but not taught, hindered and not spread, is sterile.

Everything can be summarized as follows: a professor's greatest pride is to see his student overcome him. I am proud of those students who I helped to attain such position.

We cannot be scared of one's fame or prestige. We only have to respect them. I am very thankful to God and to life for everything. Willian Shakespeare stated that "Gratitude is the only treasure of the humble."

We know about a remarkable fact — which deserves to be mentioned — that happened during the years in which you were involved with osseointegration and Implantodontics. That was when you, a Brazilian dentist, always characterized by humbleness, enabled Professor Brånemark to informally meet Queen Silvia of Sweden at the Royal Palace, in Stockholm. Could you, please, tell us about the details of this fact?

It was very interesting! During one of my trips to Sweden, as soon as I arrived at the hotel in Gothnburg for another journey at the Brånemark Center, I received a message saying that I should call my wife, Ana Luiza.

I did call her and she told me that Queen Silvia would like to meet me at the Royal Palace, in Stockholm. That happened because Queen Silvia is a relative of a couple of patients we used to treat, and whose wedding we witnessed.

Between 1975 and 1976, I had to finish a complete oral rehabilitation in one of them, which allowed us some time to get close enough so that I could be a witness at their wedding. They used to tell the queen about our work on the rehabilitation of cleft patients treated at FOB and at the university hospital in Bauru (together with Professors Brånemark, Eli Brosco, Kenji Higushi, Dr. Laércio Vasconcelos and Dr. Assunção). The treatment was performed for free, thus, it had great social impact.

I arrived on a Sunday night and on Monday morning I got in touch with Queen Silvia's secretary. I told her I was in Sweden to have an appointment with Professor Brånemark and that I would like to invite him to go to the Royal Palace with me. She promptly replied that it would be a pleasure to have him meeting the Queen (the good part was that the secretary spoke Portuguese!).

I reported the news to Professor Brånemark who promptly accepted the invitation. It was a great and pleasant meeting in which Queen Silvia was impressed by the social impact of treatments performed at the university hospital, with thousands of cleft patients being rehabilitated. The university hospital is currently known as the Hospital for Rehabilitation of Craniofacial Anomalies/USP. It was built upon and has been working on the basis of a unique philosophy thanks to the dedication and effort of a great person: Uncle Gastão (Prof. Dr. José Alberto de Souza Freitas). Outside de Royal Palace, there was a limousine waiting to take us to the train station. Prof. Brånemark used to take the front seat in the car. At this time, he preferred to take the back seat. At first, I did not understand why. Afterwards, on our way back, he rested his hands on my shoulders and thanked me for the opportunity to meet Queen Silvia and privately talk to her, which had never happened before despite the great importance Professor Brånemark has for the world.

Prof. Francischone, Queen Silvia from Sweden (Queen consort of King Carl XVI from Sweden) and the Sweden scientist and physician Prof. Per Ingvar Brånemark.

"The world shall be much better when envy, intolerance and ingratitude are banished!"

On recollecting a sentence of yours which says that "smiling is the ultimate expression of happiness", what is the message you leave for Dentistry undergraduate students? Is it still worth it to be a dental surgeon? Can they make their dreams come true by working in the oral health field and rehabilitating orally disabled patients?

Our message to undergraduate students is that they indefatigably and insistently seek good moral and professional development, and that they practice excellent Dentistry — an amazing field of work which requires intense dedication. We are used to say the dentist is a different kind of artist. Painters and sculptors need to have their artwork thoroughly displayed whereas our art must be imperceptible. This becomes a daily challenge. Every day, we must thank God for giving us the opportunity to restore or maintain ones smile which is the "ultimate expression of happiness", oftentimes restoring patient's self-esteem, especially of dental mutilated patients who need rehabilitation in different areas of Dentistry.

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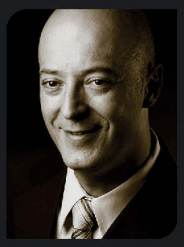

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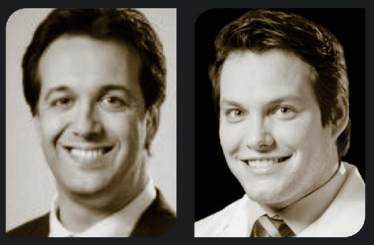

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Histomorphometry of the interaction between implant and bone in rabbit mandible

Fernando Vacilotto **GOMES***
Carlos Eduardo **BARALDI***

Histomorphometric image with magnification of 40x, taken in the interface between bone and Nanotite™ implant (3i Biomet) in rabbit mandible 21 days after osseointegration, with toluidine blue staining. Close contact between bone and implant can be observed by the impregnation of the staining solution on the newly formed bone tissue.

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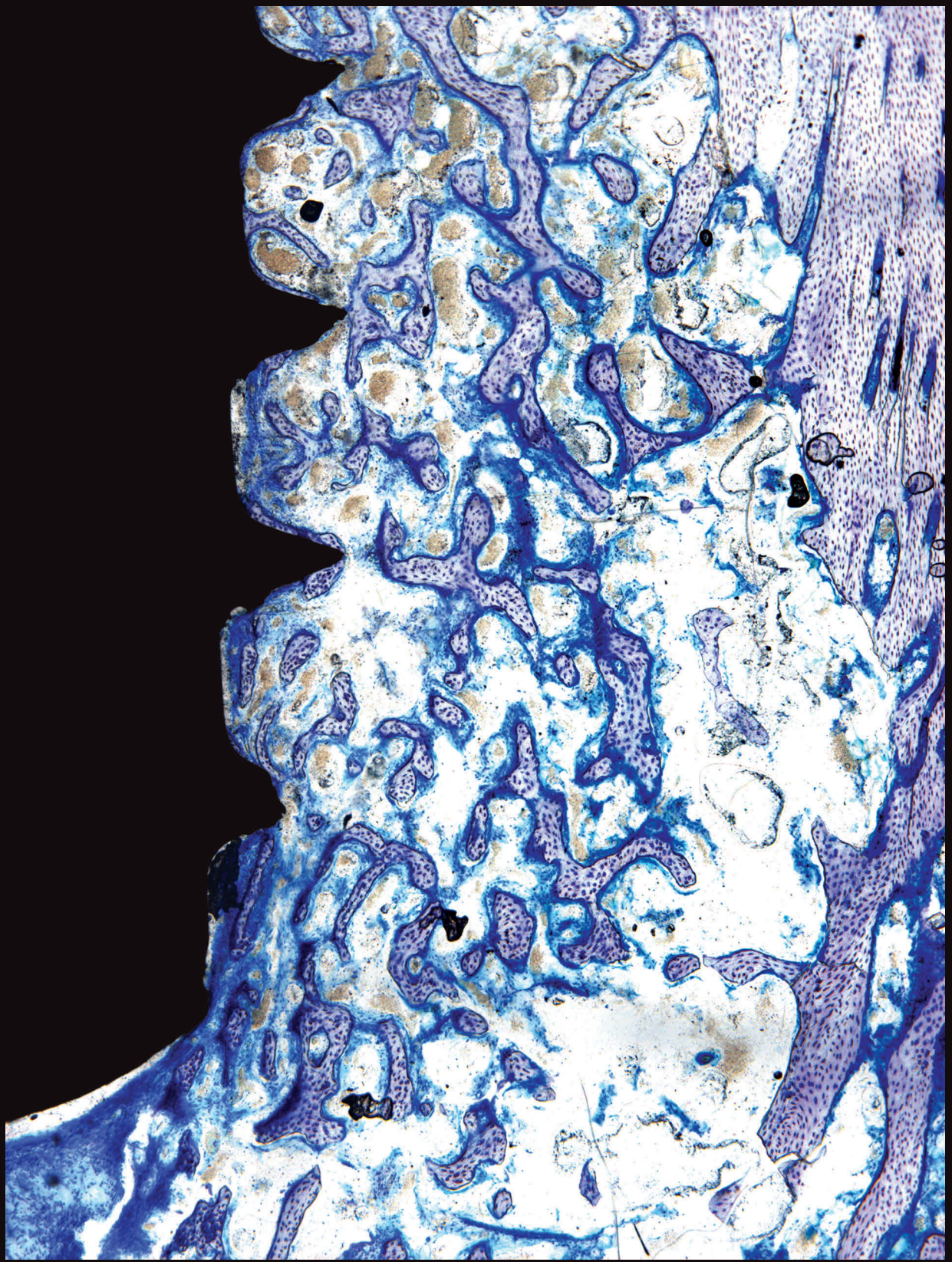

Attrition: aging of tooth shape, interdental spacing and its meanings

Alberto **CONSOLARO***
Leda **FRANCISCHONE****
Renata Bianco **CONSOLARO*****

Abstract

Attrition may explain some of the alterations that occur after months or years of rehabilitation treatment, since it causes changes in shape and mesiodistal and occlusal-apical size of dental crowns, changing their position and relationship with dental implants. Dental attrition may: 1) represent a sign of occlusal maladjustment; 2) suggest the existence of parafunctional habits such as clenching and bruxism; 3) reduce the circumference of the dental arch because the proximal dental contact points turn into wear facets over the years; 4) age the mouth due to some morphological details that vary with age, namely: absence of serration caused by smoothing of the incisal edge until the dentin appears and a dark yellow line can be seen between the buccal and the incisal enamel of incisors and canines; 5) worsen aging caused by dental crowding; 6) aggravate aging by causing loss of facial vertical dimension; 7) be associated with diastemata between osseointegrated implants and natural teeth a few years after rehabilitation treatment is finished.

Keywords: Tooth wear. Demastication.

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» The patient displayed in this article previously approved the use of her facial and intraoral photographs.

The beginning

Maintenance of healthy teeth and oral rehabilitation that reproduce teeth functional and esthetic patterns increase patient's requirements as they tend to have more detailed questions about teeth positioning, color, size and shape.

Some names and concepts such as attrition, abrasion, abfraction and erosion seem to be similar, which explains the confusion set among them. This may hinder one to take preventive measures in case of rehabilitation treatment with or without dental osseointegrated implants.

Attrition may explain some of the alterations that occur after months or years of rehabilitation treatment, since it causes changes in shape and mesiodistal and occlusal-apical size of dental crowns, changing their position as well as their relationship with the dental implants. Diastemata between natural teeth and adjacent implants as well as anterior mandibular crowding are among those alterations.

"Tribology" is the science that studies wear, friction, lubrication and corrosion in Materials Engineering, especially in Metallurgy. The concepts of Tribology for attrition, abrasion and erosion are not equivalent to those applied in Dentistry. In Metallurgy, for instance, abrasive wear is known as "erosion", whereas wear caused by chemical or electrochemical action is known as "corrosion". In Dentistry, the widespread use and sedimentation of concepts for more than a century hinder changes and adaptations in the concepts employed by Tribology. Thus, the concepts employed in this article for wear and loss of mineralized dental tissue cannot be extended to materials, especially metals.

In previous articles,[3,4,6-11] we described the concept, history, pathophysiology, clinical characteristics and therapeutic implications of "mineralized dental tissue lesions induced by physical and chemical agents" so as to contribute to sediment more precise and specific concepts about each one of these alterations. In this article, some paragraphs are literally the same as those found in the aforementioned articles. However, other parts are specifically geared towards dental implant practice.

In oral rehabilitation, what does attrition represent to planning, treatment and post-treatment performed with osseointegrated implants? To answer this question, it is necessary to review some concepts of dental attrition.

Attrition: the concept

"Attrition" is the name given to mineralized dental tissue wear caused by contact between teeth without the interference of any physical factor, but food (Figs 1 to 8). It can occur in permanent or deciduous teeth. Attrition results in the formation of wear facets that have a well-polished appearance (Fig 1).

Attrition may occur naturally, as a result of mastication and other physiological contact between teeth. It may result in facets in the incisal edge of anterior teeth (Figs 2 to 6) and in occlusal facets of posterior teeth. Normal loss of enamel, in a period between six months and one year, ranges from 20 to 38 μm, in other words, from 0.02 to 0.038 mm.[17,20]

A type of attrition commonly found in proximal crown surfaces — which highly interests implant dentists — is caused by constant friction between both surfaces of the enamel, promoted by intrusive movement of teeth in the alveolus, especially during mastication. This constant friction alters the contact points in the proximal surfaces, which results in the formation of facets or contact areas between adjacent teeth. With age, throughout the extension of the dental arch, from third molar to third molar, proximal attrition may lead to a

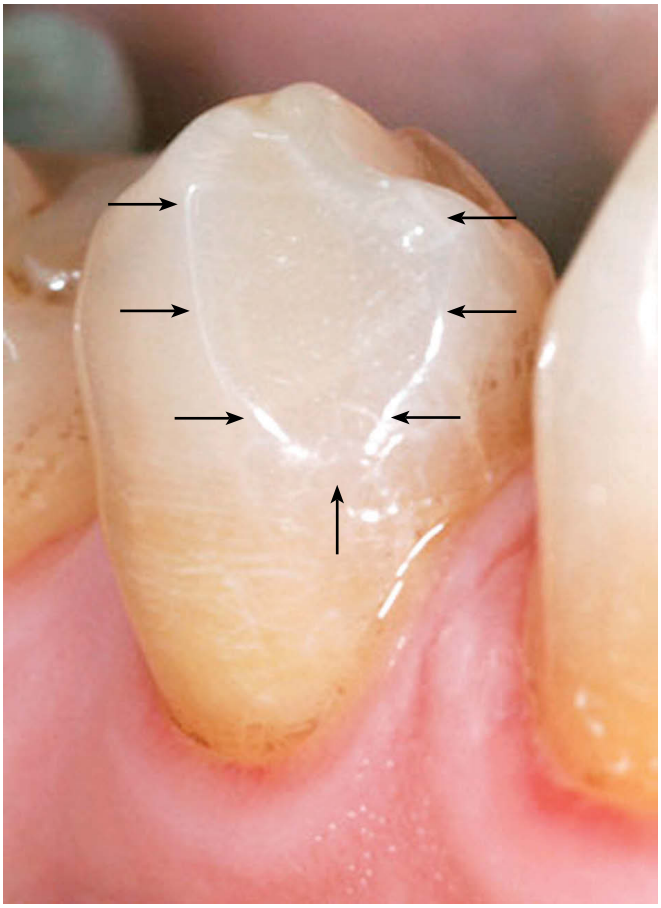

Figure 1 - The most classic manifestation of attrition: a wear facet.

Figure 2 - Attrition gradually alters the shape of the crown as well as its inciso-apical and mesiodistal size, thus, aging the dental arch. The tubercles of enamel (**A**) gradually give place to smoothed incisal edges (**B**) until the dentin is exposed and a dark yellow line can be seen between the buccal and the incisal enamel (**C** and **D**).

reduction not greater than 1 cm.[18] Those alterations pertain to aging and must be taken into account during esthetic and prosthetic restorations.

Intensified attrition was diagnosed in skulls dated from the beginning of civilization and in Egyptian mummies dated from 5 to 3000 BC. In primitive races, a loss of 1 mm was detected to occur every 5 years in the height of teeth. Eskimo tribes that subsist with a typical diet present more attrition in comparison to other tribes adapted to food of European origin. This fact denotes the influence of food over the level of severity of attrition.[18] Food that damages the dentin is more abrasive and not necessarily more consistent.

The presence of saliva alleviates wear, probably due to a potential lubricating action that occurs on the surfaces. Therefore, subjects with less or nearly none saliva present greater level of dental attrition. Another plausible explanation for such a fact is the plug effect of saliva over the acid and microbial components of diet, which potentially contribute to cause a more severe tooth wear.

The severity of attrition is not only related to age (Fig 2), eating and parafunctional habits (Figs 3, 4 and 5), but also to characteristics such as muscle strength, morphology of the face and lifestyle,[1,2,12,16,17] which are inherent to a particular individual. The level and morphology of attrition comprise the system of references used to determine age and other identifying characteristics[2,16,21] in Forensic Dentistry.

Tooth wear caused by attrition may be quicker and more severe when:

1) The enamel is hypoplastic, as in cases of dental fluorosis and hereditary amelogenesis imperfecta.
2) The dentin is dysplastic, as in cases of hereditary dentinogenesis imperfecta.
3) There are occlusal disorders that result in premature or inappropriate contact, with more constant and severe friction.
4) There are parafunctional habits, such as bruxism and/or clenching.
5) The patient has the habit of daily chewing tobacco or other related products.

Attrition and parafunctional habits

In normal conditions, attrition promotes mineralized dental tissue loss that ranges from discreet to mild, however, this condition is worsened in the presence of parafunctional habits (Figs 4 and 7). Attrition is part of the clinical presentation of patients with bruxism and dental clenching, and can lead to significant losses in the clinical crowns, considerable reduction in vertical dimension and potential changes in the facial profile and smile pattern of the patient.

The cause of severe attrition in only one or a few teeth must be found, since it is generally related to occlusal interferences (Fig 3) or local postural habits. Wear facets on the occlusal facets and incisal edges are one of the classic signs of occlusal trauma (Figs 1 and 6).

Some people around the world have the habit of chewing products made from tobacco, nutmeg, lime, seeds and other vegetables — the "betel" in India, for example — which increase the prevalence and severity of attrition. Tobacco is chewed, instead of smoked, by millions of adolescents and young adults and its use increases the prevalence and severity of dental attrition, even though additional studies are warranted to further investigate the topic.

Some researchers, whose studies focus on tooth wear, claim that severe attrition caused by solid and extremely abrasive food, as well as by the habit of chewing products such as betel and tobacco, also present char-

Figure 3 - Increase in tooth wear caused by attrition in the incisal edges cause them to be sharp and the enamel partially supportless, which result in microfractures that affect esthetics and may damage the oral mucosa. Proximal contact points turn into facets due to attrition between teeth caused by intra-alveolar movement during normal mastication.

acteristics of abrasion. The interposition of substances between worn teeth characterizes abrasion and not attrition. Tooth wear caused by the interposition of foreign matters between involved teeth during masticatory movements has a specific pathophysiology. For this reason, this condition is named demastication.

Classifying attrition

Even though attrition represents tooth wear promoted by occlusal and proximal contact between antagonist and adjacent teeth in the incisal edges, without involving the cervical region of the crown, it is often covered in classes and book chapters about non-carious cervical lesions.

Many books and articles published outside Brazil and translated into Brazilian Portuguese may contribute to establish confusion between the concepts used to talk about tooth wear.[18] In Germany and Scandinavian countries, for instance, the terms "attrition" and "abrasion" are used interchangeably. For this reason, attrition is classified as follows.

Figure 4 - Generalized attrition with typical wear facets, sharp and very thin enamel edges, and incisal microfractures. Bruxism is the main cause. Numerous enamel cracks are highlighted.

Figure 5 - Accentuated reduction in the clinical crown caused by attrition, with exposure of dentin, which promoted precocious aging.

a) Physiological: when it results from the cumulative effects of age (Fig 1).
b) Intensified: when it is intensified by parafunctional habits such as bruxism and clenching, in addition to excessively abrasive food habits (Figs 4 and 5).
c) Pathological: when it occurs in only one tooth or in group of adjacent teeth.

In Brazil, as well as in most countries, the concept of attrition that predominates is that of mineralized dental tissue wear promoted by tooth-to-tooth contact without interposition of any other physical factor besides food.

Attrition can be classified[12] into:

» Level 1: attrition limited to the enamel.
» Level 2: attrition with exposed dentin.
» Level 3: attrition with reactive dentin and/or dental pulp exposed.

Biological consequences of attrition

Tooth wear worsened by attrition leads to exposure of

dentin not only with sclerosis of many tubules, but also with dead tracts. Dead tracts are empty tubules, without odontoblastic prolongation and without peritubular dentin closure.[5] It can be clinically observed that the pulp space is affected in the central area of the widest and deepest wear facets, and that it is filled with reactive dentin that occupies the pulp chamber and the root canal (Figs 7 and 8). In such conditions, the reactive dentin usually has a darker yellow color.

The inner anatomy of the pulp chamber and the root canal of teeth with attrition usually change because many layers of reactive dentin are formed on the pulp surfaces that correspond to surface tooth wear (Figs 7 and 8). The dental pulp has its volume reduced and usually presents accelerated aging characterized by extensive hyalinization and pulp fibrosis associated with many false pulp nodules. Even a diffuse calcification of the pulp can occur (Fig 7). In summary: attrition can speed up pulp aging, even in young people.[5]

The incisal and occlusal edges affected by severe attrition are usually sharp (Figs 3 and 4) and constantly wound the oral mucosa. In this area, the mucosa presents a diffuse white color, has a well-defined white patch or sometimes presents lesions caused by constant and sharp friction. This change found in the mucosa is known as "frictional keratosis", an adaptive hyperplastic response of the mucosa to a repetitive and constant mechanical aggression, which is not of neoplastic or carcinogenic nature.

Compensatory mechanism for attrition in the clinical and esthetic crown

The compensatory mechanism for occlusal and incisal tooth wear is an important phenomenon associated with attrition. Within physiological limits, occlusal and incisal wear is compensated by cementum deposited in the apical third of the root. That mechanism is known as "passive tooth eruption" which, for being continuous and slow, preserves the height of the clinical crown, even if the enamel-cementum junction is apparent in the mouth[13,14,15,19] and the root is partially exposed (Fig 2D), affecting crown esthetics.

The majority of patients with attrition does not present loss of facial vertical dimension due to this compensatory mechanism. The cementum that is formed in the apical third, faster than it does when it is continuously deposited, tends to be cellular; and the apical part of the root is gradually and naturally rounded. Whenever there is loss of vertical dimension associated with attrition, generalized tooth wear and the high speed of tooth structure loss must be considered.

Attrition: esthetics and prevention

In their incisal edges, the incisors present three tubercles that resemble a fleur-de-lis and remain as such until attrition occurs with the flattening of the incisal surface (Fig 2) and the formation of living angles with free and proximal facets. At the same time, the contact point is also related to young teeth: the wear facets denote longer elapsed lifetime.

Teeth crowding in the anterior region has already been considered as the "wrinkle" of dental arch aging (Fig 6). It is possible to extend that and affirm the same for attrition of incisal edges. The absence of serration, the presence of sharping angles and exposure of dentin between the facets of the worn enamel of anterior teeth give the appearance of precocious aging.

In case of reconstruction of incisors as well as of other teeth that appear in the smile line, the original shape of the crown and the contact points must be considered and compatible with the facial esthetics of the patient's age group. Due to its cumulative effect, attrition is related to age and to the occurrence of aging which, in some cases, is worsened by facial vertical dimension loss.

Figure 6 - Attrition in the incisal edges may be associated with aging that results from teeth crowding, especially when the dentin is exposed, separating buccal and lingual enamel.

In an oral health program, in addition to the aspects related to oral hygiene and a cariogenic diet, the orientations must — or at least should — include not only the type of food (in terms of its abrasiveness),[21] but also prevention and limitation of the damages caused by bruxism and clenching, as well as a periodic evaluation of occlusion. In addition to causing precocious aging of the dental pulp, attrition also affects the shape of the tooth and the patient's esthetics.[2,16]

In many cases, attrition will be compensated by esthetic and functional restoration of tooth wear. However, with the night use of bite plates, it is necessary to prevent new accelerated losses by avoiding tooth-to-tooth contact that promotes attrition during sleep, especially if the patient presents bruxism or other parafunctional habits.

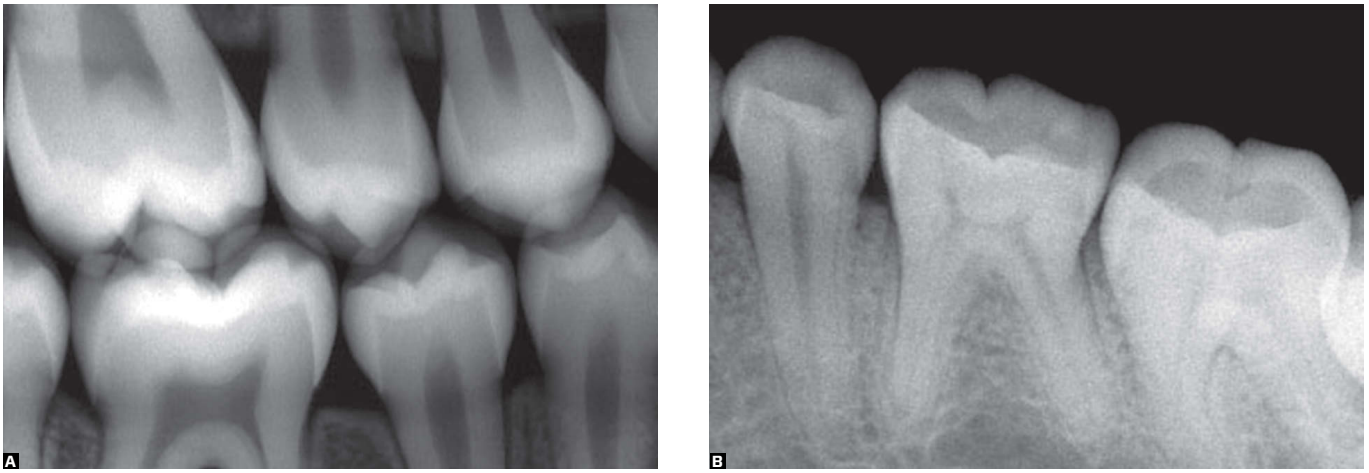

Figure 7 - Reduction in pulp spaces (**B**) due to reactive dentin deposition induced by attrition between teeth affected by bruxism, in comparison to normal pulp spaces (**A**).

Alterations in the shape of teeth and the line of the occlusal plane, flattening of the incisal edge, presence of enamel-cementum junction and root surface are within a context that involves the skin, the hair and the smile, and is associated with deepening the expression lines, including the nasolabial fold and the facial vertical dimension. Recovering tooth esthetics and function without harmonizing them with the face, including the lips, the skin and the expression lines, is having the contrary as the truth. In other words, it is caring about the face without concerning the teeth!

Nowadays, esthetics is highly valued, therefore, preventing and correcting attrition is relevant. In a population in which tooth loss is decreasing, the preservation of teeth becomes more and more thorough.

Implications and specific situations: attrition and dental implants

The possibility of increasing attrition with natural antagonist teeth must be taken into account in cases in which prosthesis is placed onto osseointegrated implants.

Nevertheless, when the prosthetic crowns are being prepared, they must be in accordance with the patient's age group because attrition not only alters the incisoapical crown height and the facial angles near the incisal edges, but also transforms the contact points into wear facets.

Similarly to what occurs to ankylosed teeth, osseointegrated implants do not have intra-alveolar mobility due to the absence of periodontal ligament. Additionally, when osseointegrated implants are placed in the supero-anterior region of younger patients, they tend to be in infraocclusion after a few years.

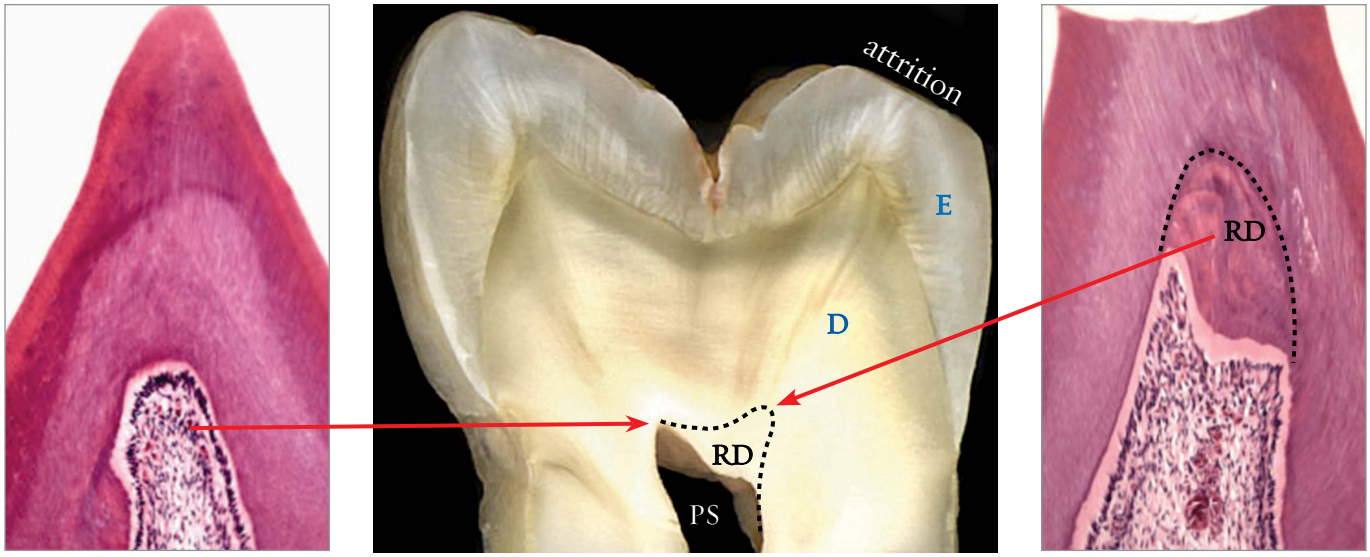

Figure 8 - Reduction in pulp space (PS) due to reactive dentin (RD) deposition induced by attrition in human teeth of which inner anatomy was altered (H.E.; original magnification = 40X). E = enamel; D = dentin.

Likewise, osseointegrated implants do not undergo the same type and extension of natural tooth movement, which results from growth and functional vectors and tend to move the teeth towards the central region of the mandible.

With age, this process, which results from active vectors, naturally leads to teeth crowding of lower incisors in most patients. For many years, it was believed that those vectors were a result of the presence of third molars that would "push" the other teeth to the central line. Now, it is understood that even without the third molars, patients present teeth crowding, as a result of congenital absence.

The presence of osseointegrated implants does not intervene in the occurrence of neither growth nor arrangement vectors of the dental arch throughout life. Moreover, it does not prevent teeth crowding, except in very specific conditions. Similarly, the presence of osseointegrated implants does not prevent proximal attrition in natural teeth.

Over the years, gaps in the form of diastema can be observed between osseointegrated implants and natural teeth as a result of attrition and/or teeth crowding. Those gaps can cause food impaction or can intervene in esthetics. It is possible to understand them and plan their readjustment, but nothing can be done to avoid these gaps, given that they are a result of the natural aging process that happens in the dental arch.

Synthesis and final considerations

Dental attrition may:

1) Represent a sign of occlusal maladjustment.
2) Suggest the existence of parafunctional habits such as clenching and bruxism, which must be considered in treatment prognosis.

3) Reduce the circumference of the dental arch because the proximal dental contact points turn into wear facets over the years.
4) Age the mouth due to some morphological details that vary with age, namely: absence of serration caused by smoothing of the incisal edge until the dentin is exposed and a dark yellow line can be seen between the buccal and the incisal enamel of incisors and canines.
5) Worsen aging caused by dental crowding.
6) Aggravate aging by causing loss of facial vertical dimension.
7) Be associated with diastemata between osseointegrated implants and natural teeth a few years after rehabilitation treatment is finished.

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Cement-retained versus screw-retained dental prostheses: Literature review

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Abstract

Due to the advancement of research related to osseointegration, Implantology has become a treatment with satisfactory prognostic in Dentistry. However, in order to achieve more lasting success in prosthetic work, it is very important to choose the proper type of retention of the prosthesis, whether it is cement-retained or screw-retained. The present study consists of a literature review on the subject concerning cement-retained prosthesis as opposed to the screw-retained ones, addressing their advantages and disadvantages, and issues such as aesthetics, passivity, reversibility, retention, and occlusal aspects. The choice between screw-retained or cement-retained prosthesis is of interest to the professional, as it will contribute to the long term success of treatment.

Keywords: Cement-retained prosthesis. Screw-retained prosthesis. Reversibility. Passivity. Occlusal aspects.

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Introduction

Due to the advancement of researches related to osseointegration, allied to the increase in life expectancy and aesthetic and functional exigency by patients, Implantology has become a reality in the current Dentistry.[1,2] The first oral rehabilitation using a protocol with osseointegrated implants occurred in cases of fully edentulous patients in the lower jaw. The indication of this kind of prosthesis has growth a lot, also becoming used in unitary and partial cases, in the maxilla and mandible.[3,4] The search for long term foreseeable results has pointed out several questions related to the material used, as well as the techniques. One of these questions is about the kind of implant/prosthesis connection: screw-retained or cement-retained, or a combination of both, for example, cement-retained prosthesis with lingual or palatal screw.[5]

Initially, screw-retained prostheses were used, and they consist in an abutment screwed to the implant, on which is positioned a crown, attached to a gold or titanium screw.[3] Branemark standard protocol, proposed in 1965, was already part of this kind of connection. Over the years, cement-retained prosthesis has arisen and they are conquering more and more space in Implantology, generating doubts among clinical professionals about what connection system should they use. However, compared to screw-retained prosthesis, cement-retained restorations have limited scientific documentation.[5]

The evolution of cement-retained prostheses has begun after a change in UCLA abutment, conducting the fabrication of abutments in order to improve esthetics and solve problems in implant angulation.[5] Lewis et al[30] were the first to describe techniques for cement-retained restorations. Thus, in order to achieve a good prognosis for implant-supported prosthesis, the retention system should be chosen in the preoperative planning, aiming at a better positioning of the implant.[6] For example, in fixed screw-retained prosthesis, anterior implants are installed more toward lingual than in a cement-retained restoration, as the orifice to access the prosthetic screw must be inserted in the cingulum. It is more difficult to correct an implant installed excessively to vestibular in a screw-retained restoration, and it can lead to an unavoidable aesthetic commitment. This highlights the necessity to establish in the preoperative the retention system to be used.

Considering this questioning, the present study searched for relevant articles in the literature which discuss the advantages and disadvantages of cement-retained and screw-retained prosthesis, approaching biomechanical factors, like passivity, reversibility, retention, occlusal aspects and also aesthetic factors, in order to discuss the better indications and limitations of each one of them.

Literature review

The use of implants in Dentistry has earned the confidence of professionals since the early 80's, when long term longitudinal researches were presented, resulting in a foreseeable and satisfactory treatment option. This success was due mainly to the osseointegration, and also to the screw-retained connections over implants. At that time, abutments for cement-retained prosthesis were not used yet.[2]

Over the years, as in all other areas, requirements, mainly the esthetic ones, have increased and led to the rising of abutments for cement-retained prosthesis. This has made the range of alternatives to considerably increase, but one doubt remained: should one fix a prosthesis on the implant using cement-retained or screw-retained system? Besides personal preferences, the professional must know the advantages and disadvantages of each one of them in order to elect the appropriate component to solve the case.[7]

Following, biomechanical and aesthetics factors will be addressed, which should be considered in the planning of an implant-supported prosthesis.

BIOMECHANICAL FACTORS

Passive adaptation

The passive adaptation has been shown as an essential requirement for maintenance of bone-implant interface, and for the longitudinal success of implant-supported prosthesis. It is defined as the maximum contact between the infrastructure basis and the abutments, without generating tension between them.[1] There are several factors which directly affect the adaptation and passivity of prosthesis, among them, the precision on the whole manufacturing process, including casting and foundry, besides the skills of the surgeon and prosthetic technician.[4,8]

In conventional fixed prosthesis teeth move to compensate small mistakes in prosthesis adaptation. In the case of implants, this does not occur, therefore, the absence of passive adaptation will bring on an increase of forces transmitted to the bone, causing prosthetic failures, like loosening or even screw fracture, metal frame or ceramic fracture, accumulation of bacteria, mucositis, peri-implantitis, and even osseointegration loss.[1,4,5,8,9]

It is known that passive adaptation of screw-retained prosthesis is virtually impossible to be obtained. Screw-retained restorations can create two or three times more permanent deformation in the implants than cement-retained prosthesis.[6] Some authors also assert that, both to cement as screw-retained prosthesis do not have total passive adaptation, and it can produce low magnitude tension in implants.[10,11]

Passivity of screw-retained prosthesis is difficult to achieve due to the dimensional discrepancy inherent to the process of manufacturing, what does not occur with cement-retained prosthesis, because the cement layer has the capacity to compensate small discrepancies, facilitating the prosthetic adaptation, helping the forces to be transferred along the whole prosthesis/implant/bone system.[4,6,10,12]

It can be noticed that passive casting has a considered advantage in cement-retained prosthesis. Die spacers create a abutment/crown interface with about 40 μm — which compensate somewhat laboratory materials dimensional changes — and where the cement will be deposited, allowing a more passive adaptation in cement-retained prosthesis.[4]

Several authors assert that the action of cementing agents — absorbing impacts and reducing tensions transmitted to the bone and implant — makes cement-retained prosthesis to have more passive adaptation than the screw-retained ones.[13,14] However, it is noticed that screw-retained prosthesis possess smaller gap in the interface between their connections than the cement-retained ones.[4,14] The study conducted by Keith et al,[15] quantifying the marginal discrepancy in the abutment-crown interface in screw and cement-retained prosthesis confirm this statement. As a consequence, in cement-retained prosthesis there is higher risk of space colonization with microflora and dissolution of cement, besides gingival inflammation. This better passivity obtained by screw-retained prosthesis is due to the section of infrastructure in parts and to laser welding.[12]

The section of metal infrastructure has to respect certain specific dimensions, in order to guarantee the precision in welding (0.008-in). An excessive space causes contraction of welding and a weakened union; a reduced space can causes distortion by expansion during the heating of foundry. The union of pieces separated requires more time, and the patient has to return to another appointment after the process of welding in the laboratory. It is important to consider that this 0.008-in space is necessary in cases of conventional welding, because in punctual welding (laser or TIG) it is observed that, the closer the better resistance of welding and lower the distortion (dimensional change).[6]

Some authors have evaluated the adjustment between the abutment and the infrastructure of a screw-retained

prosthesis with three elements. The monobloc group presented higher marginal gaps, while the conventional and laser welding groups have presented similar degrees of misfit with better distribution of tensions, without significant differences between them.[16] Another work has shown significant statistical differences among laser and TIG welding and the brazing.[17]

The extent of metal contraction during the process of manufacture of an infrastructure is variable and depends on the manufacturer and on the technique, but it is near to 1.5%, whether considered that semiprecious alloys can present twice this quantity. Therefore, during the foundry of the infrastructure, separated and welded castings are necessary in order to obtain a more passive infrastructure. The casting of an infrastructure in parts and posterior laser welding normally provide more passive structure than the fusion in monobloc. When a monobloc structure is molten and does not present passivity, its section with thin disk is necessary (cut dimension must be thinner than a playing card) in the region of misfit abutments. After separated, the passivity of these components must be tested singly, and then proceed the process of union with Duralay, for posterior welding.[6]

Other authors have performed a study comparing the passivity of adaptation in four techniques for construction of screw-retained prosthesis infrastructures: Method of fusion in single piece (the piece is waxed, fused and fixed in a single piece); cut and welding (the piece is waxed, fused, sectioned, welded and fixed); welding (the structure is waxed in parts, fused, welded and fixed); and passive adaptation (in which there is an association of screw and cement-retained techniques). There was a stress generation in all prosthesis fixation methods; the higher tension has occurred in the single fusion method, followed by the cut and welding method and by the welding method. The lower tension has occurred in the passive adaptation method.[18]

It was has also performed a study evaluating the marginal discrepancy and passivity of adjustment in screw and cement-retained prosthesis before and after the torque on screw, and/or cementation. There was no significant difference in marginal adaptation between the groups before the screw was tighten or cementation. After the screw was tighten and cementation, marginal openings were much lower on screw-retained prosthesis. In relation to the stress generation, screw -retained prostheses have presented higher stress generation than the cement-retained ones.[19]

An in vitro study has measured the maladjustment compensation capacity of three prosthetic infrastructure systems: CerAdapt (cement-retained crown) and Standard and Estheticone systems (screw-retained crowns). Devices adapted to the implants have simulated rotations errors (rotation and inclination) and translation errors (height and distance). The authors have concluded that CerAdapt system (cement-retained) presented better capacity to compensate translation errors. For other rotation errors, the Standard system obtained better results, and the Estheticone system presented the worst values.[20]

Reversibility

Reversibility is described by several authors as the main advantage of screw-retained restorations.[5,21,22] These, among others, considered that the practicality in removing and repositioning screw-retained prostheses facility the control appointments for repairs, changes in rehabilitation after lose or failure of an implant, maintenance of hygiene mainly in elderly patients — who does not have complete coordination — and monitoring of peri-implant tissues. Considering these facts, the facility in removing prosthesis becomes very important for work durability.

Despite several authors consider that cement-retained prostheses cannot be removed, there is the possibility to remove them using provisory cements. These cements, whether used in metal interfaces with appropriate adap-

tation and surface area, offer adequate retention, besides can be removed for eventual control.[6,12]

As asserted before, the great advantage of screw-retained prostheses is that it can be removed. However, due to several disadvantages, some authors have suggested the temporary cement retention, or the use of a lateral screw, that once tight, provides disruption of the cement film, allowing the prosthesis to be removed.[3]

Some authors have cited the use of provisory cement associated with Vaseline to easily remove the prosthesis. They have also observed that screw-retained prostheses were developed in answer to a need to remove prostheses in a period in which there was 50% of success rate of implants. Nowadays, this index has increased to 90%, decreasing the clinical significance of reversibility.[12]

On the other hand, other authors have agreed that currently, with the evolution in materials field, the relaxation of screw become less frequent, but they also have asserted that with the increase in the amount of treated patients, the number of relaxation episodes tends to be enhanced. As the removal of cement-retained prosthesis sometimes is only possible by destructing the restoration; some authors consider more indicated to use screw-retained restorations, as they can be easily removed.[13]

However, it is verified that screw-retained single prostheses have higher reversible complications than cement-retained prostheses, with success rates of 36.3% and 2.9%, respectively.[23] The study performed by Jemt and Petterson [24] corroborates these results, and they have cited that screw-retained prostheses can present higher relaxation of screw, due to the lack of passivity.[25]

It is known that, to remove a screw-retained restoration in which the access orifice is covered by composite resin, the dentist must remove the occlusal restoration, the subjacent cotton and the prosthesis screw. After reinserting the prosthesis, the screw is substituted, the torque is carried out and the occlusal orifice is restored again (this procedure takes a considerable amount of time). Then, it will be easier and faster to remove and re-cement a prosthesis fixed with temporary cement.[6]

In order to facilitate this process, some authors describe a technique in which is used a polytetrafluoroethylene tape (PTFE), known as plumber tape, to seal the access to the abutment screw. It is a radiopaque material, easy to manipulate and does not cause bad smell as cotton. This technique allows its fast removal in one single piece, when it is necessary. It can be sterilized in autoclave and inserted with a presser plier inside the access orifice, on the screw head.[26]

In relation to the cement-retained prostheses, it is possible to assert that the so-called definitive cements do not adhere to the titanium abutment with the same tenacity than they adhere to the preparation on the teeth. Consequently, more resistant cements can be used in implants, and these can be removed easier. Implant-supported prostheses can be sealed with cements of variable resistance, which can be selected according to the localization, height, width, convergence degree, retention and the abutment shape. A provisional restoration must be used as a guide to find the type of cement that allows latter removal, but which does not loosen during function.[6]

On the contrary of this information, some authors have asserted that progressive cementation as described by Mish[6] increases clinical time, even during the provisory phase. In this way, more appointments will be necessary, not only to discover the ideal consistence of cement, as well as re-cement restorations which have become loosen.[7] Another item considered by these authors is the difficult to completely remove the excess of cement around the prosthesis, what can cause grooves in the piece or even inflammation in adjacent tissues.

Some authors have agreed that the prostheses can be difficult to remove even using provisory cement. The ideal taper of abutment, jointly with its long wall allow the use of provisory cement for a long period.[4]

Occlusal aspects: transmission of loads

Some authors have described, in relation to occlusion, that due to the low elasticity of cement-retained or screw-retained components over the implant, a carefully planning must be performed in order to avoid overload.[9]

The cement-retained prosthesis and the implant body can receive axial load, reducing the load on the bone crest. While in a screw-retained prosthesis the load must be applied in the region of the occlusal screw, which is covered by a resin layer. That highlights the advantage of cement-retained restorations due to the better distribution of occlusal loads along the implant axis, establishing contacts directly on the crown, and not on the resin that obliterates the occlusal orifice in cement-retained prostheses.[6]

The orifice for screws usually measure 3 mm in diameter, what represents 30% or more of the hole occlusal surface of posterior teeth, and 50% of functional area, because only two thirds of occlusal face are localized in the functional regions of loads. Ordinarily, the screws are in the region of primary contact; therefore, in order to address the loads along the axis of implant body, occlusal adjusts are performed on the occlusal screw or in the composite resin on the screw. Some authors have also suggested to transfer the point of contact (load) to a lateral region in the occlusal area of screw. These restorations require additional clinical time and wear out faster than porcelain or metal, which are the materials for contact used in cement-retained prostheses.[6] It is important to remember that restoration materials, in screw-retained prostheses affect the direction of occlusal load, making distribution of loads to occur laterally, instead of in the axis of the implant.[14]

Likewise, regarding cement-retained prosthesis and the occlusion, it is necessary to consider the full occlusal face, which allows to establish many occlusal contacts in the typodont, reducing the working time to adjust it in the patient's mouth. The center of occlusal face allows a better transmission and absorption of axial loads by bone-implant interface. It is also important to highlight that, when anterior cement-retained prostheses are manufactured, the crowns are made with normal palate region and without over-contouring; it enables that excursive movements of jaw occur without interference. Besides, it is also important to mention that ideal occlusal contacts which remain stable for long time are possible to be established in a cement-retained prosthesis.[5,9]

Literature provides evidences that non-axial loading can cause an elevated incidence of components failure, or screw loosening. Some authors report that the better way to avoid occlusal problems is to displace the orifice as much as possible off the occlusal face and make it as smaller as possible.[13]

A study was carried out in order to evaluate the fracture strength of cement-retained and screw-retained prosthesis. Compression strengths were performed on the crowns. Statistical analysis has shown there were no significant statistical differences between the two groups (cement-retained and screw-retained). All the samples have suffered cohesive fractures in the porcelain. Screw-retained crowns have shown microcracks at the level of access to the occlusal screw and extensive fractures in all the thickness of porcelain. Cement-retained crowns were affected by marginal fractures in the porcelain, and they resulted in a higher value of fracture strength in relation to the screw-retained ones.[21]

Another study has carried out to evaluate the fracture strength of three kinds of prostheses: cement-retained (control); screw-retained with metallic support in the orifice of access to the screw; and porcelain. The crowns were submitted to dynamic and static loads

until the limit of resistance of crowns. Higher resistance to the fracture was observed in the cement-retained group; however, there was no significant statistical difference between the two groups of screw-retained prostheses. Occlusal discontinuity of screw crowns affects its resistance, irrespective of the presence or absence of metallic support in the orifice to access the screw.[27]

Retention

The retention of an implant-supported prosthesis is an important factor which will influence in the longevity of rehabilitation works.[9] Some authors have reported that prosthesis retention depends on several factors, like angulation of the preparation, surface area, abutment height, surface roughness and type of cementation agent.[12,13,14]

The primary advantage in a screw-retained structure is the possibility to place a prosthesis over abutments with low retention profile; in other words, when the inter-occlusal space is reduced. Cement-retained prostheses require a vertical component with at least 5 mm height in order to offer retention and resistance. When the intermediary has 4 mm, the retention decreases 40%. Then, it is possible to conclude that the screw-retained system is more resistent to occlusal forces than cement-retained ones, when the height is less than 5 mm.[6,13]

In relation to the cement-retained prostheses, as we have seen in the item 'Reversibility', Michalakis et al[5] assert that cements used to fix prostheses can be provisory or definitive. Definitive cements increase the retention and provide appropriate marginal sealing in the restoration. Provisory cements have as main function the easy of removal.

For an effective retaining, the cement needs preparation with long and parallel walls as possible. According to Southan and Jorgensen,[31] ideal inclination of preparation walls should be near to 6°, avoiding loss of frictional retention. This concept can be used both to preparation and teeth, and to abutments over implants. Most manufacturers of implants produce abutments with 6° of inclination. Thus, the retention achieved with the prosthesis on the cement-retained implant is about 3 times higher than that achieved with natural teeth, because most professionals can prepare natural teeth with angulation from 15 to 25°, reducing considerably the retention of prosthesis (75%).[5,9,12]

As adjunct for the affirmation above, it is possible to cite that, due to this angulation in 6° present in abutments of cement-retained prosthesis, it is not necessary to perform additional retentions with diamond or abrasive blasting to make the intermediate surface rougher and increase the retention.[12,14]

There are authors who reports the use of progressive cementation technique for cases in which the desired retention does not exist. This technique profess the use of cements increasingly strong until achieve the desired retention.[12] In addition to this study, Mish[6] accentuates that provisory restoration can guide the professional to find an appropriate cement that does not release when in function.

In relation to the screw-retained prosthesis, the retention is obtained by fixation of the screw, and its loss by relaxation. Several factors will affect retention of screw and, consequently, of prosthesis, like insufficient torque on screw, overload, loads out of the implant axis, maladjustment of prosthesis, among others.[14]

To achieve enough force to close the screw, torque should be performed according to the manufacturer specifications. Another torque on screw is also indicated 5 minutes after the initial torque and another one some weeks late. Overload, loads out of the implant axis and prosthesis-implant maladjustment should be adjusted, because they increase the stress on the screw, leading to relaxation.[14]

ESTHETICAL FACTORS

On the esthetical issue, most authors consider cement-retained prostheses better than screw-retained ones.[5,6,12,21] Cement-retained prostheses allow surgical location of implant more related to the along the axis of dental element, obtaining crowns with more natural anatomy.[28]

The absence of occlusal orifice to the access of screw on cement-retained prostheses avoids the existence of changes in design, compromising esthetics.[1] Hebel and Gajjar[12] consider that the main motive of aesthetic disadvantage of screw-retained prosthesis is the orifice of access to the screw. Once this orifice makes the occlusal surface to present a different material from the crown, it results in a different shade. Cement-retained crown makes easy the confection of shape, with a functional and esthetical masticatory surface.[6]

Other authors assert that integrity of surface is the higher advantage in cement-retained prostheses. It allows the technician to manufacture an esthetical prosthesis, similar to the conventional fixed prosthesis, because it does not require the presence of orifices of access to the screw for retention; and also in treatments in which the implants are placed in vestibular position, they can perform the adjustment of angulation.[9] In screw-retained prostheses, the adjustment of angulation can be performed by installation of angled abutments, however, it can interfere negatively with the esthetics in cervical region. Meanwhile, according to Shadid and Sadaqa,[14] the implant placed at the ideal position will allow good esthetical results, both to cement-retained and screw-retained prostheses.

In screw-retained prostheses, anterior implants should be installed more to the lingual direction than cement-retained restorations, in order to place the access orifice for the screw in the cingulate region[6].

The emergency profile of an anterior cement-retained crown can show a satisfactory esthetical result, because the implant can be inserted beneath the incisal border, instead of the cingulate. It facilitates the preparation of an abutment slightly angled towards the vestibule, as a natural tooth. A screw-retained restoration positioned towards the vestibule direction may not be modified without the presence of an angled abutment. If the body of implant is modified, a personalized abutment, with additional appointment and costs, is required.[6]

Some authors assert that the use of composed resin to mask the access orifice for the screw may totally resolve the esthetical problem of screw-retained prostheses, but the color choice should be properly done.[3]

Esthetics largely depends on the selection of patient, on the type and volume of tissue which enfold the implant, and on the position of implant. Trajectory of implant will simply determinate the method of retention. Retention with cement can be universally used, while screw restoration can be used only when it allows an access to the screw in non-esthetical areas.[13]

Weber et al[29] performed a study where evaluated, besides the conditions of peri-implant soft tissues, the esthetical performance of implant-supported restorations in 80 patients. Patients didn't show statistically significant esthetical preference between the two types of implant-supported prostheses, while dentists shown higher satisfaction with cement-retained crowns.[1,29]

Conclusion

There are no universal truths in health area; neither extrapolated principles for all situations. Decision between using cement- or screw-retained prosthesis is one of these examples. After the present review, it is clear that both the techniques have pros and cons and the decision on the type of fixation is a professional duty for each specific case. This decision should be based on knowledge and professional experience, always achieved in the search for scientific evidences, as well as the needs of the patient.

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Topographic analysis of the surface of commercially pure titanium implants. Study using scanning electron microscopy

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Abstract

Objective: This study aims at carrying out a descriptive comparative analysis of four types of surfaces of commercially pure titanium implants by means of scanning electron microscopy (SEM). **Material and Methods:** Four implants of different commercial brands were used, as follows: Conexão – Sistemas de Próteses (Prosthesis system) and Straumann. The samples had their surfaces machined by means of acid etching, anodization (Conexão) and blasting followed by acid etching (Straumann) techniques, and were divided into four groups with one implant each. The areas of thread top and valley were determined for SEM analysis at different magnifications. **Results:** All samples assessed presented characteristics of surface rugosity, including the machined surfaces. The implants treated by anodization and blasting followed by acid etching had a greater surface pattern in comparison to the implants treated by acid etching due to their greater degree of rugosity. **Conclusion:** Surface treatment influences surface macro structure. Surfaces treated by anodization and blasting followed by acid etching presented a surface pattern that provides a greater area for bone apposition.

Keywords: Titanium implants. Surface treatments. Scanning electron microscopy.

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Introduction

The objective of modern Dentistry is to restore patients' masticatory function, speech, health and esthetics, regardless of atrophy, diseases or lesions found in the stomatognathic system. Since the advent of osseointegration, the use of implants has proved to be a treatment option for edentulous patients.[1] After years of research as well as laboratory and clinical development, Branemark presented a system of implants that can replace lost natural teeth.[2]

In his researches, after trying to remove a titanium piece implanted in the tibia of a rabbit, Branemark observed that the piece had adhered to the bone. Based on this phenomenon, other studies, researches and trials were conducted and that is how the concept of osseointegration, defined as a stable union between the bone and the implant which can hold a prosthesis,[2,3] was developed.

Dental implants are considered suitable for masticatory function and esthetics when osseointegration is effective.[4] The high number of successful cases of osseointegrated dental implants led it be considered a realistic treatment option in modern Dentistry. However, despite the high number of successful cases reported by researches, there has been some failure in clinical practice regarding treatments performed with implants, causing some inconvenience for both professionals and patients.[5,6]

Commercially pure titanium is chemically stable and, for this reason, it allows satisfactory tissue reaction, stimulates bone matrix formation, presents high resistance to corrosion and does not cause significant immunological reactions, being the main material of choice for the manufacture of implants.[9]

Surface treatments promote different increases in rugosity that, when associated with the physical-chemical characteristics and properties of the material, influences not only the initial mechanical retention of implants, but also the increase in the contact area with the receiving bone bed, thus favoring osseointegration.[7] Studies confirm that textured surfaces have better implant-bone integration in comparison to smooth surfaces.[8]

Within this context, modifications carried out on implant surfaces have become of paramount importance for the researches conducted in the last few years. Different mechanical, chemical and optical methods have been used with the purpose of producing surfaces with different topographies. Furthermore, different types of coating can also be used to modify surfaces, and can be applied by means of different techniques.[10]

Among the techniques used to treat the surface of implants, the most important ones are: deposition of hydroxyapatite, acid etching, blasting of particles or blasting followed by acid etching, laser treatment, anodic oxidation, ion implantation, and isolated or simultaneous electrochemical deposition of calcium, phosphate, iron and magnesium.[11] These treatments, with their own peculiarities, promote different rugosity patterns.[12]

Based on the aforementioned facts, considering that the topography of implant surfaces directly influences osseointegration and that each type of surface, with its own peculiarities, has advantages, disadvantages and indications for use; the present study aims at carrying out a descriptive and comparative analysis of the different surfaces of commercially pure titanium implants by means of scanning electron microscopy.

Material and Methods

Implant selection

Four commercially pure titanium implants with different surface treatments were used for this research. They were obtained from the following implant systems: Conexão

Sistemas de Próteses (Prosthesis system) and Straumann. The material was divided into four groups in accordance with the surface treatment it had received. Such information is shown in Table 1, according to data provided by the manufacturers.

Analysis

The topographic characterization of surfaces was carried out by means of a Tescan scanning electron microscope, model VEGA 3 LMU, at the laboratory of the Federal Institute of Education, Sciences and Technology of Bahia (IFBA). The implants were provided by the manufacturers in specific, sealed and sterilized wrapping, each one containing a single sample. The samples were removed from the wrapping and directly placed into the sample holder by means of sterilized clinical tweezers so as to avoid contamination of surfaces. Afterwards, they were directly placed onto the scanning electron microscope and subjected to analysis for topographic characterization of surfaces.

A kilovoltage of 20 KV was used, and magnification was set at 10 to 37 mm, according to the intended degree of increase. Images at different magnifications (10x, 50x, 500x and 1000x) were obtained. With the objective of showing a panoramic view of the threads as well as their pace and shape, magnifications of 10x and 50x were used; whereas to show more details of the surface, magnifications of 500x and 1000x were used in the thread top and valley.

Results

The characterization of the implant surfaces carried out by scanning electron microscopy showed different aspects in the topographies of the surfaces in both thread valley and top due to the different treatments used by the manufacturers. In group I, which comprised machined implants without surface treatment, it could be observed that, with magnification set at 10 x and 50 x, the implant threads were uniform, the surface was regular and the thread tops had round angles, as shown in Figures 1A and 1B.

At a closer view, with 500 x magnification (Figs 1C, 1E) and 1000 x (Figs 1D, 1F), it could be observed that the thread top and valley had been marked by tools that are usually used for machining, which caused slight rugosity on the surface. No differences were found with regard to the topographic aspects between the marks found in the thread top and valley (Fig 1).

In group II, a sample treated by means of double acid etching was analyzed. With magnifications set at 50 x (Fig 2B), this sample presented uniform threads, with round tops and regular contour in the thread top and valley. With magnification set at 500 x (Figs 2C, 2E) and 1000 x (Figs 2D, 2F),

Table 1 - Specifications of implants according to data provided by the manufacturers.

Group	Brand	Implant	Surface treatment	Batch	Due date
Group I	Conexão	Master Screw	Surface machining	119881	June, 2015
Group II	Conexão	Master Porous	Acid etching	128272	May, 2016
Group III	Straumann	Straumann SLActive	Blasting + acid etching	CA212	July, 2016
Group IV	Conexão	Master Actives	Anodization	121175	August, 2015

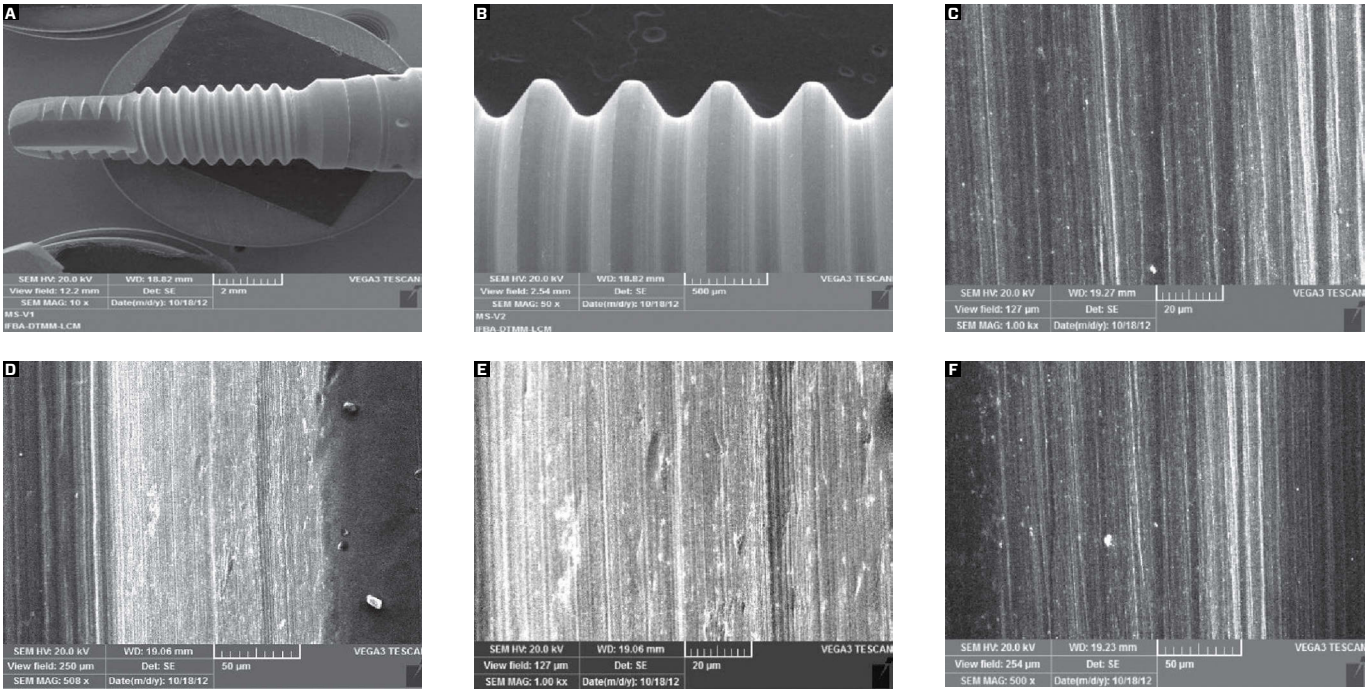

Figure 1 - Panoramic view of group I implant and threads with magnification set at 10x and 50x (**A, B**), and close view of the valley and threads with magnification set at 500x (**C, E**) and 1000x (**D, F**).

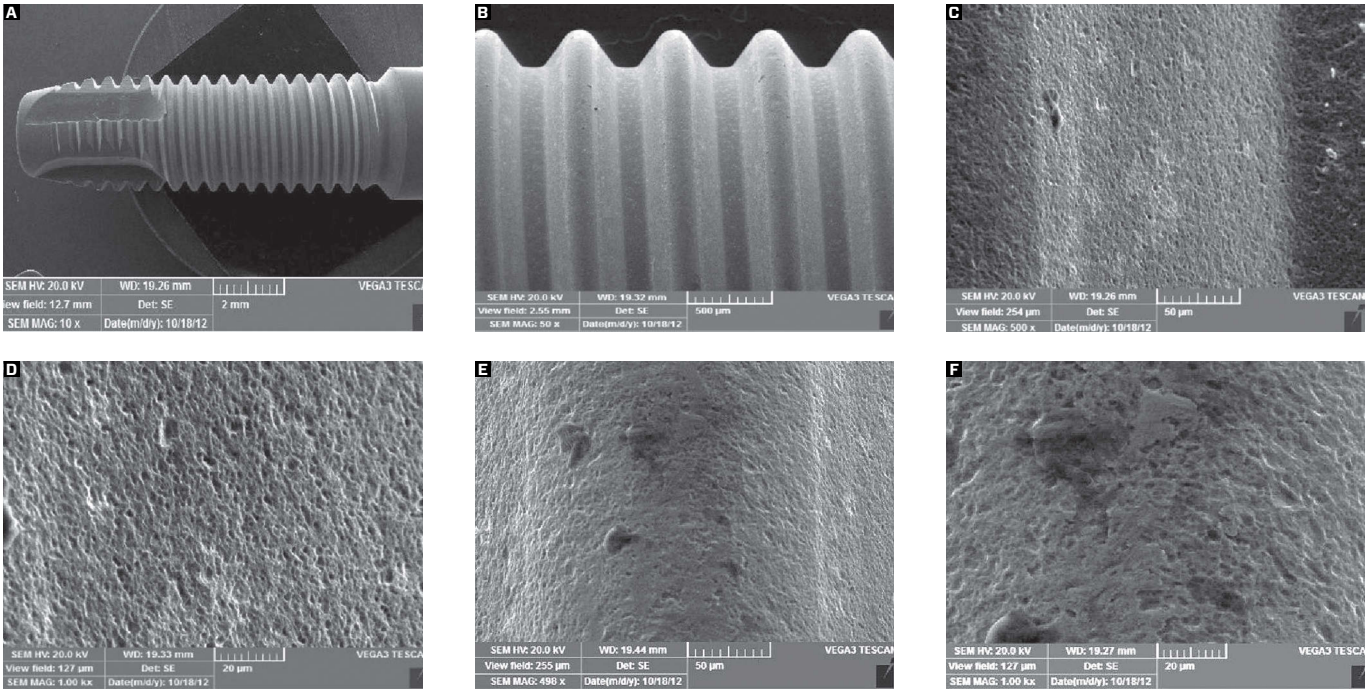

Figure 2 - Panoramic view of group II implant and threads with magnification set at 10x (**A**) and 50x (**B**). Surface porosity can be seen with magnification set at 500x (**C, E**) and 1000x (**D, F**).

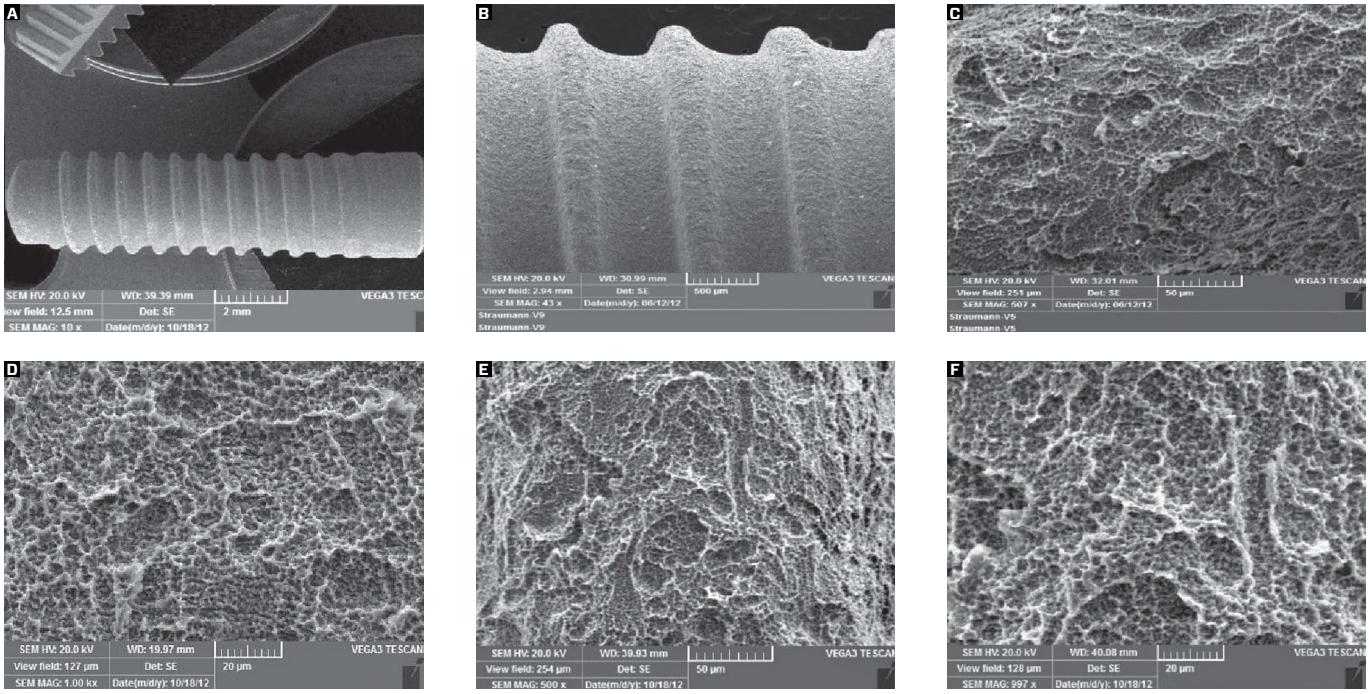

Figure 3 - Group III implant seen with magnification set at 10x, (**A**) 50x, (**B**), 500x (**C, E**) and 1000x (**D, F**) shows a rough surface with no differences between the thread top and valley.

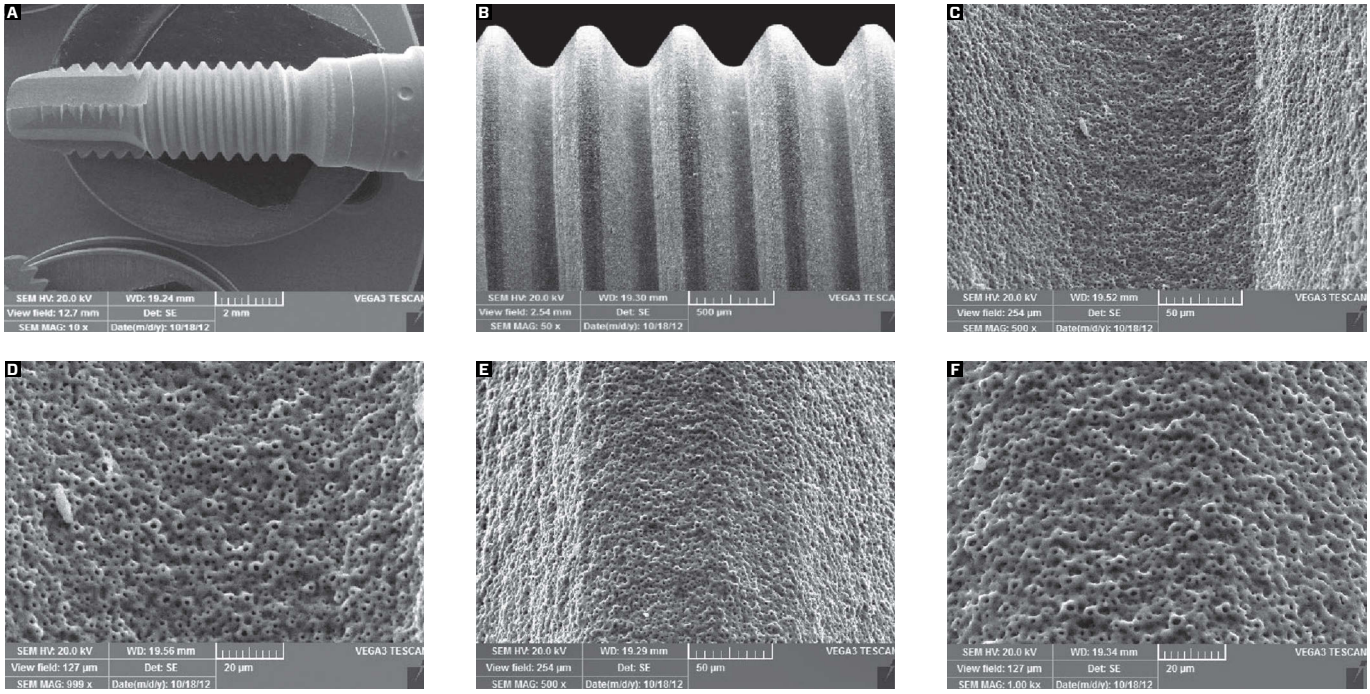

Figure 4 - Group IV implant seen with magnification set at 10x (**A**), 50x (**B**), 500x (**C, E**) and 1000x (**D, F**) present little volcanoes that vary in size and height.

areas with pores, typically caused by the surface treatment employed by the manufacturer, could be observed. However, the upper area of the thread top presented plane areas, with a mixed aspect. Using the same magnifications in the area of the valley, a regular and homogeneous pattern was observed in the pores, without any evidence of plane areas. All images obtained from the samples of group II presented the aforementioned topographic characteristics, in which acid etching removes the implant surface material, producing the porous aspect seen in these images.

In group II, a surface named SLA and which was treated by means of blasting followed by acid etching, was analyzed. With magnification set at 10 x (Fig 3A) and 50x (Fig 3B), this sample presented uniform threads, with round tops and minor irregularities in the contour of the thread top and valley. With magnification set at 500x (Figs 3C, 3E) and 1000x (Figs 3D, 3F), significant rugosity uniformly distributed in the thread top and valley was observed. No differences regarding the topographic aspect of these areas were found.

In group IV, a surface treated by means of anodization was analyzed. With magnification set at 10x (Fig 4A) and 50x (Fig. 4B), this sample presented uniform threads, with a round shape and regular contour in the top and valley. With magnification set at 500x (Figs 4C, 4E) and 1000x (Figs 4D, 4F), small volcanoes different in size and height, equally distributed between the top and valley, were observed. In comparison to the samples comprising groups II and III, the samples of group IV have a larger area for bone anchorage. The pattern observed in this group is characteristic of the surface treatment employed by the manufacturer.

Discussion

Based on the fact that the quality of osseointegration is directly related to the topography of dental implant surfaces, many techniques related to the modifications carried out on implant surfaces have been tested during the last thirty years. These tests take into account the principle that the topography of a rough surface presents an area for bone anchorage that is much larger than a smooth surface does.[13]

Although surface rugosity appears to be a favorable factor for cell biofixation, this is not considered as a general rule. A study conducted by Wennerberg et al[24] compared the tissue bone response to commercially pure titanium implants blasted with thin and thick particles of aluminium oxide. They found that surfaces blasted with thin particles produced medium rugosity topography that was more favorable to the healing process than surfaces blasted with thick particles, thus suggesting that the level of rugosity must be controlled.[8,14]

Some studies have been carried out with different methods of analysis with the purpose of assessing the characteristics of each treatment as well as their influence over the osseointegration process. Topography can be characterized by three methods with different purposes. Atomic force microscopy enables one to observe the surface at a level that is near the atomic level, and can be used with the objective of differentiating the nanotexture of surfaces. Interferometry, on the other hand, is used to analyze the microrugosities of larger areas. The third method is known as SEM, chosen for analysis of surfaces at a micrometric level.[15,16]

In the present study, the method chosen to characterize the topography of implant surfaces was SEM. We agree with Sardinha[17] who used SEM with the same reason of this research: for being a direct-viewing method that allows us to choose the most appropriate magnification for each image.[17]

According to Kahn,[18] the rugosity produced by different implant surface treatment techniques can be visualized

through SEM by the mechanism of emission of electrons generated by a heated tungsten fiber, in a vacuum environment, which scans the surface of the samples, generating the images. The method also has the advantage of being operationally simpler, with a favorable cost-benefit relationship.[18] This method has been cited with the same purposes by other authors who have been mentioned in our study, namely: Ciotti et al,[7] Elias et al,[11] Joly et al,[12] Silva[20] and Ciuccio et al.[23]

Machined implants are considered of first generation. They have a soft surface texture and, for this reason, they are considered smooth.[19] In this study, the analysis of group I characterized a machined surface (thread®). With magnification set at 500x and 1000x, the areas of thread top and valley (Fig 1) presented grooves over the surface, which were caused by tools used in the machining process and resulted in mild rugosity, thus characterizing a surface liable to osseointegration.

The same author also claims that mild rugosity enables minimal osseointegration. In these surfaces, growth of cells occurs over the marks left by the machining process, however, these biological process are slower in the bone-implant interface due to the fact that there are no mechanical retentions that allow bone interlock. Additionally, these surfaces are not inducers.[11,20]

Stability and removal torque are two important factors of which values are used as an indication of success or failure of treatment performed with implants. Studies investigating the effect of implant surface treatment on stability and removal torque by comparing machined surfaces with implants being placed onto guinea pigs' bones, demonstrate that machined surfaces present lower primary stability and removal torque in comparison to implants that had undergone surface treatment. For this reason, some authors claim that these implants have currently been in decline.[11,20,21]

The decline of machined surfaces led to the development of many studies that aim at finding scientific evidence that suggests which surface treatment best produces a topography that is favorable to the osseointegration process. One of the most frequently mentioned treatments is that performed by acid etching. According to the researches carried out, acid etching results in an implant surface topography that stimulates bone apposition and surface decontamination.[22]

The second group analyzed in our study consisted of a surface treated by means of double acid etching (Porous®). Figure 2 shows a regular surface, presenting topography with uniform rugosity pattern, without any grooves caused by the machining process. Furthermore, small cavities surrounded by tapered micropeaks were also seen and, as a consequence, the area available for the osseointegration process was larger. These data corroborates the findings by Ciuccio et al.[23]

Other authors also studying this type of treatment found that it resulted in uniform rugosity that is favorable to increase the contact area between the bone and the implant. Moreover, they claim that treatment performed with acid not only results in a more homogeneous surface in comparison to machined surfaces, but also removes the marks left by the tools. Primary acid etching has the function of changing the micromorphology, whereas the second one has the function of allowing the formation of a more stable and uniform surface.[7,11]

Elias et al[11] conducted a study on implants placed on the tibia of rabbits and confirmed that they are recommended for low-density bones. Additionally, the authors found that implants induce a minor reduction in healing time, given that their morphology facilitates cell adhesion and differentiation, causing the time spent for load application to be inferior to that spent with machined implants.[11] However, although this type

of surface presents many advantages in comparison to machined ones, it has been proved that although acid etching results in a rough surface, it may not be appropriate and it can affect the resistance of the material.[24]

Modifying the implant surface with blasting of particles followed by acid etching becomes a favorable treatment option, since this technique results in semiporous rugosity that favors strong bone anchorage in comparison to surfaces treated with acid, only. Such surface is named SLA.[24] Blasting the implant surface results in texture macro rugosity and the acid etching that follows it promotes micro rugosity, decontamination and hydrophobic state of the surface, allowing better protein absorption.[25]

Modifying the SLA method by altering the surface chemical structure and changing it into active and hydrophilic allows quicker osseointegration and increases stability, thus suggesting that not only rugosity, but also the chemical characteristics of implant surfaces exert influence over osseointegration. This surface is known as SLA active.[26]

In group II, the topography of SLA active surface was analyzed. According to the manufacturer, it had been treated by means of thick sandblasting followed by acid etching. With magnification set at 500x and 1000x (Fig 3), this surface presented topography with significant micro rugosity that is interposed between microcavities in addition to being homogeneously distributed between thread top and valley, in accordance with what was described by the manufacturer.

According to some authors, these chemically active hydrophilic surfaces increase cell dissemination as well as the number of cells connected to the surface, which also increases the speed with which they produce the regulatory factors of differentiation in bone cell formation (osteoblasts), thus decreasing the activity of bone destruction cells (osteoclasts).[24] SLA active surfaces allow direct cell interaction in the first phase of the osseointegration process, which allows bone formation to immediately start, thus increasing initial stability, one of its advantages in comparison to other types of surfaces.[27]

A study conduct by Buser et al[29] assessed removal torque forces by comparing two different surfaces: a polished surface undergoing acid etching and a SLA one, in guinea pigs. After 4, 8 and 12 weeks of healing, a resistance test was performed to the removal torque. The authors concluded that the mean torsion removal force for the SLA was 75% to 125% greater than that of polished and acid-etched implants after 3 months of healing. This is due to the fact that SLA implants promote quicker osseointegration.[28]

Treatment carried out by means of anodization proves to be a favorable option for clinical use since it incorporates calcium and phosphate to titanium oxide, thus speeding up osteoblastic response and, as a consequence, osseointegration. This treatment significantly changes the morphology of implant surfaces, since titanium oxide grows in the shape of little volcanoes, different in size and height, which causes rugosity to significantly increase.[11]

The information aforementioned corroborates the present study. Group IV sample (Fig 4) shows an anodized surface (Vulcano actives) that presents a heterogeneous morphology with little cavitation that varies in size and height. Furthermore, this surface also presents greater rugosity in comparison to the samples that had been treated by acid etching, thus making a larger bone-implant contact area available.

The study carried out by Elias et al[11] on this type of surface proves that the removal torque was significantly

greater for adonized implants in comparison to other groups that had been treated by acid etching, in a rabbit model after 12 weeks. Histologic results demonstrate that this is an inducing surface. Additionally, the authors show that bone deposition on the implant surface occurs simultaneously with bone growth from the alveolus walls. According to Elias et al,[11] clinically speaking, the implant that presents quicker osseointegration is the one with anodized surface followed by acid etching treatment.[11,21]

Our study presented the following limitation: no parameters regarding rugosity measurement were employed; only a description of what was observed through scanning the implants surfaces by means of SEM was adopted. In addition to the present study, other studies are warranted to further assess the topography of surfaces as well as the quality of the osseointegration process obtained with the different types of macro, micro and nanostructures.

Conclusion

Based on the results obtained through scanning electron microscope as well as in the literature review, it is reasonable to conclude that:

1. All groups analyzed revealed the presence of surface rugosity, however, with different characteristics according to the treatment employed by the respective manufacturers.

2. Machined surfaces presented a mild degree of rugosity, therefore, they cannot be considered as totally smooth.

3. Surfaces treated by adonization and those treated by means of blasting followed by acid etching (SLA) present a rougher surface patter that results in a larger area of bone contact, in comparison to surfaces treated by acid etching, only.

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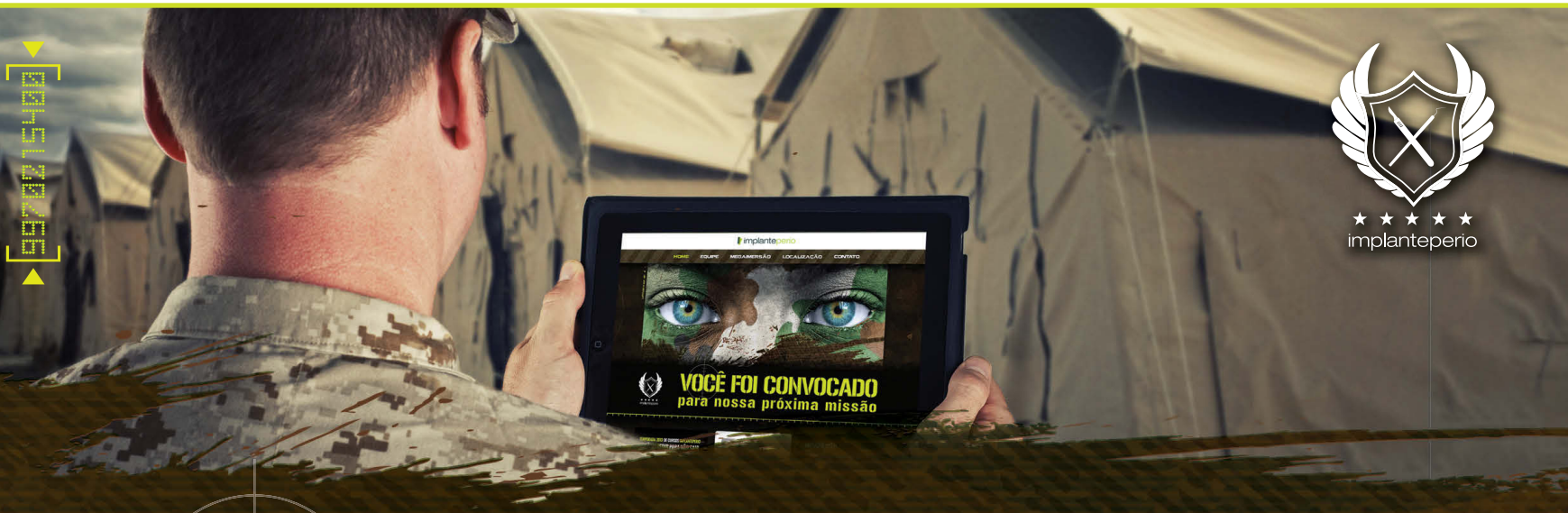

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The interaction between Implantology and Materials Science

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Abstract

Introduction: Materials Science has been of paramount importance to Dentistry because the biomaterials involved have specific characteristics that allow them to have a predictable application. In Implantology, the following may be emphasized: biomaterials, membranes and implant surfaces. It is of vital importance to study the physicochemical characteristics of biomaterials in order to correctly choose what provides a specific biological outcome. Therefore, analysis of properties such as crystallinity, particle size, porosity, and specific surface area is crucial to understand the *in vivo* performance of materials. Implant surfaces have also been developed to improve the osseointegration process in areas with poor quantity or quality of bone. **Objective:** The aim of this study is to carry out a literature review about the importance of Materials Science in the development of biomaterials used in Implantology.

Keywords: Materials Science. Biomaterials. Membranes. Implant surface.

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Introduction

Nowadays, Implantodontics faces a daunting challenge. Given the increase in the life expectancy of the world population and their relentless pursuit of better quality of life, one often encounters partially or totally edentulous patients who require oral rehabilitation, but have severe limitations in terms of bone availability for implant fixation.

Research in the field of Implantodontics began as early as 1965, when the concept of osseointegration was first introduced. In the past, treatment planning was carried out based on existing bone tissue, and did not take into account the three-dimensional position of implants nor there was any esthetic concern regarding how cases were finished.[2] However, planning is currently reversed, to the extent that it is the prosthesis that determines implant position, and in many situations, the amount of bone available is inadequate for the case.

Materials Science correlates the properties of a given material with its microstructure. Microstructure can be defined as the atomic organization of crystalline solids, and it is related to their intrinsic and extrinsic properties. With the aid of engineering, one can develop materials with controlled characteristics which improve their *in vivo* peformance.[3] Implantodontics makes use of various biomaterials for specific applications, geared towards restoring the form, function and esthetics of patients.

This study aims at reviewing the development and application of biomaterials used in Implantodontics.

Literature review

Biomaterials for bone graft

By definition, a biomaterial is a pharmacologically inert substance or a combination of two or more substances, of natural or synthetic origin used to partially or fully replace, augment or enhance tissues and organs.[4]

Bone reconstructions involving treatment with dental implants have been on the rise, driving the development of materials that enable replacement, or even the use of autogenous graft.[5]

Biomaterials must perform certain key functions for which they were developed in the first place, such as being biocompatible and biofunctional as well as leading to predictable results. Biofunctionality refers to the physical and mechanical properties that enable the implant to perform its intended function, whereas biocompatibility is defined as a state of mutual existence between a material and its physiological environment whereby no harmful effects are produced in either one of them.[6]

Biomaterials can be classified according to their origin and action mechanism. In terms of origin, they may be classified as autografts, allografts (e.g. bone bank), xenogenous (e.g. Bio-Oss®), and alloplastic (e.g. Alobone Poros®).[7] In terms of action mechanism, biomaterials can be classified as osteogenic, osteoinductive and osteoconductive.[8]

Ceramic materials used in Dentistry are known as bioceramics. Among these, calcium phosphate [$Ca_3(PO_4)_2$] and hydroxyapatite [$Ca_{10}(PO_4)_6OH_2$] are widely studied due to the fact that their chemical composition and crystal structures are similar to the inorganic chemical composition of bone tissue. The remarkable advances in bioceramics resulted in the development of materials with chemical, physical and mechanical properties that are suitable for biomedical applications.[9]

Physicochemical properties are responsible for the integration of biomaterials into living tissue. Physical properties comprise the surface area, shape (block or granule), porosity (dense, macro or microporous), and crystallinity (crystalline or amorphous). Chemical properties refer to the calcium/phosphorus (Ca/P) ratio and the chemical composition.[3]

Knowledge of the physicochemical properties of biomaterials is of paramount importance for the implant dentist to select the most suitable biomaterial for a given application.[3]

Membranes

The concept of guided tissue regeneration (GTR) was developed with the purpose of regenerating periodontal tissues lost due to periodontal disease. GTR seeks to exclude unwanted cells during repopulation of the wound area through membrane barriers, thus, fostering proliferation of specific tissue cells in order to ensure that wound healing occurs with the desired tissue type.[10]

The principle of mechanical barrier is also applicable in reconstructive bone surgery, in which placing a barrier membrane prevents soft connective tissue growth within the bone defect. The membrane is placed in direct contact with the bone surface, thereby positioning the periosteum on the outer surface of the membrane. The ultimate goal of guided bone regeneration (GBR) is the use of a temporary material that promotes a suitable environment, allowing the body to deploy its natural healing potential and regenerate lost and missing tissues.[11]

It is imperative that the membranes used in regenerative procedures meet certain prerequisites if they are to act as a passive physical barrier, i.e., biocompatibility, space maintenance, integration with tissues, adequate clinical management and occlusive properties.[12]

Occlusivity is intended to prevent the migration of cells from the connective and epithelial tissues into the defect, whereas tissue integration stabilizes the wound and develops a biological seal between the tissues. Maintaining the space produced by the membrane is essential for blood clot formation and subsequent tissue regeneration.[12]

In order to maintain adequate space for regeneration, the membrane must have mechanical or structural characteristics capable of withstanding the forces exerted by the tension of the flaps or by chewing, thereby preventing the membrane from collapsing over the defect. Furthermore, barrier function must be maintained for as long as necessary for tissue regeneration to occur.[13] To ensure bone formation and maturation, a period of at least six months is recommended.[8]

While meeting the criteria described above, nonresorbable and resorbable membranes have been developed for both GTR and GBR.

Nonresorbable membranes

Most nonresorbable membranes comprise cellulose or expanded polytetrafluoroethylene (e-PTFE). Because they feature high stability in biological systems and do not generate immune responses, e-PTFE membranes (Gore-Tex Augmentation Material, WL Gore) used to be the most widely employed.[12]

The e-PTFE membranes feature chemical and biological inactivity, as demonstrated by absence of adverse tissue reactions.[14] Their greatest advantage is the ability to maintain the function of a barrier throughout the period required for bone formation. Their major disadvantage is the need for a second surgical intervention to remove the nonresorbable membrane.[15]

Resorbable membranes

Resorbable membranes must be fully made of bioresorbable materials which belong to the group of natural or synthetic polymers (collagen or polyester). Collagen, polylactic acid, polyglactin 910, poly-glycolic acid and polyurethane[16] membranes can be cited as examples of resorbable membranes.

Resorbable collagen membranes feature several advantages. They stabilize the wound, allow early vascularization by attracting fibroblasts through chemotaxis,

and are semipermeable, which facilitates the transfer of nourishing elements.[17] Furthermore, resorbable membranes do not require a second surgery to be removed. The major disadvantage of resorbable membranes is that their barrier function does not last long.

Resorption may occur before the minimum period required for bone formation and maturation. Moreover, space creation and the collapse resistance characteristics (hardness) of a GBR membrane are important considerations when choosing a suitable material. This is true for degradable materials, as they will lose mechanical strength during the degradation process.[12]

Implant surfaces

Implant surfaces have undergone a number of changes not only with the purpose of improving osseointegration in areas with poor quantity and/or quality of bone, but also accelerating bone healing in order to enable early or immediate loading protocol. Among the different parameters that help to determine a successful implant, the implant-bone interface plays an important role in longevity and improves the function of implant-supported prosthesis.[18]

Different kinds of surfaces are available in the market, vary according to the treatment received, and can be grouped into five types, i.e., untreated, machined surface; surfaces of which roughness is modified by abrasive particles through acid etching, coating by deposition of titanium oxide particles or laser treatment; modified by hydroxyapatite or other chemical products; electrochemical treatment with alkaline solutions to change the surface energy of titanium or vary the thickness of the oxide layer (anodizing); and mechanical subtraction by means of ion bombardment.[19]

On titanium surfaces, the biological effects of surface chemistry are mainly related to the architecture of the titanium oxide layer (TiO_2). Given that osseointegration is directly related to dynamic thickening of the layer of TiO_2, implants with a thick TiO_2 layer, such as anodized implants, exhibit a better bone response since they increase mineral bone matrix precipitation on the surface of the implant.[20]

Impregnation or coating with inorganic elements stimulate a biochemical imbrication between the bone matrix and the TiO_2 layer.[21] Impregnation with calcium phosphate[22] and coating techniques[23] have been widely investigated and show favorable bone responses, but a consensus has yet to be reached regarding the precise underlying mechanism, the optimum levels of calcium phosphate and the methods of incorporation. Impregnation with phosphorus[24] or magnesium[25] also significantly increases bone response, and low impregnation with fluoride[26] stimulates bone cell differentiation by means of direct cell signaling. Nevertheless, the exact mechanism is still unclear. The biological results yielded by crystal architecture are positive, as previously shown in implants covered with anatase titanium oxide.[27] The ideal microroughness for bone formation is found in moderately rough implants, with an average height deviation (Sa) of 1.5 μm.[1]

Modulation in the nanotopography of an implant surface exerts a significant impact on the behavior of bone cells. It is possible to design a specific nanotopography geared towards increasing or controlling the proliferation and differentiation of bone cells.[28]

The application of nanotechnology represents a step forward in the development of the surface of dental implants, and the results point to an improvement in the response of bone implants known as nanomodified.[29]

Discussion

There is a wide range of dental biomaterials available in the market that exhibit different behavior *in vivo*, and are dependent on their physicochemical features.[3]

Porosity increases the surface area of bone graft biomaterials, enabling bone formation. Therefore, the higher the porosity the faster biomaterials are resorbed.[30] The pores must have a minimum diameter of 100μm.[31]

Porosity can be affected by temperature in the sintering process of thermally treated bioceramics. Increases in sintering temperature result in lower porosity of the biomaterial.[32]

Crystalline biomaterials have a well defined atomic organization, unlike amorphous materials which have an irregular crystal form. Crystallinity is a property that alters the resorption rate of bone graft biomaterials.[3] Highly crystalline biomaterials are more resistant to degradation.[33]

There are differences in the crystal structures of bone graft materials, which shows that small crystals resembling those of the bone are desirable. The different sizes of crystals may stem from differences in processing. Biomaterials processed at temperatures above 1000°C induce crystal growth.[34] High sintering temperatures can cause changes in the atomic structure of HA crystals[35] and can thus substantially affect the behavior of bone graft materials.[36]

Particle size is an important factor because it directly affects the surface area available to react with cells and biological fluids. Thus, the smaller the particle size the smaller the resorption time and, as a consequence, the new bone formation.[37]

A balance must be struck between the rate of resorption of the biomaterial and the rate of bone formation, whereby the biomaterial cannot be resorbed too quickly, nor can it fail to be resorbed as it is the case of crystalline biomaterials.[38]

It has been shown that when bone graft biomaterials are used in conjunction with membranes a higher success rate is achieved due to the fact that a greater proportion of vital bone if formed.[39]

Membranes produce an efficient barrier against the invasion of mucosal tissue while inducing bone regeneration without complications.[12]

With the advent of resorbable membranes, the use of nonresorbable membranes has been decreasing since resorbable membranes eliminate the need for removal surgery. Nevertheless, e-PTFE membranes remain the benchmark in GBR procedures.[15]

Stabilizing the membrane during GBR procedures is essential for achieving predictable results. This was demonstrated in a study in which the authors compared the results of regenerative procedures using allograft, bioresorbable membrane and membrane stabilization. They reported that in cases in which the membrane was stabilized with screws, bone loss was lower after the healing period in areas where the width had been increased.[40]

In addition to the use of biomaterials for bone grafts and membranes for GBR, studies have investigated various surface treatments of dental implants in order to improve clinical outcomes related to rehabilitation with this therapeutic approach. In this context, the results of different experiments showed increased implant-bone contact in implants that combined micro and nanostructures.[41] Studies have shown increased bone response thanks to this combination (micro + nano) compared with micro only, in both humans[41] and mice.[42] However, in an eight-week follow-up of dogs, similar values of bone-implant contact were found between implants with microstructure versus micro + nano.[43] The benefits of nanostructures are not yet widely acknowledged by the scientific community, and several factors contribute to this reluctance. Noteworthy among these factors is a difficulty in attaining an adequate characterization of 3D topography on a micrometric and nanometric scale. Future experiments are warranted to clarify the importance of nanostructures in bone response. A correct characterization of the surface is a key factor in comparing and analyzing results.[29]

Conclusions

It can be concluded that Materials Science plays a crucial role in the development of metallic, ceramic and polymeric biomaterials. Stringent control should be exerted when processing these materials to ensure that their microstructure indeed contains the properties required by any given clinical application.

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Immediate implant placement in esthetic zone

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Abstract

Immediate implant placement is considered a viable technique due to its reduced surgical time. However, many factors such as quality and position of the attached gingiva, alveolar process integrity, gingival height and shape must be taken into consideration in order to yield excellent final esthetic results. The characteristics of an ideal surgery include tooth extraction with low trauma, placement of a temporary smooth crown as well as a polished and emergence profile that keeps the gingival contour. As a requirement for the use of immediate loading, we should analyze, immediately after implant placement, primary stability (existence of bone for the initial stabilization of the implant), integrity of the alveolar walls, gingival phenotype as well as integrity and amount of soft tissue. Although it is considered a predictable procedure, its indication depends on careful planning.

Introduction: Dental implants. Single tooth. Dental prosthesis. Implant supported. Dental implantation.

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» The patient displayed in this article previously approved the use of her facial and intraoral photographs.

Introduction

In the early stages of dental implant usage, Branemark[1] proposed a protocol in which implants should be submerged during a period of time that varied according to the quality of bone without masticatory load.[2] This happened because it was believed that micro movements interfered in the process of implant loss.[3] However, some researches have shown that under conditions such as primary stability it is possible to successfully apply immediate load to recently installed implants.[4,5,6]

Immediate implant placement after extraction has been a reality for single-tooth implants since 1994, when Becker et al[7] claimed that, whenever possible, an implant should replace a tooth root during the same procedure when the latter is removed in order to avoid additional bone loss that may occur in the horizontal and vertical directions.

The use of implants with immediate load is common in the esthetic zone, given that intercurrences such as sports accident, iatrogenesis, traumas and fracture of old prosthesis may occur without prior warning in the oral arch, in which case it is recommended that alveolar resorption be avoided, as it may hinder esthetics.[8]

Clinical studies have demonstrated the possibility of performing osseointegration followed by one single surgical stage and immediate load placement on titanium implants in edentulous maxilla provided that the final implant placement torque exceed 35N/cm. According to Salama et al,[10] the key to successful immediate implant placement is assessing the prognosis of adjacent soft tissues, of which satisfactory result depends on untraumatic extraction and absence of damages caused by the placement appliance. Extraction in esthetic zones must be carefully carried out, given that the vestibular bone wall may be thin and subject to fracture. For this reason, any bone loss may be compromising.

Implant selection is also important. Therefore, it is advisable that cone-shaped or cylindrical/cone-shaped implants (hybrid) be chosen, since they present a larger contact surface in relation to the bone and are better adapted to the receiver bed. Additionally, primary stability should also be considered to achieve success in osseointegration. The former accomplished when the implant is placed in a bone site and direct mechanical adaptation occurs between the bone and the implant surface.[11] However, successful adaptation depends on several factors, including the amount and quality of bone, implant geometry (length, diameter and shape, i.e., its macrostructure) as well as the surgical technique for implant bed preparation.[11-16] Immediate placement presents several advantages for tissue cicatrization. Based on that, we herein describe a case report.

Case report

A 42-year-old female patient presented root fracture of #11 tooth. After clinical and radiographic analysis (Figs 1 and 2), the tooth was untraumatically extracted. We began with an open-flap debridement procedure around the tooth. The crown was removed with the aid of a forceps and removal of the molten metallic core 3) as well as minimally invasive root extraction were carried out (Fig 4). The alveolus was examined and alveolar curettage was performed (Fig 5). Subsequently, we began the perforations with the Neodent kit. GenMix® composite bovine bone graft (Figs 7 and 8) was used in the vestibular bone wall and after placement of 4.3 x 13 mm Alvim CM implant with 60N torque (Figs 9 and 10) and 4.5 x 6 x 1.5 mm post with 20N torque (Fig 11), suture and placement of the temporary crown (Fig 12). One week later, the control of the site was carried out. The patient returned after three weeks for site control during which a radiographic examination, photos and ceramic planning were carried out (Figs 13 and 14).

Figure 1 - Frontal view of patient's smile.

Figure 2 - Initial radiograph.

Figure 3 - Removed crown and molten metallic core.

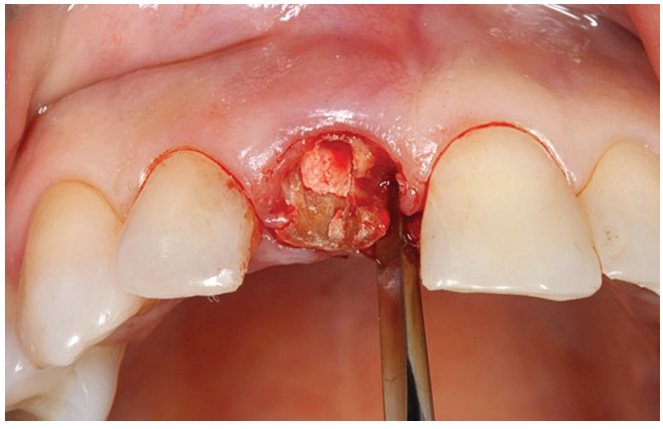

Figure 4 - Minimally invasive extraction.

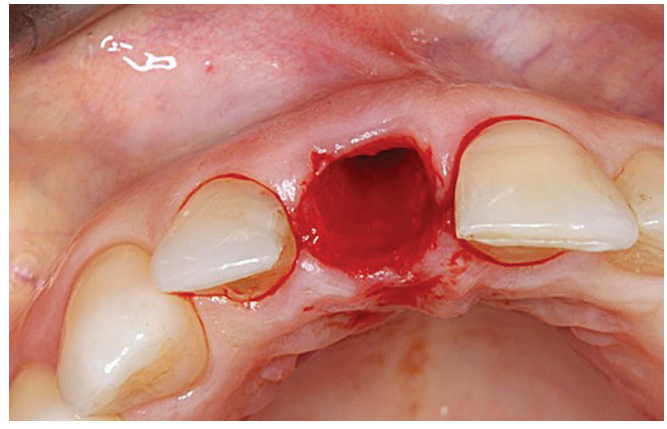

Figure 5 - Alveolus after examination and curettage.

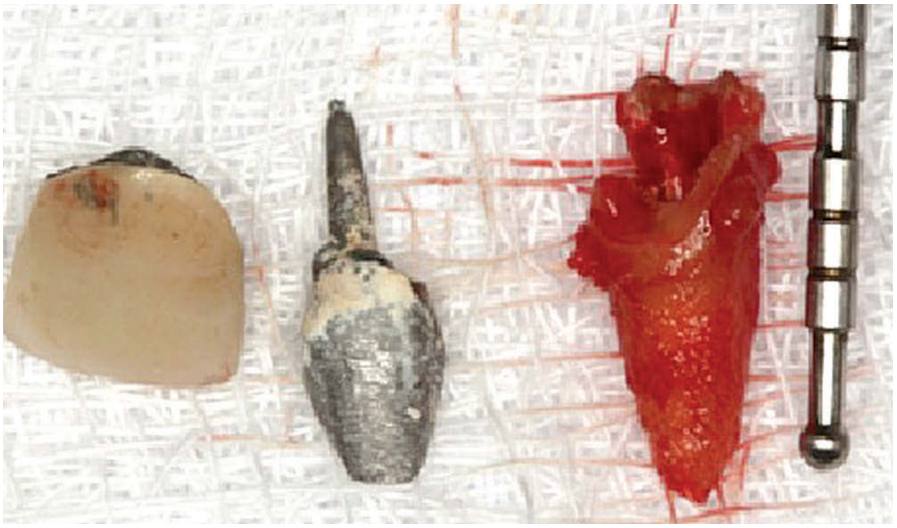

Figure 6 - Removed elements.

Figure 7 - Graft insertion in the vestibular wall.

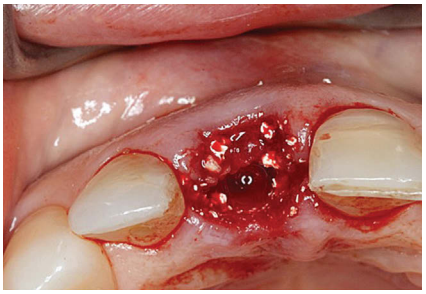

Figure 8 - Alveolus after graft insertion.

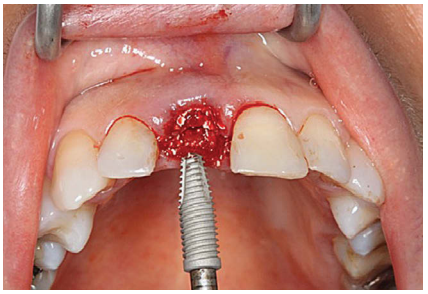

Figure 9 - Insertion of 4.3 x 13 mm graft with 60N torque.

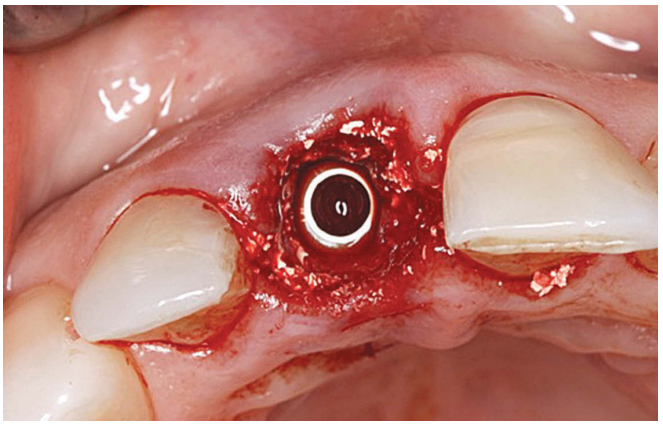

Figure 10 - Alveolus after placement of 4.3 x 13 mm Alvim CM implant with 60N torque.

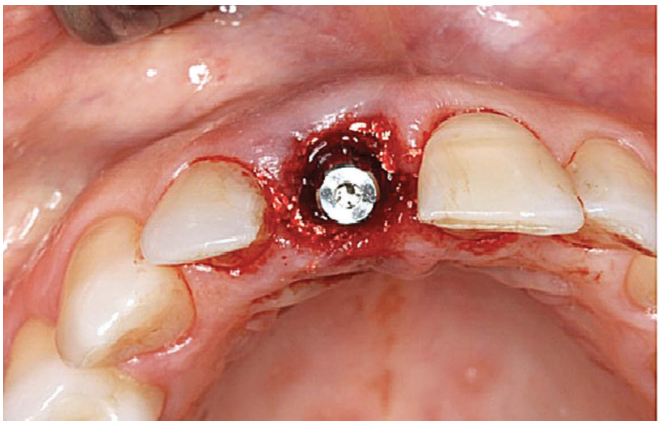

Figure 11 - Placement of 4.5 x 1.5mm universal post with 32N torque.

Figure 12 - Frontal view after placement of temporary crown. Note the developing papilla.

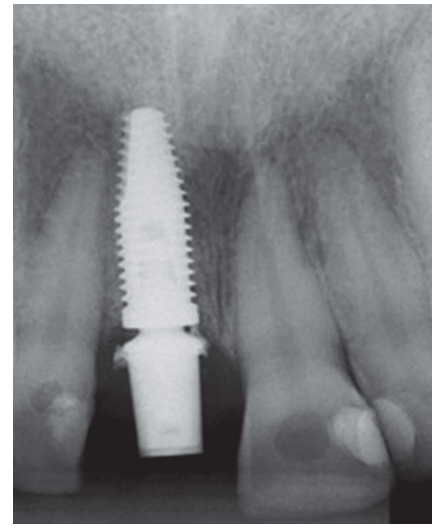

Figure 13 - Control radiograph after three weeks. Well-positioned 1-2 millimeter infraosseous implant.

Discussion

The immediate implant of single teeth in esthetic zone is recommended mainly to tooth loss cases caused by resorption, root perforation and recent fractures. Clinical studies demonstrate that the survival rates for implants immediately placed, early or late, are similar and range between 93 and 100%.

Extraction must be performed as carefully as possible in order to avoid bone loss. Additionally, choosing the appropriate instruments optimizes the final outcome. The most frequently used instruments are as follows: surgical mini-blades for the open-flap debridement procedure, periotome, mini levers, surgical burs/high speed, curettes, forceps for residual roots and anterior crowns.

The receiver site must be carefully examined with regard to the amount of bone available for the initial mechanical stabilization, integrity of alveolar walls, gingival phenotype (amount and integrity of soft tissues) and presence of contaminated zones.

Implant positioning must be slightly lingual in order to achieve greater bone anchorage. When implant is palatally positioned we keep the vestibular cortical integrity and increase primary stability. Should a gap be created due to such positioning, it will be filled up, given that implants in the center of the alveolus or nearer the vestibular wall may cause gingival recession.

Extraction associated with implant and crown placement presents many esthetic, psychological and func-

tional advantages which minimize treatment time. Cicatrization of soft tissues concomitantly occurs with osseointegration, promoting stability in the gingival level.

Conclusions

Using immediate load in single implants, when carefully recommended and planned, presents satisfactory results due to the fact that when vestibular bone support and the architecture of mucogingival tissues are preserved, natural prostheses and their peri-implantar tissues will emerge more naturally.[17] According to Lazarra,[18] immediate implant placement may favor the fabrication and final esthetic results of the implant-supported prosthesis, since the implant is in the same position and similar inclination in relation to the natural tooth.

Immediate implant placement presents advantages such as: reduction in the number of surgical procedures and treatment time, ideal implant orientation, preservation of bone in the extraction zone, great esthetics of soft tissues and maintenance of the gingival contour, in addition to the fact that patient's appearance immediately recovered.

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Determining factors for formation and/or maintenance of peri-implant papilla: Literature review

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Abstract

Introduction: The interproximal papilla, among other requirements, is considered essential to achieve success in esthetic prostheses placed over implants. **Methods:** This article is based on a literature review carried out with periodicals published from 1984 to 2011 on LILACS and MEDLINE. Twenty-one articles were selected in order to highlight the determining factors for the formation and/or maintenance of peri-implant papilla, namely: the ideal distance between a tooth and an implant, the distance between implants, the above/bellow bone level positioning of an implant and the necessary distance from the contact point to the bone crest. **Conclusions:** We concluded that the ideal distance between a tooth and an implant is 2 mm, whereas the distance between implants is 3 mm, given that the height of the gingival papilla is supported by the formation of biological space. With regard to the positioning of the implant, above/bellow bone level, no differences regarding papilla formation were reported. The height from the contact point of the crown to the bone crest, which is a determining factor for papilla formation, should be up to 5 mm.

Keywords: Gingiva. Dental implants. Periapical tissue.

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introduction

The interdental papilla is of great interest for Implantodontics, given that its presence may lead to either esthetic success or failure in the majority of implant-supported dental prosthesis cases. Some factors should be analyzed during planning, namely: bone height and thickness, bone crest height in relation to the dental contact point, gingival tissue biotype and architecture as well as tridimensional implant positioning, all of which can determine and prevent the prognosis of treatment in Implantodontics.[1,2]

Loss of gingival papilla will result in the formation of a relatively dark area popularly known as "black hole". Therefore, a surgical planning implemented for implant placement should take into account the distance between the tooth and the implant, the distance between implants, above/bellow bone level positioning and the distances from the dental contact point to the bone crest that should be adjusted to the patient's anatomy, healing potential and remodeling of hard and soft tissues in order to avoid loss of the papilla or to prepare the patient for a potentially unfavorable prognosis.[3,4]

Literature review

This study aims at conducting a literature review on periodicals published between 1984 and 2011 in the following databases: LILACS and MEDLINE. Additionally, it aims at analyzing the determining factors for formation and/or maintenance of peri-implant papilla, namely: the ideal distance between the tooth and the implant, the distance between implants, implant above/bellow bone level positioning and the necessary distance from the contact point to the bone crest.

The following are considered as determining factors for formation and/or maintenance of the papilla:

Manipulation of soft and hard tissues around implants

According to Kois,[5] surgical techniques can affect the shape of the gingival papilla, thus, immediate implant atraumatic protocols should be developed not only to reduce the damage caused to soft tissues, but also to preserve esthetics. In these cases, an immediate provisional implant can be placed, which is ideal to preserve the integrity of tissues as well as meet patients' expectations with regard to esthetics. Moreover, implants can also receive a healing cap with a provisional implant (fixed or movable), and that is when the technique of gingival conditioning by compression can be used in order to provide an appropriate gingival contour with papilla formation.

Should there be any bone or gingival deformities, the prognosis will be considered extremely unfavorable, even if the most modern restorative system has been selected. Additionally, even though methods for increasing the thickness of the ridge and the keratinized gingiva have been used,[6] and given that the success rate in interproximal areas is the same that is achieved in edentulous alveolar ridge areas or tooth free surfaces, Salama et al[6] developed a classification that takes into account the degree of alveolar bone crest height resorption in esthetic areas:

» Class I: bone crest is present, 2 mm distant from the cementoenamel junction, which results in a optimum prognosis.

» Class II: bone crest is present, 4 mm distant from the cementoenamel junction, with a questionable prognosis.

» Class III: bone crest is present, 5 mm (or greater) distant from the cementoenamel junction, which results in an unfavorable esthetically prognosis.

In another study, Phillips et al[7] describe the need for appropriate bone support in order to preserve soft tissues. The authors report that, in cases with insufficient bone, bone graft or orthodontic manipulation must be included in the planning. Additionally, they advocate the use of surgical guide based on the waxing of the future crown in order to appropriately locate the implant on the three planes that must be considered (mesiodistal, buccolingual and apico-coronal). Moreover, they suggest that the implant platform in the vertical aspect (apico-coronal) be placed 3 mm apical to the marginal gingiva line or 2 mm from the cementoenamel junction of adjacent teeth, so as to compensate the expected gingival retraction around the implant.

Distance between dental implants and between implants

Some researchers radiographically assessed marginal bone loss around Brånemark System implants and adjacent teeth.[8] Fifty-eight adults with 71 prosthesis (47 of which had restorations with single implants, while 9 received two implants and 2 received three implants) were monitored for a period not greater than three years, after the crowns had been placed. The following aspects were considered: age, reason for bone loss, vertical relationship between the prosthesis and the teeth, distance between adjacent teeth, distance between the prosthesis and natural teeth, and the region in the mandible or the maxilla where implants were placed. The distances, the level of marginal bone around the implants as well as the dental surfaces were measured through enlarged and standardized intraoral radiographs. Before implant surgery was carried out, initial radiographs were taken in order to observe bone tissue height in relation to adjacent teeth. All 71 implants were monitored for a week after the prosthesis had been placed. Forty-one of them were observed for a year, while 30 of them were observed for three years. The results showed bone loss around the implants, with a mean value of 0.97 mm at the moment when the prostheses were being placed. After a year, such loss increased in 0.08 mm; and after three years, it increased in 0.32 mm. The highest rates of bone loss were observed for upper lateral incisors, whereas the lowest rates were observed for the molars. Furthermore, the results showed that there was marginal bone loss of teeth adjacent to implants during the interval between the pre-operative and crown placement phases. Such loss exceeded the loss occurring over the following years. A strong correlation between bone loss of adjacent teeth and the horizontal distance from the implants to the teeth was found. As distance decreased, bone loss increased, especially in the region of the upper incisors. It seems rather difficult to predict which individual conditions may have a greater risk of bone loss due to intra and inter individuals' variations.

A longitudinal study was conducted on 36 patients with adjacent implants and whose periapical radiographs were taken by means of the paralleling technique, using special positioners with the purpose of standardizing and making the study reproducible within at least one and not longer than three years after implant exposition. The radiographs were scanned and enlarged so that the measures from the bone crest to the implant surface as well as from the bone crest to a line drawn between the adjacent implant platforms could be taken. The samples were divided into two groups according to the distance between implant shoulders. The results showed that lateral bone loss was 1.34 mm on the mesial of the implant, and 1.40 mm on the distal of adjacent implants. Moreover, loss of bone crest at a distance of 3 mm was 0.45 mm, whereas at distances shorter than 3 mm, loss of bone crest was 1.04 mm. Thus, there should be enough space for the bone crest and, as a consequence, for the preservation of the best interproximal space. Therefore, it is suggested that implants with smaller diameters be used in esthetic areas,[9] and that it is harder to maintain or create papillae between two adjacent implants than between an implant and a tooth.

Another study conducted by Gastaldo et al[10] assessed the effects of vertical and horizontal distances between adjacent implants (group 1) and between an implant and a tooth (group 2) on the incidence of interproximal papilla. Forty-eight patients were included, of which 96 interproximal areas between implants and 80 implant-tooth areas were assessed, totalizing 176 interproximal areas. The areas presented fixed prostheses that had been installed for at least 18 months and for a period not greater than 6 years. Measurements were taken by means of a periodontal probe, with the implant shoulders and the root surface of adjacent teeth as reference. The papilla was visually assessed, and the distance from the contact point base to the bone crest (D1), the tooth-implant distance or the distance between implants (D2) and the distance from the contact point base to the end of the papilla (D3) were measured. The

authors concluded that, in both groups, the papilla was often present when D2 was 3, 3.5 or 4 mm ($P < 0.05$); whereas it was always absent when D2 was 2 or 2.5 mm ($P < 0.05$). Additionally, in group 2, the papilla was often present when D1 was between 3 and 5 mm ($P < 0.05$). However, in group 1, the papilla was often present only when D1 was 3.0 mm ($P < 0.05$). For both groups, the analysis demonstrated that there was interaction between D1 and D2 (D2 < 2.5 mm papilla was absent, and with D2> 3.0 mm there was interaction between D1 and D2). The ideal distance, from the base of the contact point with the bone crest, between adjacent implants was 3 mm, whereas between an implant and a tooth it ranged from 3 to 5 mm. Lateral spacing between implants and between a tooth and an implant ranged from 3 to 4 mm.

By carrying out an extensive literature review, Grunder et al[11] wrote an article that discusses the 3D bone-implant relationship and its influence over the esthetics of soft tissues around implants. The limiting factor for esthetic results of treatments performed with implants is the level of bone on the implant site. Clinicians should focus on the bone-implant 3D relationship in order to establish the basis for an ideal and harmonious situation in which the soft tissue will remain stable during a long period of time. With regard to papilla preservation, the following measures should be adopted: 2 mm between the implant and the tooth, 3 mm between implants, and distance greater than 3 mm between implants in the anterior region. Wide-platform implants are not recommended for the region of central incisors as they can cause esthetic problems in the prosthesis due to difficulties of keeping a minimum space of 2 mm between the implant and the buccal cortical, which leads to potential retraction of the peri-implant mucosal margin.

Distance from the contact point of the crown to the bone crest

The distance from the contact point of the crown to the bone crest determines the height and geometry of the space that will be filled by the soft tissue forming the gingival papilla.

Tarnow et al[12] observed the vertical relationship between the level of bone crest with natural teeth through probing and demonstrated the importance of such relationship for proper maintenance of soft tissues. They assessed the presence or absence of papilla in the interproximal region of 288 interdental areas of 30 patients. Should the space be visualized apically in relation to the contact point, the papilla was considered absent; should the space be completely filled, the papilla was considered present. When the distance between the contact point and the bone crest was 5 mm, papilla formation occurred in 100% of the cases; when the distance was 6 mm, it appeared in 56% of the cases; and when the distance was 7 mm, the papilla was present in 27% of the cases, or even absent. The authors concluded that the vertical distance from the base of the contact point to the bone crest is one of the factors responsible for the presence or absence of papilla.

Choquet et al[13] conducted a clinical, photographic and radiographic retrospective that focused on the papilla around the implant-supported dental prostheses and their adjacent teeth. The authors assessed 26 patients who had received 27 implants in the anterior region of the maxilla. Six months after the implants had been placed, 17 of them were exposed to the oral environment by means of a standard technique, while 10 of them were exposed to the oral environment by means of a modified technique so as to favor papilla formation around the implants. The presence and/or absence of papillae was determined and the effects of the following variables were analyzed: the influence of the two surgical techniques employed in the second implant surgical phase; the vertical relationship between the height of the papilla and the bone crest present between the implant and the adjacent tooth; the vertical relationship between the level of papilla and the contact point between the crown over the implant and the adjacent tooth; and the distance from the contact point to the bone crest. The results demonstrated that when the distance from the contact point to the bone crest was 5 mm or less, the papilla was present in 100% of the cases; however, when the

distance was 6 mm, the papilla was present in 50% or less. The interproximal soft tissue height (distance between the bone crest and the papilla peak) was 3.85 mm. Additionally, a comparison between conventional and modified techniques revealed that the relationship changed from 3.77 mm to 4.01 mm, respectively. Based on the results obtained, the authors concluded that the bone crest influences the presence or absence of papilla between the implant and the tooth. Moreover, it also positively influences the modified surgical technique that aimed at reconstructing the papilla at the moment of implant reopening.

Tarnow et al[1] conducted a study in which the distance from the bone crest to the contact point between teeth was related to the presence or absence of papilla in the interproximal space. The authors assessed the height of the papilla in 136 areas between implants with prostheses that had been fixed for at least two months in 33 patients. Measurements were taken by means of a millimeter periodontal probe that was vertically positioned from the bone crest to the papilla height. When the distance from the contact point to the bone crest was 5 mm or less, the papilla filled the interdental space in nearly 100% of the cases; when the distance was 6 mm, the interdental space was filled in nearly 55% of the cases; whereas when it was 7 mm, the space was filled in 25% of the cases. Therefore, when planning to place two adjacent implants in an esthetic area, one should be aware that the height of soft tissues ranges from 2, 3 to 4 mm (with a mean value of 3.4 mm) and it is formed over the crest and between implants.

Above/bellow bone level positioning of implants

Hammerle et al[14] clinically and radiographically observed the effect of implant placement below the bone crest in peri-implant hard and soft tissues in 11 patients who had received two implants in the same quadrant (test and control). Implant placement was carried out as follows: one implant was placed in compliance with the manufacturer's instructions (control), whereas the other one was placed so as the most apical portion of the implant was approximately 1 mm below the alveolar bone crest. After 12 months, the authors concluded that bone crest resorption also occurred in the implants placed bellow the bone crest. Additionally, they also found that the bone underlying the polished surface of implants that were most deeply placed was lost over time (from a biological standpoint, the authors claim that it is not advisable to place implants below the bone crest, since this practice does not favor the formation of biological space).

Discussion

Dental implants are considered a highly predictable treatment option that is performed to replace lost teeth. They should offer function, esthetics and phonetics. For this purpose, the interproximal area must be intact due to the fact that the gingival papilla performs an important physiological function related to mastication and phonetics: for instance, the fact that it restrains the accumulation of food in the interproximal area and prevents air from escaping while some sounds are being pronounced.[8,12,13]

Some authors even claim that the presence of an esthetically appropriate gingival papilla is determined more by a combination of previous anatomic factors than by the operator's skills and techniques.[8] However, several studies demonstrate the influence of manipulation of soft tissue and implant placement techniques over papilla formation.[6,15]

With regard to anatomic factors, Phillips et al[7] and Tarnow et al[16] describe the need for quantity and quality of soft and bone tissue, while Henriksson et al[17] claims that the contour of soft tissues is not necessarily determined by the adjacent bone tissue. As for gingival biotype, Kan et al[4] and Kois[18] report that thick gingival tissues present a better prognosis when compared to thin gingival tissues.

Surgical techniques can affect the shape of the gingival papilla,[4] thus, immediate implant atraumatic protocols should be developed not only to reduce the damage caused to soft

tissues, but also to preserve esthetics. Becker and Becker[19] take the manipulation of soft tissues into account, and describe new methods for gingival flap that, according to the authors, minimize gingival recession. Other studies conducted by Choquet et al[13] and Oliveira et al[20] describe a modified reopening technique that influences papilla maintenance, in which placing an appropriate provisional implant is essential to avoid the formation of "black holes". In these cases, the use of provisional implants may lead to gingival conditioning by means of three different techniques: gradual pressure, scarification or electrosurgery.

Three dimensions should be considered with regard to the techniques and procedures concerning implant bone status: mesiodistal, buccolingual and apico-coronal.[7,11,16] It is on the basis of these dimensions that one should consider the adaptation of bone and soft tissues before surgery is performed. Some studies[4] report, for instance, that the simultaneous removal of adjacent teeth causes the bone crest to collapse, which, as a result, leads to bone plate remodeling. According to Kois,[5] bone plate remodeling is an important diagnostic factor for papilla formation.

As for the buccal palatal dimension, Grunder et al[11] claims that, according to the amount of bone available, the implant must be 2 mm from the vestibular cortical, whereas for Priest[21] this distance must be 1 mm. This minimal thickness is required to avoid loss of bone height, since in cases in which bone height is not available, the vestibular bone plate will be lost during remodeling and, as a result, cause a high risk of soft tissue recession.

Several authors[1,5,6,8,9,10,13] agree that the distance from the bone crest to the interdental contact point with or without interproximal gingival papilla effectively exerts a major influence over the dimensions of the gingival papilla, not only for natural dentition, but also for areas with implant restorations. The dimensions that have been suggested for the aforementioned height diverge: for some authors,[12] this height must be equal or less than 5 mm between natural teeth as well as implants. Conversely, other authors[9,13,22] claim that this dimension is also appropriate for rehabilitation with implants, since the soft tissue varies an average of 3.4 mm of tissue that is formed over the bone crest.

Many studies[10,23,24] advocate that the contact point height must not exceed 6 mm. On the contrary, Henriksson and Jemt[17] do not establish any relation between the papilla and the contact point. Their study yielded satisfactory esthetic results when the contact point was 6 mm from the bone crest.

Similarly, many authors tried to relate the distance between adjacent roots and implants, as well as between the implant platform and the axial wall of the adjacent tooth, with interproximal gingival papilla formation.[8-1,17,21,23,24] Thus, given that the height of gingival papilla is basically supported by the formation of biological distances, it is expected that the gingival papilla have a more esthetically appropriate topography in teeth than it does in implants.[1] Thus, it is interesting that we search for studies that investigate the potential bone loss around implants.[8] In cases of implants adjacent to natural teeth, nearly all authors consulted for the present research agree that the bone crest adjacent to the tooth is more determinant in gingival papilla formation in the proximal area than bone loss in the implant platform, which causes this papilla to be similar in height and topography to a gingival papilla between teeth.[22]

Esposito et al[8] report that when the distance between implants decreases, bone loss increases. Tarnow et al[9] and Priest[21] state that the minimal distance between implants should be 3 mm, while the implant-tooth minimal distance should be 2 mm. Conversely, Gastaldo et al[10] claim that the distance between adjacent implants should be 3 mm, while the implant-tooth distance should range from 3 to 5 mm. On the other hand, for Degidi et al[23] distances greater than 4 mm causes more loss of vertical bone crest, while distances shorter than 2 mm causes more loss of lateral bone crest

and distances greater than 4 mm present lower frequency of papillae. Therefore, the authors recommend a distance that ranges from 2 to 4 mm. Tarnow et al[1] and Grunder et al[11] also found values of 2 mm for implant-tooth distances and 3 mm or greater for the distance between implants. However, on a study conducted with experimental implant geometry, Choi et al[25] did not find any significant differences in bone loss with distances of 2 and 5 mm. Nevertheless, the authors justify such fact by the use of experimental implants that could have been used in larger numbers on critical sites, given that this geometry would reduce marginal bone loss.

According to Scarano et al,[24] the clinical meaning resides in the fact that an increase in the loss of bone crest results in increase in the distance between the base of the contact points of adjacent implants and the bone crest, which can determine whether the papilla will be present between two implants. The findings by Gastaldo et al[10] corroborate the aforementioned data. The authors claim that should the distance between implants be greater than 3 mm, the height of the contact point will exert greater influence over papilla formation. Furthermore, they report that when the interimplant distance is shorter than 3 mm, this interaction between factors does not occur. Similarly, Buser et al[26] claim that if the distance between teeth is too narrow and the contact point is high, the papilla does not fill the entire space. However, if the distance between teeth is large and/or the contact point is short, the papilla will fill the entire space; which corroborates the aforementioned interaction.

Studies[14,26] conducted with non-submerged implants undergoing different surface treatments did not present any complications of bone loss or migration of soft tissue. Additionally, no differences between the above/bellow bone level positioning of implants were found. Nonetheless, Yi et al[27] and Hartman et al[28] found a higher rate of bone loss for below bone level implants.

In addition, the depth of attachment regarding soft tissues should be mentioned as well. Kan et al[4] claim that the gingiva is what guides the depth of attachment (apico-coronal dimension). As for single implants, they should be apically placed 3 mm in relation to the most apical point of the cervical-buccal margin that is planned for restoration. Similarly, the studies conducted by Priest[21] agree with the aforementioned assertion, having the gingiva as a guide to attain satisfactory esthetic results.

Based on this literature review, we reassert that implant placement should consider not only the highest bone height due to osseointegration, but also the appropriate space in order to yield satisfactory esthetic results. As for above/bellow bone level positioning, it did not prove to exert any influence over papilla formation. Furthermore, prosthetic rehabilitation should also be considered, particularly with regard to the contact point, given that this factor also proved to exert considerable influence over the occurrence of "black holes".

Conclusion

Based on the results of this literature review it is reasonable to conclude that:

1) The ideal tooth-implant distance is 2 mm, whereas the ideal distance between implants is 3 mm, due to the fact that the height of the gingival papilla is basically supported by the formation of biological space.

2) The above/bellow bone level positioning of implants did not present any differences with regard to papilla formation.

3) The distance from the contact point of the crown to the bone crest should have a mean value of 3.4 mm. Such height determines the space where the papilla will be, and the soft tissue will rarely fill dimensions with height greater than 5 mm.

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Minimally invasive peri-implant procedures to obtain esthetics in the transmucosal profile

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Abstract

Introduction: Connective tissue graft techniques are widely used previously and during placement and rehabilitation of dental implants with the purpose of obtaining satisfactory esthetic results. However, surgical techniques are not the only options for correcting tissue volume deficiencies. **Objectives:** The aim of this article is to present through a clinical case, the slow orthodontic extrusion, the semilunar incision during the implant second surgical stage and the use of composite resin flow for soft tissue conditioning in three phases: the ovate pontic, the polymer healing abutment and the provisional crown on the implant. **Results:** Slow orthodontic extrusion promoted better leveling in the gingival collar height. Semilunar incision favored the displacement of the buccal mucosal tissue and the preservation of adjacent papillae. The composite resin flow proved to be easy to handle, in addition to having good polishing, which contributed to obtain an appropriate transmucosal profile. **Conclusion:** After an 1-year follow-up, we concluded that the combined procedures not only aided to yield esthetic peri-implant results, but also contributed to the practice of a minimally invasive Implantology.

Keywords: Dental implant. Tooth movement. Composite resins. Dental polishing. Healing. Friction.

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» The patient displayed in this article previously approved the use of her facial and intraoral photographs.

» The authors inform they have no associative, commercial, intellectual property or financial interests representing a conflict of interest in products and companies described in this article.

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Introduction

In the recent past, Implantology believed that excellent esthetic results could only be obtained by employing surgical techniques and procedures at the moment of implantantion. In many cases, in which tissue deficiencies had not been previously corrected, there were unsatisfactory esthetic results.[1]

Connective tissue graft techniques have been currently used to correct these deficiencies. Used separately, they promote an increase in thickness of the soft tissue,[2] but lead to greater patient's morbidity due to the removal of graft in the donor sites. When they are performed after implantation, they represent a second surgical stage.

In an attempt to compensate these deficiencies, researchers began to further explore the use of prosthetic tissue conditioning, since the design of the transmucosal portion of the prefabricated abutments can not replicate the emergence profile of a natural tooth. This conditioning promotes support for the papillae and improves the stability of the buccal mucosal tissue.[3] The case report reported herein shows the use of surgical-prosthetic procedures employed to obtain an ideal emergence profile in the implant rehabilitation of the upper central incisor region.

Case report

A female patient sought a private clinic for prosthetic rehabilitation treatment. The treatment planning aimed to rehabilitate the upper teeth with metal-ceramic crowns (Fig 1). After installation of provisional crowns in teeth #13 to #23, mobility and the presence of root fracture were observed in tooth #11 (Fig 2).

In order to avoid proximal bone loss that could affect the esthetic outcome of the case, it was decided to conduct orthodontic treatment, with the purpose of extruding the failed tooth prior to beginning implantation in the area. After orthodontic movement (Fig 3), it was possible to extrude tooth #11 so as its gingival margin was approximately 3 mm below its homologous tooth.[21]

The crown and the post were removed (Fig 4) for minimally traumatic extraction of tooth #11 and for socket inspection. The existing bone defect was small and located in the lingual face of the socket. A locking taper implant (Kopp, Curitiba - Brazil) was installed and the gap between the socket and the implant was filled with Bio-Oss biomaterial. It was closed with a polymer healing plug 2 mm in height, and a Collatape membrane was used to cover the biomaterial.[4] During the same session, the implant and its respective healing plug were installed in the region of tooth #24. A new set of provisional crowns was installed in the upper anterior teeth, so as to unite teeth #21 to #12 in a fixed bridge, ensuring that the pontic maintained its support of the gingival tissue and aided the closing of the alveolus (Fig 5).

Figure 1 - Initial clinical image.

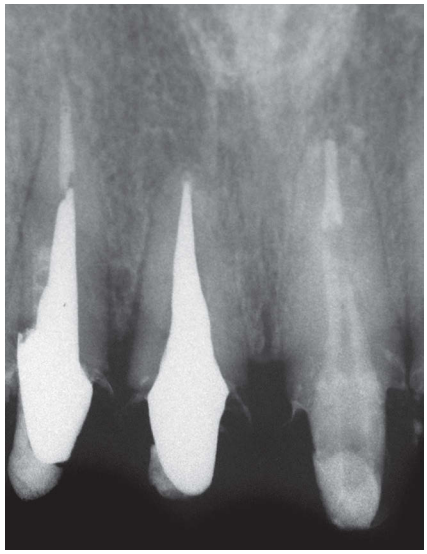


Figure 2 - Initial periapical radiograph.

Figure 3 - Clinical result after slow orthodontic extrusion of tooth #11.

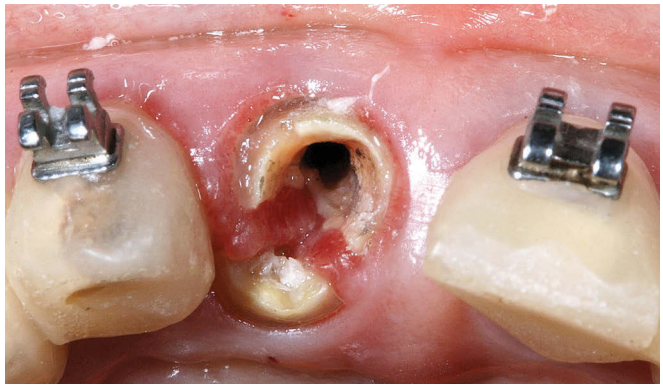


Figure 4 - Dental root after the removing the provisional crown and the metal post.

Figure 5 - Cementation of the provisional bridge between teeth #21 and 12.

Four months after implantation (Figs 6 and 7), the implant of region #11 was reopened with a palatal semilunar supra-crestal incision (Fig 8) and the healing plug was removed so that it could be replaced by another one 6 mm in height (Fig 9). The latter was customized and its surface was previously made coarse by means of burs. Additionally, it was enlarged on the sides with a light-curing composite resin (Fig 10). At the end of customization, a new profile was obtained (Fig 11), which allowed the flap to bucally shift, creating an increase in buccal soft tissue and in the cervical region (Figs 12 to 15).

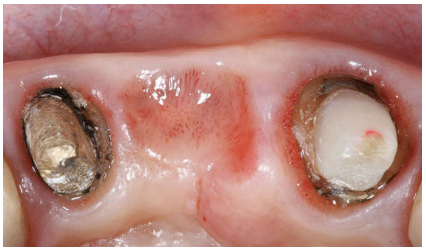


Figure 6, 7 - After epithelial healing of the implant area, we can see the gingival profile outcome obtained with the provisional prosthetic pontic.

Figure 8 - Occlusal image of the supra-crestal semilunar incision.

Figure 9 - Comparison between the healing plugs before customization.

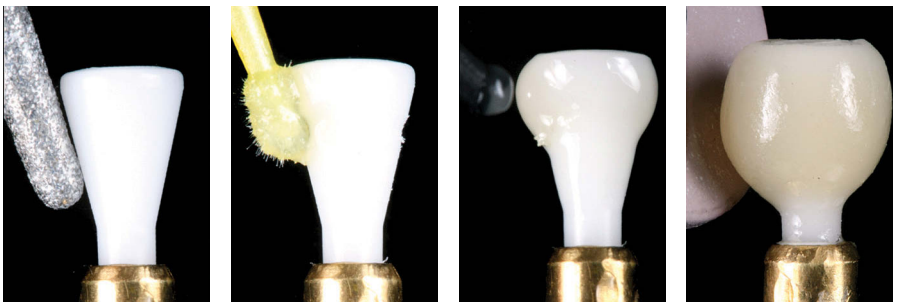
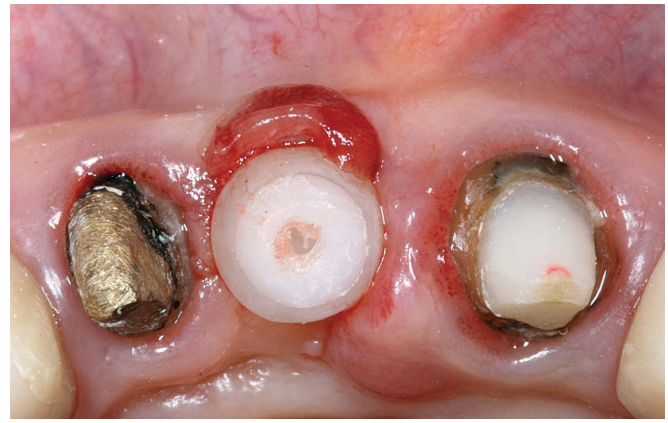
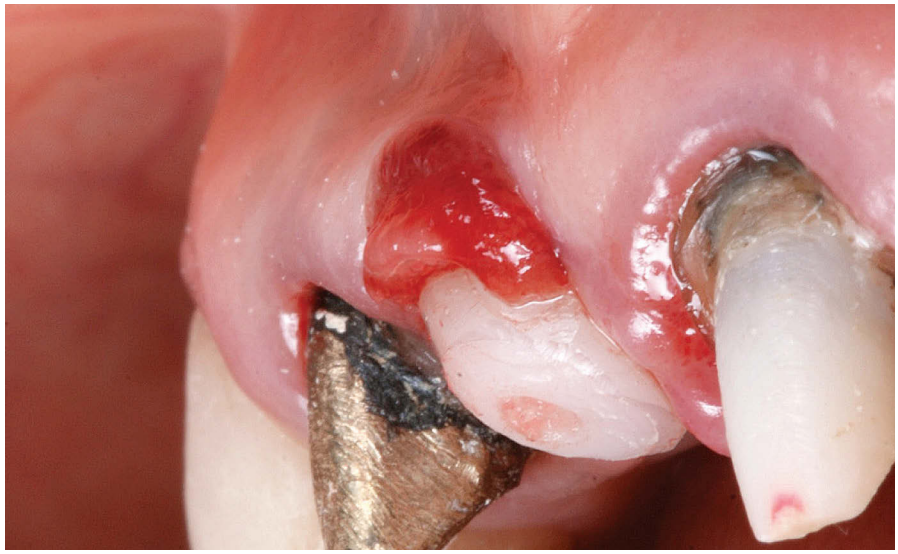
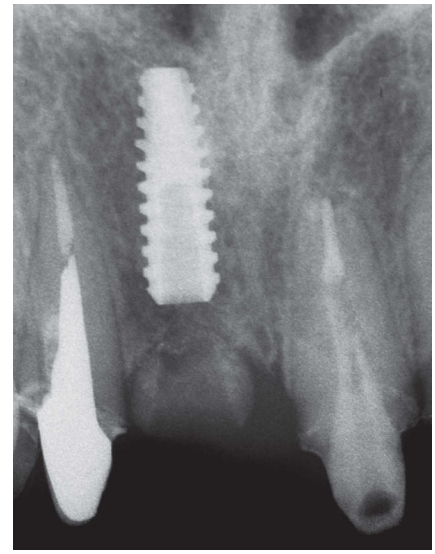


Figure 10 - Customization and polishing of the healing plug.

Figure 11 - Comparison between the healing plugs after customization.

Figures 12, 13, 14, 15 - After the insertion of the new customized healing plug. Periapical radiograph after healing plug customization.

After three months (Fig 16), the implants were loaded with the installation of crowns/provisional abutments that were a little coarse so as to enable addition of light-curing resin on their sides. The same procedure was employed with the polymer healing.

After the conditioning period of one month, the emergence profile obtained with the provisional implant crown was transferred by using a laboratory putty silicone matrix and a titanium transfer/abutment with acrylic resin (Fig 17). Afterwards, it was shaped with Polyvinyl siloxane using the double cord and closed tray techniques (Figs 18, 19 and 20).

The plaster model, the abutment for tooth #11 and the copings were prepared in the laboratory together with the metalceramic crowns for teeth #13 to #23.

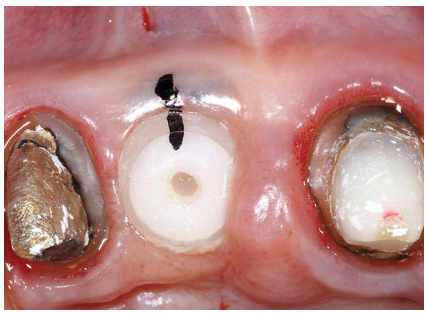


Figure 16 - Gingival conditioning with the customized healing plug after three months.

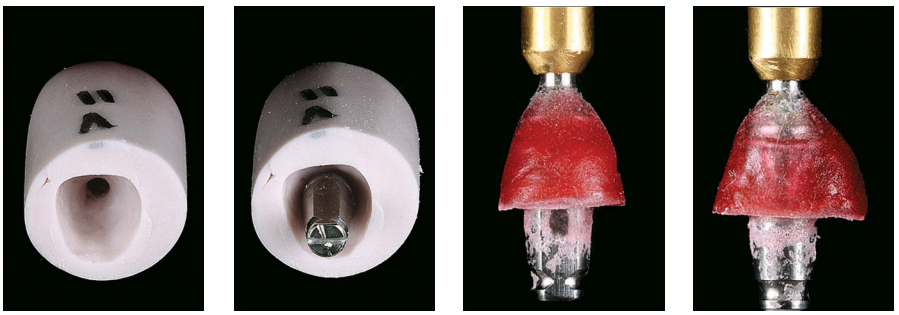
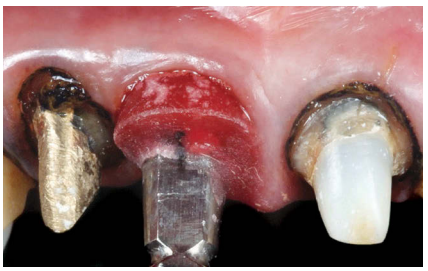


Figure 17 - Transferring of the emergence profile obtained with the provisional implant crown by means of a laboratory putty silicone matrix and a titanium transfer/abutment with acrylic resin.



Figures 18, 19, 20 - Frontal and occlusal images before the implant impression.

The crowns for teeth #13, 12, 21, 22 and 23 were tested and then luted by inserting the retractor cord. The crown for #11 was tested and extra-orally luted with zinc phosphate cement. The excess cement was removed (Fig 21) and the integrated crown/abutment was activated by means of an acrylic resin guide. This guide was used to direct the activation force which must be consistent over the long axis of the implant (Figs 22 to 24). This direction prevents inadequate activation of the integrated crown/abutment, which would make the connection susceptible to failure and looseness.

At the end, a periapical radiograph was taken (Figs 25, 26). The final occlusal adjustments were made and the excess cement was removed from the dental crowns.

After one year, new periapical radiographs and an intraoral photo of the case were taken (Figs 27 and 28). Healthy and stable peri-implant mucosal tissue was observed, and the difference between the incisal edges of the incisors was of approximately 0.5 mm. Occlusal contacts were checked and adjusted.

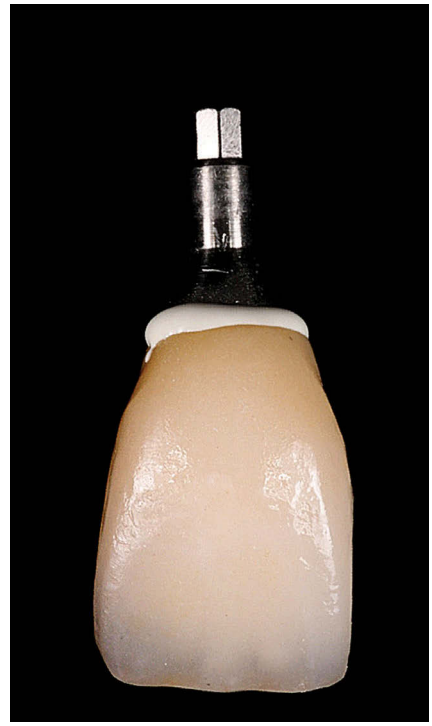




Figure 21 - Extraoral luting of the crown and implant abutment as well as removal of excess zinc phosphate cement.

Figure 22 - Inserting the integrated crown/abutment in tooth #11 implant.

Figure 23 - Placing the acrylic resin guide in the implant crown.

Figure 24 - Proximal view of the acrylic resin guide used to direct the activation force.

Figure 25 - Clinical case outcome soon after all metal-ceramic crowns had been luted.

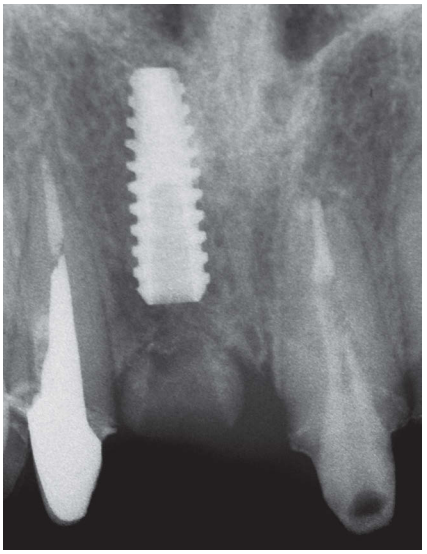


Figure 26 - Periapical radiograph after conclusion of the clinical case.

Figure 27 - Clinical case after one year.

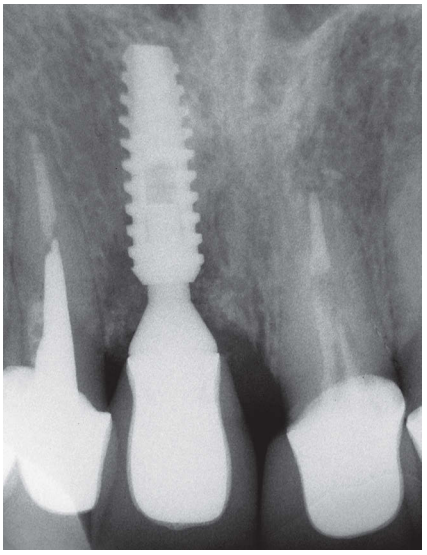


Figure 28 - Periapical radiograph after one year.

Discussion

This case report showed clinical procedures carried out before implantation, which created an ideal site for the extraction of tooth #11 and immediate implantation. Moreover, it showed procedures performed after implantation, which resulted in an ideal prosthetic emergence profile.

The slow orthodontic extrusion is a tooth movement technique that induces the formation of periodontal supporting tissues,[5] leveling the height of the gingival base and promoting the recovery of the gingival papillae.[6,7] This technique was chosen because there were signs of fracture in the root of tooth #11, and consequently, the presence of bone defects.[8]

We emphasize, however, that post-treatment control should be performed since one of the possible causes of the difference between the incisal edges may have been the passive extrusion of tooth #21.

After extraction, the gap was filled with slow reabsorption inorganic xenograft and collagen membrane cover so as to avoid an extreme reabsorption of the buccal wall of the alveolus, which could result in loss of tissue volume.[9] Implant closure was performed with a low-height healing plug instead of an implant cover in order to initiate the formation of an emergence profile. Furthermore, it was used so as, after bone modeling, there was no formation of bone tissue on the implant cover, which is flush with the implant platform.

Tissue conditioning with composite resin added to the rounded prosthetic pontic[10,11,12] was another important step taken at this stage. It ensured support to the papillae of the adjacent teeth and the buccal gingival margin.

Repeatedly used (in the pontic, the healing plug and the provisional implant crown), the light-cured composite resin proved to be a good modeling material (increase and tear) if compared to chemically activated acrylic resin. It presents good working characteristics (time and handling), which allows ideal, immediate and easy polishing,[13] and does not promote irritation of the gingival tissue by the volatilization of solvents. The smoothness obtained after polishing hinders bacterial adhesion,[14] and also the emergence of bad smells, all of which result in perio-implant health at these three steps.

In this case report, the customization of the gingival profile was initiated with the healing plug and not with the temporary crown, as it is usually done. This is because of the material of which the healing plug is made: a polymer susceptible to being worn down, scratched or enlarged with a composite resin. Usually made with titanium alloy, the majority of healing screws currently available on the market do not allow an adequate transmucosal gingival profile, since they have a diameter that is smaller than what is found in the cervical area of natural teeth. A disadvantage of the polymer healing plug is that it cannot be reused, but it is disposable.

The prosthetic implant connection used was the Locking Taper connection, a screwless connection that frictionally links the abutment and the implant in a cold metal welding.[15] This connection has a bacterial seal,[16] it allows extra-oral luting and peri-implant bone stability,[17] provided that the integrated crown-abutment is correctly inserted and activated on the implant.

A second hypothesis that may have contributed to the difference between the incisal edges may have been the micrometer intrusion of the integrated crown-abutment inside the implant.[18] Be as it may, we suggest that long-term studies of both the effects of orthodontic extrusion in implant therapy and of the biomechanical behavior of the locking-taper connection, be carried out.

Another important point that should be highlighted is the change in the incision during the step of reopening the implant. The advantage of a supracrestal incision over a punch instrument incision is that the former maintains the keratinous gingival tissue. The detail is in the semilunar shape that faces the palatine. This provided a greater amount of tissue buccally flaped, increasing the soft tissue in the buccal and cervical portions.[19] There was no rupture of adjacent papillae while trying to prevent them from being damaged and lost.[20]

It is worth highlighting that, in this case, there was no subepithelial connective tissue graft, since the aforementioned clinical procedures favored a suitable esthetic peri-implant profile, which can be seen at the height of the papilla

between teeth #11 and 21, after a year. We believe that these procedures may aid the management of implant rehabilitation cases with high esthetic requirements, with the possibility of a minimally invasive therapy with less surgical steps.

Conclusion

The management of soft tissue is not restrictively dependent on surgical procedures carried out with subepithelial connective tissue grafts. This case report reveals that orthodontic extrusion prior to implantation, protection and support for soft tissue by means of provisional pontic, semilunar incision during reopening, conditioning of tissues performed with light-curing composite resin added to the healing plug and the provisional prosthesis, all contributed to a successful case. We believe that these procedures may aid the management of implant rehabilitation cases with high esthetic requirements, and with fewer surgical steps. The combination of these procedures contribute to a minimally invasive implant practice.

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Rehabilitation with dental implants and fixed prosthesis for esthetic and occlusal correction in partially edentulous patients

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Abstract

Introduction: Rehabilitation of partially edentulous patients using implant-supported fixed prostheses is now a predictable treatment and of proven success in the long term. **Objective:** The purpose of this paper is to outline a systematic approach to prosthetic rehabilitation of partially edentulous patients, exemplified by a clinical case with bone reconstruction and recovery of the vertical dimension of occlusion, occlusal plane leveling and correction of upside down smile. **Methods:** Oral rehabilitation of the patient was performed with dental implants and fixed partial prostheses. **Conclusion:** Treatment was able to restore function, comfort and aesthetics.

Keywords: Dental implants. Dental occlusion. Dental prosthesis.

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» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

Introduction

Dental loss or the use of inadequate prostheses may have a negative impact in quality of life, such as discomfort and psychological inability.[1] Partially edentulous patients usually seek for esthetic and functional rehabilitation through fixed prosthesis, which often requires a multidisciplinary approach.[2] Esthetic rehabilitation with fixed prosthesis entails the replacement and/or restoration of natural teeth with artificial elements fixed to the natural teeth or to osseointegrated implants.[3]

Implant dentistry based on osseointegration is among the most significant advances in dental science in the last 50 years.[4] In fact, Implant dentistry has become a reliable oral rehabilitation technique thanks to this progress and consistency of surgical techniques.[5]

Some patients have insufficient bone volume or bone quality for the successful placement of implants (for instance, after injury or after a long period using removable prosthesis). In order to overcome these obstacles, the residual bone crest can be augmented in width and/or thickness with bone grafts.[6] Bone defects in the anterior maxilla are usually reconstructed with autologous mono-cortical bone blocks, for the subsequent placement of the dental implants.[7] In the posterior maxilla, elevation of maxillary sinus floor was created to increase the required vertical height.[8]

In the rehabilitation of a partially edentulous patient, natural and artificial teeth must coexist in a harmonious way, both functionally and aesthetically. To achieve this result, the clinician must have a thorough understanding of the basic physiological factors that affect patient's occlusion.[9]

When oral rehabilitation is required, occlusal plane orientation must be restored.[10] Among the desirable occlusal characteristics is the incorporation of a physiological vertical dimension of occlusion (VDO). This favors the achievement of a mutually protected occlusion, so that the transmission of occlusal forces resultant is directed along the long axis of the posterior teeth, with presence of posterior bilateral and simultaneous dental contacts, and adequate vertical dimension, as well as lateral and anterior guidance, in order to protect the rehabilitation.[11] Thus, posterior teeth protect anterior teeth through contacts during centric occlusion, and anterior teeth protect posterior teeth from horizontal forces originated in excursive movements through the anterior guidances. This type of occlusion respects the principles of ideal occlusion, and, therefore, it has been considered the most convenient occlusal scheme for prosthetic rehabilitation.[12]

The present paper describes the rehabilitation of a partially edentulous patient with tooth-implant supported fixed prostheses, using associated procedures to provide satisfactory function and aesthetics.

Case report

Female patient, 55 years old, using maxillary removable partial denture (RPD) and mandibular fixed partial denture (FPD), searched our clinic seeking to improve the aesthetic condition by means of fixed prosthesis (Figs 1, 2 and 3). Presented with Kennedy's Class IV partial edentulism in maxillary arch, due to the absence of maxillary anterior teeth and left first premolar — rehabilitated by means of a RPD. In the mandible, partial edentulism was Kennedy's Class III: Second premolars, first and second molars were absent in both sides, with the latter rehabilitated by FPDs. While examining the face and smile, it was observed that the occlusal plane of the maxillary anterior teeth (removable prosthesis) was higher than the plane of maxillary posterior teeth (natural teeth), altering the natural contour of upper teeth, which must match the curvature of the lower lip.[3] There were also changes in the vertical dimension of occlusion, which was measured with a Willis bite gauge,

according to technique described by Lytle and modified by Tamaki. Vertical dimension at rest was measured, resulting in the value of free working space, which was 4.5 mm, representing a reduced VDO[29] (Figs 4, 5 and 6).

Thus, rehabilitation planning began through confection of dental study models and diagnostic wax-up, with appropriate parameters of occlusion and occlusal plane (Fig 7). Panoramic radiograph was the first auxiliary resource in planning, giving an estimate of bone height in edentulous areas, which was approximately 4 mm in line 1, as show in Figure 8; 6 mm in line 2; 14.25 mm in line 3; 15 mm in lines 4 and 5; 12 mm in line 6, and between 9 and 11 mm in all the lower lines (Fig 8).

Figure 1 - Initial photograph of the smile.

Figure 2 - Initial intraoral photograph wearing the prosthesis.

Figure 3 - Initial intraoral photograph without the prosthesis.

Figure 4 - Reduced vertical dimension, due to the maxillary bone resorption.

Figure 5 - Right side intraoral photograph with maxillary provisional prosthesis.

Figure 6 - Left side intraoral photograph with maxillary provisional prosthesis.

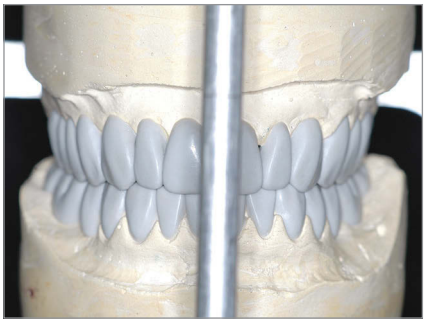

Figure 7 - Diagnostic wax-up.

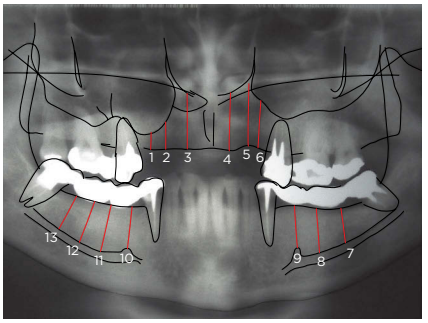

Figure 8 - Initial panoramic radiograph.

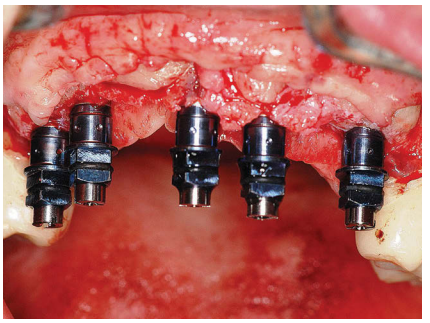

Figure 9 - Maxillary implants in place.

There was no possibility of installing fixed prosthesis in the maxilla without the use of osseointegrated implants, nor appropriate bone thickness for this option. Grafting procedures were planned and executed in hospital setting in a single surgical procedure. Six blocks of autogenous bone gathered from the mandibular ramus, bilaterally on the oblique line region, were fixed in the anterior region of the maxilla (tooth #14 to tooth #23) with screws. Simultaneously, the right maxillary sinus underwent grafting for floor augmentation with lyophilized bovine bone in small granules (Bio-Oss®, Switzerland), associated with approximately 10% of particulate autogenous bone (which remained from the blocks removed for the grafts) and covered with collagen membrane (Surgidry Dental, Belo Horizonte, Brazil). After six months, bone thickness was sufficient for implant placement, at which time they were placed in outpatient surgery (Fig 9).

Maxillary implants had 3.75 x 15 mm in teeth #14, #13, #11 and #21 regions; 4.0 x 11.5 mm in tooth #15 region and 3.75 x 13 mm in tooth #23 region (Conexão Sistemas de Prótese, São Paulo, Brazil). The primary stability, measured by means of the insertion torque, ranged from 50 to 65 N, except for the implant in tooth #15 region, which was 35 N (this implant was lost 40 days after placement). It was used a surgical guide obtained from the model with diagnostic waxing to place implants in the proper position for prosthetic rehabilitation. The implant-supported metal-ceramic FPD was installed eight months later, and a tooth-borne FPD was placed in tooth #24 to tooth #26 region to solve the edentulous space in the #25 region. On tooth #15 region, where the implant was lost, we chose a cantilever to rehabilitate teeth #14 and #15 because the patient was not receptive to undergo further attempts to implant placement. Besides that, biomechanically, prosthesis length and the size of the other implants would favor occlusal forces distribution.

In the mandibular region, FPDs were inadequate and the incisal curvature of anterior teeth was higher than that of the posterior ones, causing inversion of the ideal occlusal pattern. Anterior teeth were subjected to clinical crown lengthening and occlusal plane leveling by means of stripping with diamond bur at high speed, to obtain the proper height, visualized using a wear guide made from the diagnostic wax-up. Edentulous spaces received implants (Conexão Sistemas de Prótese®, São Paulo/Brazil) with 3.75 x 13 mm (tooth #45 region), 3.75 x 15 mm (tooth #35 region), 5.0 x 10 mm (#37 and #46 region) and 5.0 x 11.5 mm (#36 region) replacing the existing pontics (Figs 10 and 11). Lower implants presented approximately 70 N of primary stability, measured by the installation torque,

allowing the placement of screw-retained temporary crowns immediately after surgery completion. Tooth #38 was extracted due to considerable bone loss, mobility and persistent endodontic lesion. Teeth #48, #44 and #34 received metal-ceramic crowns over self-tapping abutments, which replaced the old abutments (which presented inadequate size). Implant-supported metal-ceramic FPDs were installed 5 months after surgery.

After replacing the prostheses (Figs 12, 13 and 14), the VDO was restored and a mutually protected occlusion pattern was achieved. It can be observed an overbite, and the anterior prosthesis projected toward buccal region, due to the implants position. However this pattern was chosen because of patient's aesthetic necessity (overbite with lips at rest). As the lower teeth were extruded, teeth projection to buccal direction was necessary even after occlusal stripping and clinical crown lengthening in this region.

The present case is in clinical and radiographic control after 3 years and it is observed maintenance of the achieved aesthetics and function, besides patient satisfaction and comfort (Figs 15 and 16).

Discussion

The masticatory function reflects the impact of chewing capacity on food choice and pleasure in feeding, and is associated with quality of life and general well being of the individual[11]. Missing teeth and also the use of inadequate prosthesis implies in consequences as speech problems and acceptance of physical appearance, with serious consequences such as decrease in self-esteem, socialization difficulties, perception of aging and humiliation feeling.[12] The aesthetic perspective, being imbued with cultural values, is one of the main concerns of individuals, which implies in feelings of approval or rejection eventually, thus interfering with

Figure 10 - Left side mandibular implants.

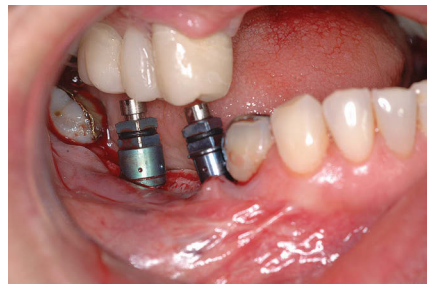

Figure 11 - Right side mandibular implants.

Figure 12 - Final left side intraoral photograph.

Figure 13 - Final frontal intraoral photograph.

Figure 14 - Final right side intraoral photograph.

Figure 15 - Final smile photograph.

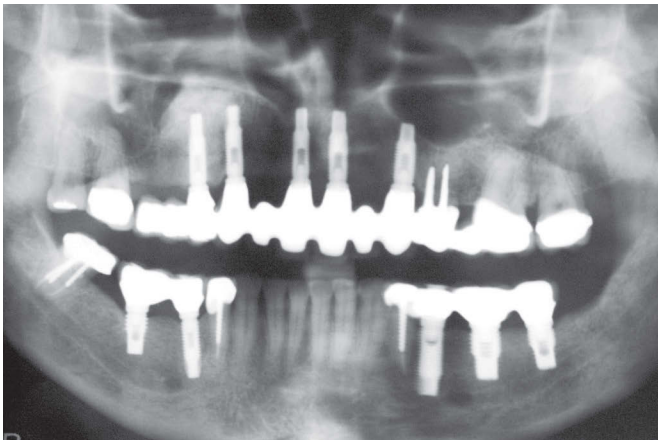

Figure 16 - Final panoramic radiograph.

interpersonal relationships[13] Thus, expectations of the patients in the face of prosthetic replacement of teeth is related to the quality of the prosthesis, especially regarding stability and adaptation.[12] Currently, prosthetic rehabilitation counts on dental implants to fulfill functional and aesthetic demands.[5]

Advances in diagnostic imaging have contributed to more precise planning, thus providing potential for a significant reduction in complications with dental implants, exerting vital role in surgical planning as well as in routine postoperative evaluation.[4] One of the most useful techniques for diagnosis of patients seeking for fixed prostheses is the diagnostic wax-up, as it allows for recovery of edentulous space and articulation, besides atypical contours.[14] In the case described in the present article, the panoramic radiograph was used as an auxiliary resource in planning.

In some patients, there is not enough bone volume or quality to allow successful placement of implants (for example, after injury or after a long period using a removable prosthesis). To overcome these obstacles, residual bone crest can be increased in width and/or thickness with bone grafts.[6] Bone defects located in the anterior maxilla are usually reconstructed with autologous mono-cortical bone blocks for subsequent placement of dental implants.[7] In the posterior maxilla, maxillary sinus floor elevation was designed to increase the required vertical height.[8]

Various graft materials have been used in maxillary sinus augmentation procedures, including: decalcified, dry and frozen autogenous bone; hydroxyapatite; β-tricalcium phosphate; deproteinized bovine bone mineral and the combination of these and other[15]. Although new techniques and bone-graft substitutes allow for viable prognostic to achieve the necessary amount of hard tissue augmentation, autologous bone is the gold standard with regard to quantity, quality, and healing without complications, especially when used in blocks in the anterior maxilla.[6,16,17] To augment the maxillary sinus floor, from a clinical point of view, the use of autogenous bone is advantageous if the prosthetic rehabilitation (with functional load) is expected within nine months. When there is no sufficient amount of autogenous bone in the oral cavity region for grafting and the patient can not or will not accept the collection of bone tissue from extraoral donor sites, the use of deproteinized bovine bone mineral alone, or in combination with autogenous bone, seems to be preferable.[15]

The procedure seems to be simple, safe and effective for the treatment of alveolar ridge defects located in partially edentulous jaw[6]; however, exposure and/or infection of the graft can occur in less than 5% of cases, which eventually leads to bone graft loss.[16] To achieve success, some features should be assessed, as the size and location of the defect; however, the vascularization of the receiving area should be the primary concern of the surgeon, as this directly influences the successful grafting of both hard tissues (one should verify the good adaptation of graft to the receiving site, to prevent the formation of connective tissue in the gap) and soft tissues (the tissue margins should allow passive coaptation of tissue by the suture and promote vascularization in the region).[16] Appropriate donor area should be chosen, which should have intramembranous origin, as in mandible body and ramus, that undergoes less resorption than those with endochondral origin.[17]

Clinical success and longevity of dental implants are largely influenced by the mechanical medium in which they operate, being occlusion a critical component of this environment.[18] In prosthetic restorations of natural dentition, treatment goal is a mutually protected occlusion. The curve of Spee plays an important role in the development of the desired occlusal scheme.[19] Occlusal condition must be properly diagnosed, corrected or compensated, and integrated into the final restoration project.[18] Adjustments should be performed in centric relation to favor the recovery of the vertical dimension and to promote the physiological adaptation of the patient to a mutually protected occlusion.[20] In the present case, occlusion in centric relation was obtained by manual guide, using the unforced guided method.

Fixed prosthesis for partial or total edentulous patients usually consist of implants connected by a bar of metal alloy that supports the prosthetic coating. The loads induce stresses in both structures, prosthesis and bone tissue. An estimate of the reliability of prosthetic systems should consider the biological, chemical, clinical and biomechanical aspects. Biomechanical aspects are important to assess the risk of bone resorption.[21]

Treatment outcomes are improved when implants does not need to support excessive occlusal forces, are placed in dense bone, are used in larger number or diameter, and positioned so as to reduce flexural torque and to support fixed prosthesis.[22] Metal-ceramic FPDs are suitable to increase fracture strength, thus presenting greater clinical longevity. This type of prosthesis is primarily used when a large number of teeth replacement is required[23]. It is also important to maintain a small space for hygiene, however this should not interfere with patient phonation. In the case presented, there was no air leakage, promoting a natural phonation.

Carefully choosing components and the system to connect implants and prosthetic restorations must be considered as a parameter for long-term success of treatment.[24] For extensive dental rehabilitations, the use of screw-retained prosthesis may be the best choice, due to reversibility, which is useful for conducting periodic reevaluations and assessment of oral hygiene.[26] Splinting is also indicated as it is a biomechanically more proper option, promoting a better force distribution both in the implant/abutment system and the bone/implant interface.[25] Periodic appointments after placement of final restoration allow monitoring the current condition of the patient and performing an early diagnosis, which enables interception of problems that can arise, avoiding any possible failure of prosthetic rehabilitation.[3]

In the presented case, metal ceramic screw-retained implant-supported FPDs have been installed and are in regular clinical control. It could be verified treatment success and patient satisfaction.

Conclusion

In conclusion, based on the reviewed literature and the case reported, oral rehabilitation with fixed prosthesis must be accomplished by careful planning according to patient needs, in a multidisciplinary approach, to restore patient function, comfort and aesthetics.

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Accuracy of linear bone measurements with cone-beam and spiral computed tomography in human mandibles

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Abstract

Introduction: Availability of imaging methods able to accurately reproduce the maxillo-mandibular dimensions is important for diagnosis and safe planning of surgical procedures. **Objective:** The aim of this *in vitro* study was to verify the accuracy of linear measurements in images obtained with a system of spiral and two systems of cone-beam computed tomography (CT). **Methods:** Ten dry human mandibles were subjected to three different CT scans: i-CAT® CBCT, NewTom-3G® CBCT, and Picker® SCT. Measurements in the mandible were taken with a digital caliper and measurements in the images were taken with the ImplantViewer® software. Six regions were measured in each dry mandible, being distributed into two regions in each of the lower first molar (LFM), lower first pre-molar (LFPM), and lower lateral incisor (LLI) sites. **Results**: Similar accuracy was observed among the three images at sites LLI and LFPM. Measurements obtained with the i-CAT CBCT scan at site LFM were shown to be more accurate than those obtained with the other two CT scan systems. **Conclusions**: It can be concluded that the three CTs studied herein showed similar limits of agreement and precision at sites LLI and LFPM, and i-CAT CBCT showed limits of agreement with smaller amplitude and greater accuracy than other examinations performed at site LFM. **Conclusion:** It can be concluded that the three CTs studied herein showed similar limits of agreement and precision at sites LLI and LFPM, and i-CAT CBCT at site LFM showed limits of agreement with lower amplitude and greater accuracy than other examinations performed.

Keywords: Spiral computed tomography. Cone-beam computed tomography. Dental implants. Three-dimensional imaging.

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Introduction

Computed tomography (CT) provides accurate and real-scale volumetric reconstruction and manipulation of images through software.[1,2,3]

In spiral computed tomography (SCT), sections in the region of interest are transformed into digital images, which are processed and reconstructed into two-dimensional and three-dimensional images. SCT allows reconstruction of images with real proportions, excellent accuracy and resolution because sections with thickness not greater than 0.5 mm can be obtained.[1-4]

In SCT multislice equipment, exposure to radiation is much smaller than in tomographies with a single slice; in addition, the time required for data acquisition is also reduced.[3,5,6]

Cone-beam computed tomography (CBCT), unlike SCT in which data are obtained by slices, is based on the emission of a X-ray conical beam in a single 360° turn around the patient's head, during which the total volume of structures is obtained. After data acquisition, images are volumetrically reconstructed in two and three dimensions by the software. According to the proponents of CBCT, patients examined with this technique receive lower effective radiation doses than those examined with SCT.[2,7,8]

Basically, CT can be divided into two categories, spiral computed tomography (SCT) and cone-beam computed tomography (CBCT).[4] Since both methods are indicated for diagnosis and treatment planning in the Medical and Dental areas, the assessment of measurements obtained with these methods and their comparison with direct measurements taken in human mandibles is justified. Thus, the aim of this *in vitro* study was to assess the accuracy of linear measurements taken by means of images obtained with a system of SCT and two systems of CBCT, comparing the results with direct measurements carried out in ten dry human mandibles.

Material and Methods

Stock teeth and tomography guides were prepared in self-polymerizing acrylic resin. The stock teeth reproduced a removable partial denture or a complete one for each mandible, depending on the presence of dental elements. As an exclusion criterion, it was established that the mandibles could not have teeth in regions corresponding to paired elements. After the teeth were mounted in wax rolls prepared with pink dental wax, the stock teeth corresponding to paired elements were all removed to simulate their absence (Fig 1).

Steel balls were placed in the cervical portion of each edentulous space, and they were used as a reference for measurements in both CT and direct measurements

Figure 1 - Mandible with teeth already mounted.

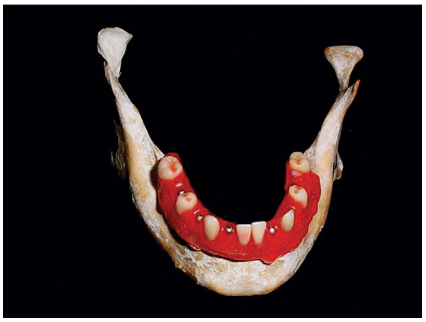

Figure 2 - Steel balls placed in the region of paired elements.

Figure 3 - Acrylised tomographic guides.

in the mandibles. The steel balls were placed in each of the ten mandibles, in the region of the paired elements (46, 44, 42, 32, 34, and 36) (Fig 2).

After the steel balls were placed, the CT guides were acrylised (Fig 3). During the tomography scans, an adhesive tape was used to properly fix the guides (at three points) in the region of the #36/37, 31/32, and 46/47 elements.

The mandibles were submitted to different CT scans: i-CAT® CBCT (Kavo, Imaging Science, Hatfield, PA, USA), NewTom-3G® CBCT (QR Srl, Verona, Italy) and Picker® SCT (Elscint, Haifa, Israel), without inclination of the gantry. For a correct positioning of the mandible in relation to the gantry, the mandibles were supported by a base of pink dental wax in the scans performed with NewTom-3G® CBCT and Picker® SCT (Fig 4). In the i-CAT® CBCT, the base for calibration of the equipment was used (Fig 5). The images were recorded in DICOM standard, converted and manipulated with an image processing software (ImplantViewer® 2604 - Anne Solutions, São Paulo, Brazil).

Direct measurements were performed by one observer on the mandible with a digital caliper (accuracy: 0.01 mm; Lee Tools, Beijing, China). The following parameters were considered: bone height in the region of each steel ball and distance from the top of the alveolar bone crest to the lower cortical border of the basal bone (Fig 6). These same measurements were repeated by the same observer, but on tomographic images of the mandible which were obtained by means of a computer software (ImplantViewer® 2604, Anne Solutions, São Paulo, Brazil) (Fig 7).

Only one software was used (ImplantViewer 2.604®, Anne Solutions, São Paulo, Brazil) in order to eliminate any possible differences existing between more than one image manipulation software. All measurements were performed twice by one observer, within an interval of seven days.

A linear mean was calculated for all measurements. In each dry mandible, measurements were performed in six regions (right and left regions of three sites): lower first molar (LFM), lower first premolar (LFPM), and lower lateral incisor (LLI) sites. Measurements were taken twice in each region and by the same observer. Ten dry mandibles were used and each measurement protocol was repeated four times, once for each measurement technique: direct measurement with a caliper, and measurements by SCT (Picker) and CBCT (i-CAT® and NewTom-3G®).

Two measurements were performed in two regions of three sites in ten dry human mandibles using four techniques, in a total of 480 measurements. The millimeter (mm) was used as unit of measurement.

In the clinical area, "quantities" (variables), such as blood pressure and bone dimensions, will often be measured in the living body. These variables can be extremely difficult or impossible to measure directly, without adverse effects on the subject of the measure (patients) and, thus, their true values remain unknown.[9,10,11]

Instead, science provides indirect methods of measurement, and when a new method is proposed, we can assess its value only in comparison to other established techniques, and not with the "real" quantity being measured. We cannot be certain that a method gives us a measure that is unequivocally correct, that is the reason why we try to assess the degree of agreement between them.[9,10,11]

What matters is the amount by which the methods "disagree" (lack of precision). We want to know how much the new method differs from the older or the reference ones , so that, if this is not enough to cause problems in clinical interpretation, we can replace the "old" by the "new", or even alternatively use both of them.[9,10,11]

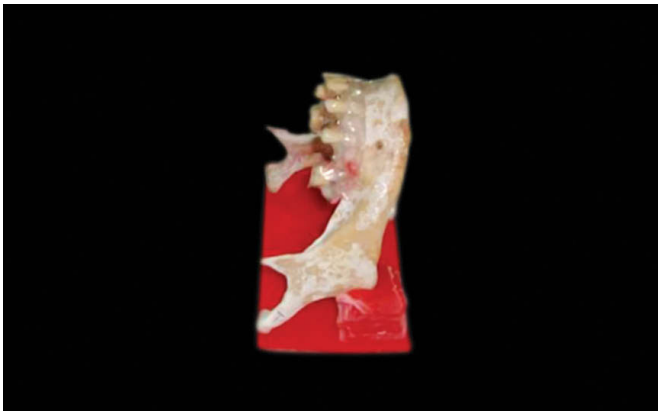

Figure 4 - Mandible placed on the sliding table (for NewTom 3G® and Picker CT Twin Flash).

Figure 5 - Mandible placed on the base for calibration of the equipment (i-CAT®).

Figure 6 - Digital caliper.

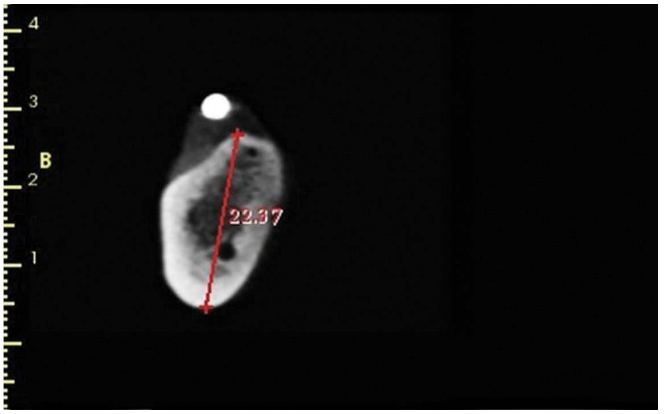

Figure 7 - Measurement taken for the tomographic images .

Limits of agreement of 95% were used for comparison between measurements using the imaging techniques and the direct measurement. The limits of agreement established the parameters within which 95% of the differences observed between the method of image and the reference method can be found in any future measurement within the same experimental conditions. The notion of accuracy between methods is based on the analysis of the amplitude of limits, so that the smaller the amplitude limits the greater the accuracy and the agreement between a given imaging method and the reference method. The key point on whether a particular imaging method, in fact, agrees with or has a greater accuracy than the reference method should be based on the clinical situation in which the method will be applied.

Results

Limits of agreement for the LFM site

Regarding the determinations made with the direct measurement, the estimates for the limits of agreement at 95% are respectively above and below the measurements obtained with SCT (2.75 to -1.08 mm), i-CAT® CBCT (0.40 to -0.90 mm), and NewTom-3G® CBCT (0.50 to -1.40 mm) (Fig 8).

Figure 8 (site LFM) reveals that the limits of agreement at 95% are larger (lower accuracy) for SCT whereas it is shorter (higher accuracy) for the i-CAT® CBCT. Furthermore, it shows the bias (the distance indicated by the vertical arrows) between the mean differences of the values determined with each tomographic technique and the direct measurement.

Limits of agreement for the LFPM site

Regarding the determinations made with the direct measurement, the estimates for the limits of agreement at 95% are respectively above and below measurements obtained with SCT (1.73 to -1.55 mm), i-CAT® CBCT (0.62 to -1.99 mm), and NewTom-3G® CBCT (0.63 to -2.59 mm) (Fig 9).

Figure 9 shows that at site LFPM the limits of agreement for the three image techniques are very close. The limits of agreement for the spiral and NewTom-3G® CBCT techniques are similar and slightly larger than those for the i-CAT® technique. Furthermore, it shows the bias (the distance indicated by the vertical arrows) between the mean differences of the values determined with each tomographic technique and the direct measurement.

Limits of agreement for the LLI site

Regarding the determinations made with the direct measurement, the estimates for the limits of agreement at 95% are respectively above and below measurements obtained with SCT (0.70 to -1.24 mm), i-CAT® CBCT (0.88 to -1.64 mm), and NewTom-3G® CBCT (0.59 to -2.16 mm) (Fig 10).

Figure 10 shows that at site LLI, the limits of agreement at 95% for SCT are lower than those for i-CAT® and NewTom-3G® CBCT, even though they are similar. Furthermore, it shows the bias (the distance indicated by the vertical arrows) between the mean differences of the values determined with each tomographic technique and the direct measurement.

Discussion

SCT presents some advantages since it is an exam with excellent accuracy and good resolution, which allows visualization of soft tissues and assessment of hard tissues in three planes.[1,2,5,6,8]

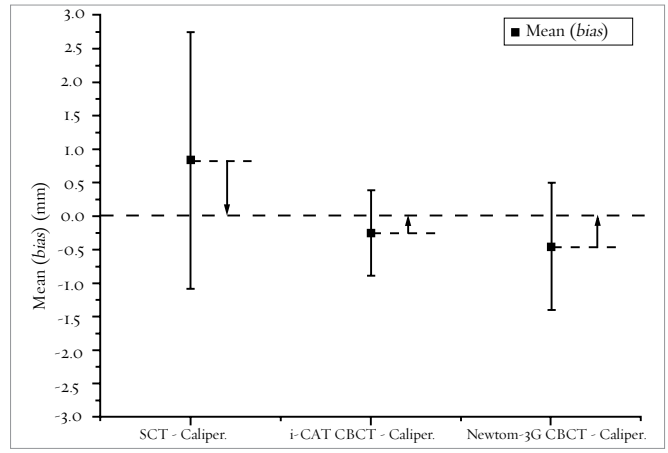

Figure 8 - Limits of agreement for the methods of image compared with direct measurement of LFM.

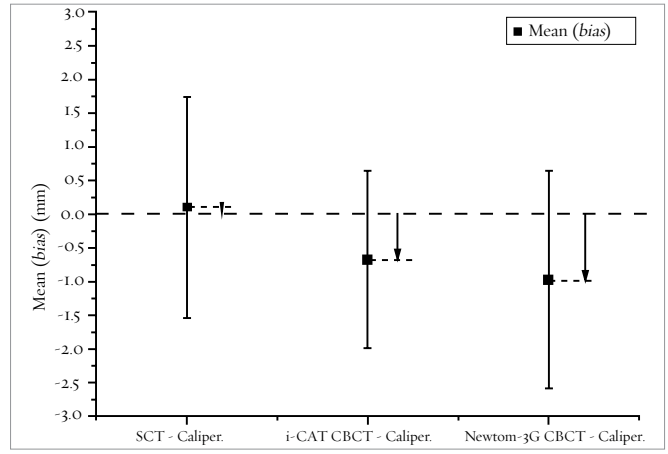

Figure 9 - Limits of agreement for the methods of image compared with direct measurement of LFPM.

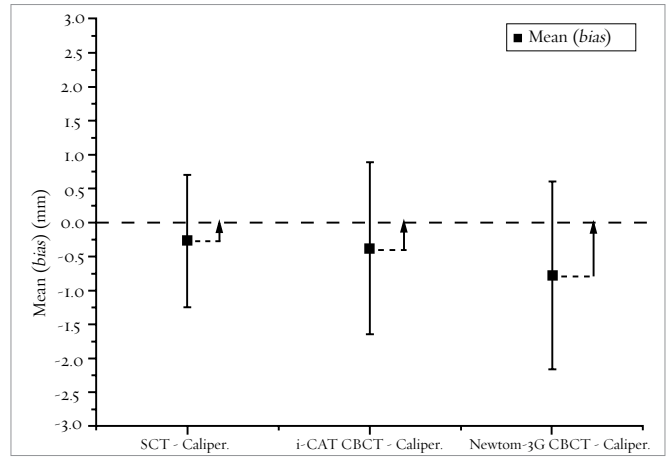

Figure 10 - Limits of agreement for the methods of image compared with direct measurement of LLI.

Imaging methods that are able to obtain and reproduce with adequate accuracy the maxillomandibular dimensions are essential for diagnosis and planning of surgical procedures, such as those commonly found in Implantology.[9,10] Due to the risks of performing operations that are inherent to Implantodontics without using rigorous tests, CTs have become a valuable tool in planning surgical procedures.[4,12-16]

In spite of the high radiation dose of SCT equipment, it is widely used for implantology surgeries, planning of procedures for maxillomandibular reconstruction and bucomaxilofacial surgeries.[13,17]

In SCT, visualization of soft tissues is clearer. However, images of hard tissues have better quality in CBCT, since the voxels (the smallest structures of an image) are anisotropic (rectangular cubes in which length is greater than height and width) in SCT; and isotropic (rectangular cubes with equal size in the three dimensions) in CBCT. Another difference between voxels is that the voxel surface can reach 0.625 mm^2 in SCT and 0.125 mm^2 in CBCT.[1,4,18,19]

As for the quality of images, it is shown in the literature[19-24] that the accuracy of both examinations is very similar. However, SCT is cited by some authors[19,24] as being slightly more accurate than CBCT. This information disagrees with the results obtained in this study which shows greater accuracy for i-CAT® CBCT, lower accuracy for NewTom-3G® CBCT, and intermediate accuracy for SCT. Nevertheless, good accuracy was shown in the three types of examination regarding direct measurements.[19-24]

Corroborating the results achieved by Ludlow et al,[25] with a difference between measures not greater than 2 mm, agreement was observed for differences of up to 2 mm(94.16%) and 1 mm (71.66%) between measurements performed with NewTom-3G® CBCT. As for CBCT, agreement was observed for a difference of up to 2 mm(97.48%) and 1 mm(82.49%) between measurements obtained with the i-CAT® system.

Indirect measurements obtained in examinations with the cone-beam technology were systematically lower than those performed with a caliper, with both the NewTom-3G® system (83.33%) and the i-CAT® CBCT (75.85%), which is in agreement with the studies of Lascala et al.[26] In SCT, indirect measurements were lower than the direct measurements in 42.5% of examinations.

Despite the fact that, in SCT, the results showed a close agreement within 1 and 2 mm, for i-CAT® CBCT the values were higher than those for the direct measurement in 56.66% of examinations (mean deviation of 0.82 mm with the greatest difference of 3.66 mm).

With regard to the limits of agreement used in this study, it was observed that the LFPM and LLI sites are similar in amplitude, with lower amplitude for SCT (LLI and LFPM sites) and i-CAT® CBCT. As for the LFM site, the amplitudes of the limits of agreement were not similar, and the lowest amplitude was observed for i-CAT® CBCT. The limits of agreement with lower amplitude indicate greater accuracy in examinations. Although greater accuracy was observed for i-CAT® CBCT and lower accuracy for NewTom-3G® CBCT and SCT, all examinations showed similar accuracy.

For the LFM, the limits of agreement were 2.75 mm above and 1.08 mm below with spiral CT. This generates some concern when borderline cases are referred for osseointegrated implants. On the other hand, a margin of error greater than 2.75 mm was observed when the direct measurement was of about 30 mm. Such a value is at least three times greater than that for a borderline case that may receive an implant. At this same site, NewTom-3G® and i-CAT® CBCT showed differences (0.50 and 0.40 mm above, respectively) with negligible differences regarding installation of dental implants, since a small change in either angle or point of election would result in a similar difference. These data are in agreement with what was

stated by Baumgaertel et al[27] who describe CBCT as a reliable and accurate examination, which can be used for quantitative analysis of the remaining bone.

With regard to the LFPM site, the positive limits of agreement were estimated to be 1.73 mm (SCT), 0.62 mm (i-CAT® CBCT), and 0.63 mm (NewTom-3G® CBCT). These limits are widely acceptable in surgical planning, especially when the mean deviations for SCT (0.09 mm), i-CAT® CBCT (-0.68 mm), and NewTom-3G® CBCT (-0.98 mm) are taken into account.[28]

As for the LLI site, means with negative values were observed in the limits of agreement for SCT (0.27 mm), i-CAT® CBCT (0.38 mm), and NewTom-3G® CBCT (0.78 mm), showing a good accuracy for all examinations performed in this region.[5,19,29] The fact that all means had negative values and the upper limits of agreement were not so different from the direct measurements, increases safety in the installation of osseointegrated implants, even in borderline cases. In this region, the maximum upper limits of agreement were 0.70 mm (SCT), 0.88 mm (i-CAT® CBCT), and 0.59 mm (NewTom-3G® CBCT).

Regarding all regions examined, greater accuracy was found for i-CAT® CBCT, which is in agreement with Loubele et al[5] who stated that this system is the most accurate among the four CBCT systems.

It can be concluded that the three CTs studied herein showed similar limits of agreement and precision at LLI and LFPM sites, and the i-CAT® CBCT showed limits of agreement with lower amplitude and greater accuracy than the other examinations performed.

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Mandibular osteonecrosis associated with bisphosphonate use after implant placement: Case report

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Abstract

Oral rehabilitation of patients with single or multiple tooth loss using osseointegrated implants has become a successful treatment option. Nevertheless, a serious complication can affect the survival of these implants: osteonecrosis of the jaw associated with the use of bisphosphonates. Bisphosphonates are a class of drugs that have the function of inhibiting the activity of osteoclasts, interfering with bone remodeling and turnover. They are recommended to postpone bone impairment in some malign conditions such as multiple myeloma as well as metastatic breast cancer and prostate cancer, also in the treatment of Paget's disease and osteoporosis. Clinically, BRONJ (Bisphosphonate-Related Osteonecrosis of the Jaw) appears as loss of continuity of the oral mucosa with exposure of the underlying bone. It can be extremely painful, persistent and does not respond to conventional treatments. The objective of this paper is to conduct a literature review on the subject and report a case of BRONJ after implant placement.

Keywords: Osteonecrosis. Bisphosphonate-related osteonecrosis of the jaw. Dental implants.

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» Patients displayed in this article previously approved the use of their facial and intraoral photographs.

Introduction

Oral rehabilitation of patients with single or multiple tooth loss using osseointegrated implants has become a highly successful treatment option. Nevertheless, a serious complication can affect the survival of these implants: osteonecrosis of the jaw associated with the use of bisphosphonates. Globally known as Bisphosphonate-Related Osteonecrosis of the Jaw (BRONJ), it is a disease characterized by necrotic bone exposure affecting both the mandible and the maxilla. Clinically, they arise as continuous loss of the oral mucosa with exposure of the underlying bone, similar to radiation-induced osteonecrosis, or osteoradionecrosis. They can be extremely painful and persistent, and do not respond to conventional treatment methods such as debridement, antibiotic therapy and hyperbaric oxygen therapy.[1,2]

Bisphosphonates are a class of drugs that have the function of inhibiting the activity of osteoclasts. They are strongly related to the bones, given that they interfere in bone remodeling and turnover and also possibly interfere in angiogenesis by hindering vascular endothelial growth factor.[2]

This condition hampers implant placement due to the fact that osseointegration process depends on normal bone physiology. In spite of that, bisphosphonates bring great benefits to patients' quality of life. They can be taken orally or intravenously, and are recommended to postpone bone impairment in some malign conditions such as multiple myeloma, breast and prostate cancer metastasis, as well as for the treatment of Paget's disease and osteoporosis. The most recent nitrogenous bisphosphonates, the aminobisphosphonates, are highly effective and present greater selectivity. The aminobisphosphonates most often used are: alendronate, risedronate, ibandronate, pamidronate and zoledronate.[2,6]

In the last few years, literature has described the association between osteonecrosis of the jaw and the use of bisphosphonates. The first case report was published in 1995, in a oral and maxillofacial surgery journal, and established a relationship between bisphosphonates and unsuccessful osseointegration of implants placed in the mandible of a patient who had been subjected to therapy with bisphosphonates to treat osteoporosis.[3]

The first extensive literature review focusing on the subject was published in 2003 by Marx et al,[4] and comprised 36 case reports of maxillary osteonecrosis associated with the use of pamidronate and zoledronate. Patients' mandible was affected in 80% of the cases, while their maxilla was affected in 14%, and in 6% of cases both were affected. The lesions were associated with dental extractions in 78% of cases, whereas in the remaining 22% they had been spontaneously developed.

Ruggiero et al[5] published an analysis of 63 cases of patients with osteonecrosis of the jaw associated with the use of bisphosphonates. The authors identified that, in most cases, the typical symptoms were pain and bone exposure where the tooth had been previously extracted. Additionally, they observed that only 14% of patients had not been subjected to any previous dental procedures, therefore, presenting spontaneous bone exposure.

Marx et al[6] analyzed 119 cases of osteonecrosis of the jaw, out of which 68.1% presented mandibular osteonecrosis, 27.7% maxillary osteonecrosis and 4.2% both mandibular and maxillary osteonecrosis. These patients were using different types of bisphosphonates to treat multiple myelomas (52.1% of cases), breast (42%) or prostate (3.4%) cancer metastasis and osteoporosis (2.5%). The causes of bone exposure were as follows: spontaneous exposure (25.2%), tooth extraction (37.8%), severe periodontitis (28.6%), periodontal surgery (11.2%), dental implants (3.4%) and endodontic surgery (0.8% of cases).

Rincón et al[7] analyzed 15 cases of osteonecrosis associated with the use of bisphosphonates, among which 10 were women (66.6%) and 5 were men (33.3%) with mean age of 64 years (41 to 75 years old). Tooth extraction was present in 6 cases. The most affected spot was the mandible (12 cases), followed by the maxilla (2 cases) and both (1 case). More severe complications were found in these patients: three cases of cutaneous fistula, two cases of oro-antral communication associated with maxillary sinusitis and one case of pathological mandibular fracture.

The risk of osteonecrosis of the jaw occurring in patients subjected to the use of bisphosphonate suggests that all elective surgical procedures, such as implant placement, must be avoided. Published data suggest that tooth extraction is the main etiological factor behind the development of BRONJ, and that only a few cases of osteonecrosis or unsuccessful implants were a consequence of surgical procedures performed for dental implant placement.[8,9]

Koka et al[8] carried out a survey in which 370 female/post-menopause patients older than 50 years of age and who had been subjected to implant placement surgery (818 implants) were included. Patients were divided into two groups: users of bisphosphonates for treating osteoporosis or osteopenia (BP group) and non-users of bisphosphonates (non-BP group), totaling 69 patients (with 148 implants) in BP group and 301 patients (with 670 implants) in non-BP group. Survival rates were generally excellent for both groups, with 120 out of 121 (99.17%) implants from BP group and 163 out of 166 (98.19%) implants from non-BP group.

Martin et al[9] also analyzed 8,572 individuals subjected to bisphosphonates therapy, out of which 589 claimed to have dental implants, including 130 who had the implants placed a year before. Implant failure was observed in 16 individuals, all of which were women whose mean age was 70.2 ± 7.6 years old. All of them had been subjected to alendronate therapy, orally taken, either to treat primary or secondary osteoporosis, or to prevent fractures. Within the subgroup comprising 16 patients with implant failure, a total of 44 implants were placed, out of which 26 were unsuccessful, with 8 implants presenting early loss (≤ 1 year) and 18 presenting late loss (> 1 year).[9]

In this context, the objective of this study is to report a case of a female patient presenting osteonecrosis of the jaw associated with the use of bisphosphonates after implant placement.

Case report

A 78-year-old Caucasian female patient was referred to the Clinic of Oral and Maxillofacial Traumatology, School of Dentistry, Federal University of Minas Gerais, in November/2012, for evaluation of active mandibular infection between foramina, after loss of implants previously placed at unknown date. During the first interview, the patient reported having used medication to control arterial hypertension. The patient was once more questioned about the use of medication, and then she reported that was taking a medication which she considered to be unimportant, given that it was taken once a week, only. After thorough investigation, it was found that she made use of alendronate sodium, a type of bisphosphonate used to control osteoporosis. It had been orally taken, once a week, for four years.

Patient's previous dental history revealed placement of four implants in the interforaminal region of the mandible, in addition to prosthetic rehabilitation (Fig 1). With the definitive prosthesis already in place, the patient complained about discomfort in the region of implants. In order to further investigate this issue, a computed tomography was requested (Fig 2).

The exam revealed a hypodense area near one of the implants, suggesting bone rarefaction as well as peri-implant bone loss. After finding out about the alterations in the implants, the patient decided to stop using the bisphosphonate without communicating her doctor/dentist. Although she was no longer taking the medication, her clinical condition worsened, including inflammation, infection and loss of implants (Fig 3).

Later, the patient presented with acute abscess, with increased volume in the submandibular region, erythema, trismus, severe pain, dysphagia and active intraoral drainage in the inferior alveolar ridge (Figs 4 and 5).

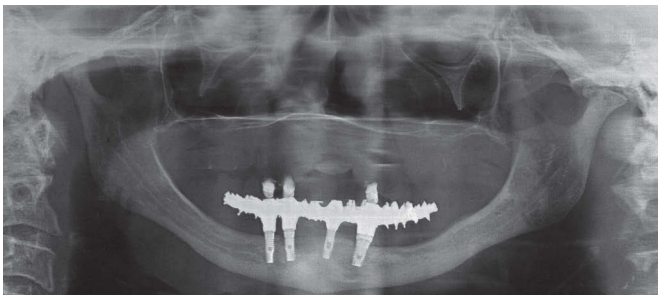

Figure 1 - Panoramic radiograph revealing four implants placed and in masticatory function.

Analyzing a new CT scan (axial slices and 3D reconstruction) absence of implants and widespread destruction of the mandibular symphysis bone was noticed (Fig 6).

Initial treatment comprised antibiotic therapy with oral clindamycin, mouthwash with 0.12% chlorhexidine gluconate, as well as surgery for conservative debridement in the area (Fig 7). Since the expected results were not achieved, the patient was referred to the Service of Head and Neck Surgery and, 3 months after the initial appointment, she was submitted to surgery for en bloc resection of the anterior mandible, under general anesthesia and in hospital setting.

The patient is currently under clinical and radiographic follow-up. A panoramic radiograph taken after two months (Fig 8) revealed absence of osteonecrosis signs, whereas clinical examinations reveal no signs of infection or further complications (Figs 9 and 10). The patient presents satisfactory mouth opening without limitations on feeding; does not complain about pain; reports improvements in her quality of life and is satisfied with treatment outcomes.

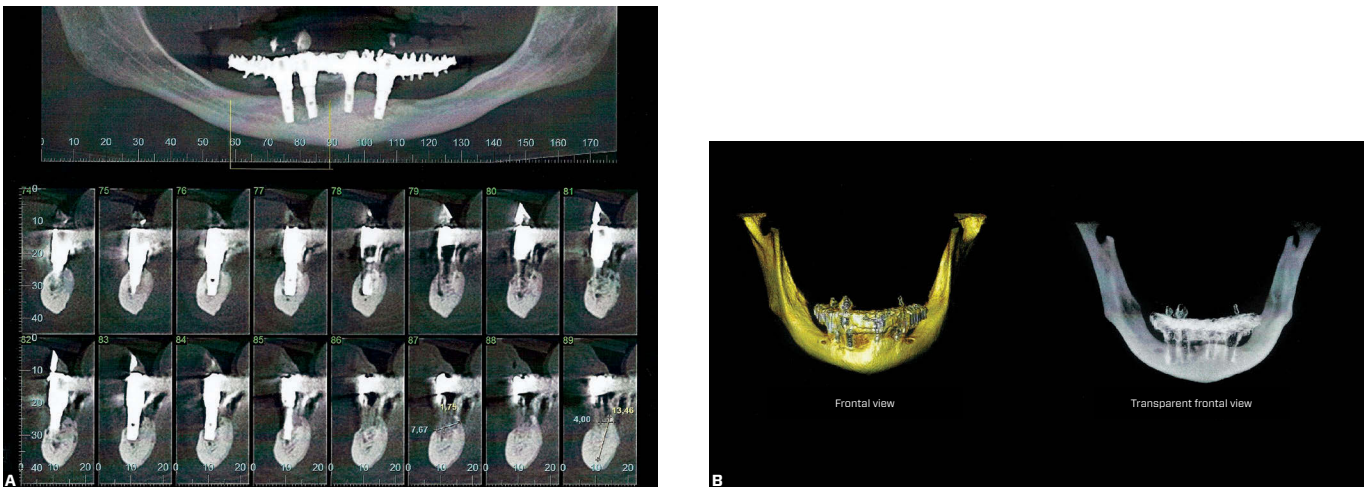

Figure 2 - **A**) Computed mandibular tomography, axial slices and panoramic reconstruction revealing hypodense area at slices 78 to 82, suggesting bone rarefaction near the implant. **B**) 3D reconstruction.

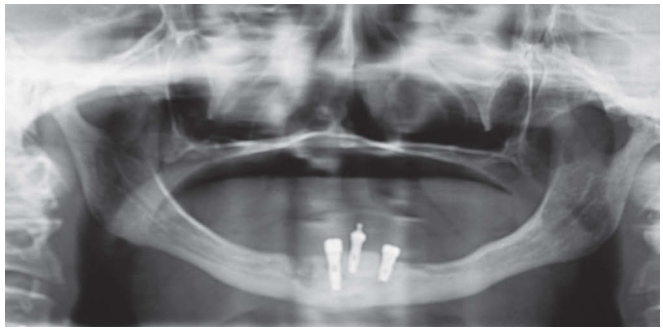

Figure 3 - Panoramic radiograph revealing loss of implants, associated with bone rarefaction.

Figure 4 - Extraoral view of abscess: increase in submandibular volume and erythema.

Figure 5 - Intraoral view: active drainage in the alveolar ridge, increase in volume and erythema.

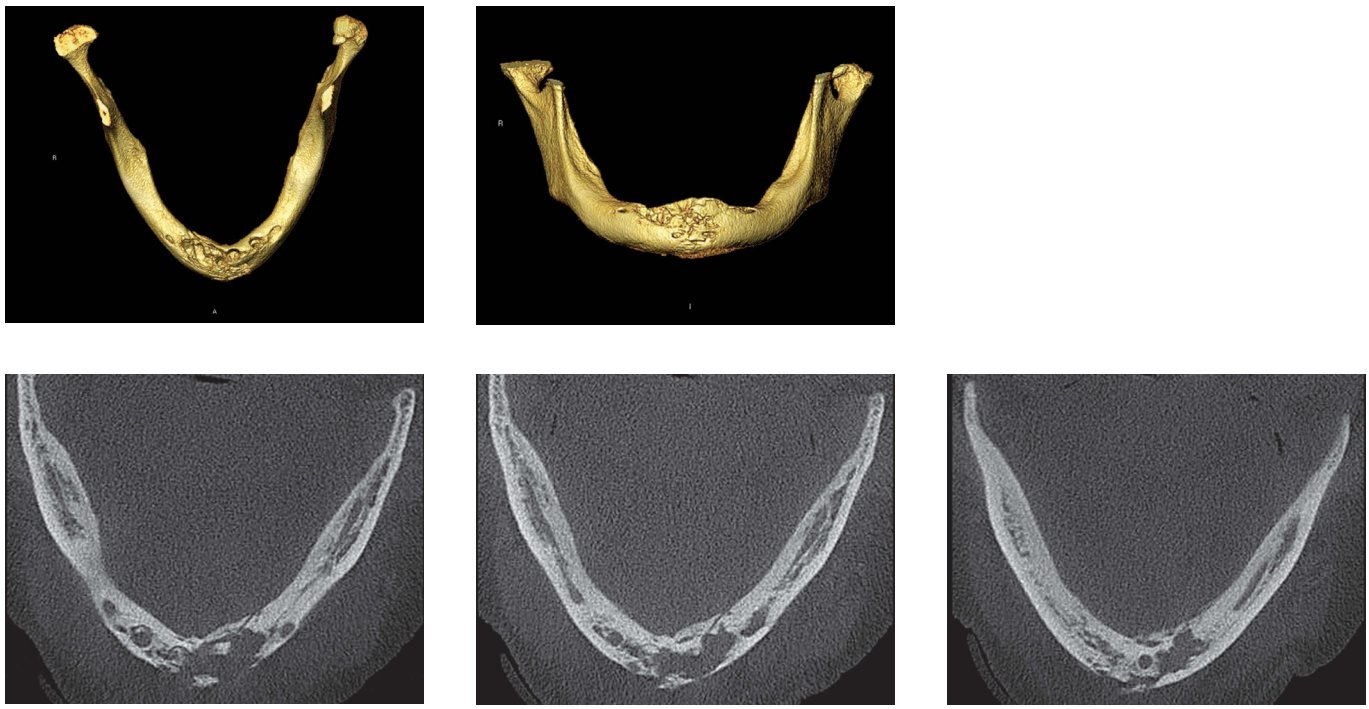

Figure 6 - Computed tomography (axial slices and 3D reconstruction), revealing absence of implants and severe destruction of mandibular symphysis bone.

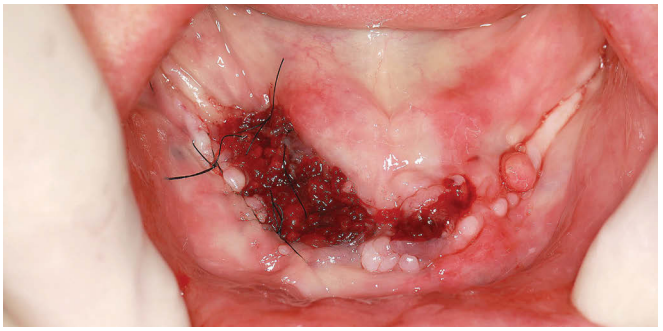

Figure 7 - Immediate postoperative intraoral view of debridement surgery.

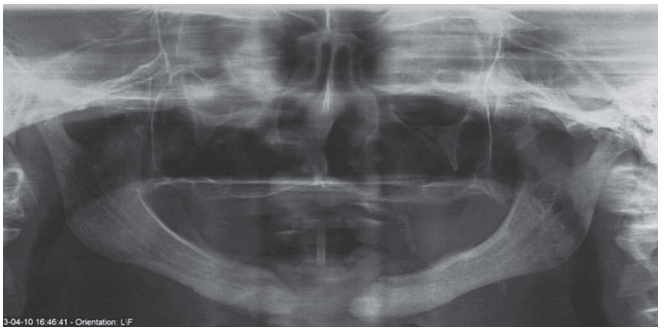

Figure 8 - Panoramic radiograph revealing resection of anterior mandible and absence of osteonecrosis symptoms.

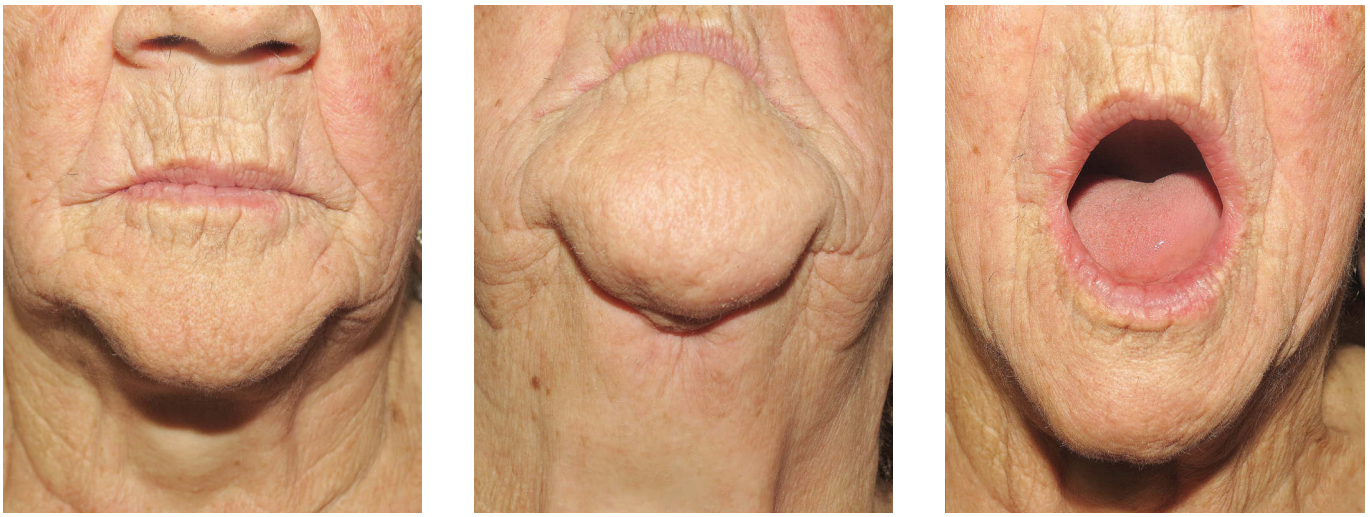

Figure 9 - Postoperative extraoral views two months after en bloc resection surgery. Good mouth opening, no signs of infection, deformities or complaints.

Figure 10 - Postoperative intraoral view two months after en bloc resection surgery.

Discussion

Although additional studies are needed to further investigate the relationship between osteonecrosis of the jaw and the use of bisphosphonates, a direct correlation between them cannot be ignored. Many cases have been reported in the literature, and show evidence that women comprise the majority of affected individuals,[4-8] as shown in the case reported herein. Additionally, it should be highlighted that there is a marked tendency of osteonecrosis occurs in the mandible[4-8] (which corroborates the present paper), and that the most common BRONJ clinical presentation consists of pain, incomplete or late tissue repair, soft tissue collapse, infection, bone necrosis and osteomyelitis.[2]

Many authors claim that most patients with maxillary osteonecrosis are under use of bisphosphonates to treat hypercalcemia associated with multiple myeloma and breast cancer, followed by osteoporosis and prostate cancer. Oral bisphosphonates are the most common osteoporosis therapy.[2,6] In the case reported herein, the patient made use of oral alendronate sodium, a type of aminobisphosphonate.

According to the literature, osteonecrosis can spontaneously occur, however, a precipitating event is present in the majority of cases.[6] Tooth extraction is the main etiologic factor, but implant placement can also lead to BRONJ, as in the case reported herein. Although many studies recommend rehabilitation with osseointegrated implants in patients under use of bisphosphonates,[8,9] this therapy must be carefully performed and multidisciplinary measures must be taken in order to minimize any potential risks. Additionally, it is required that clinicians carefully carry out the first interview with the patient and discuss with the doctor in charge about the feasibility of surgical interventions in these patients. Additional studies are required to further investigate the topic, given that it is a new condition for which no evidence-based protocol has been developed.

Moreover, whenever oral surgeries are necessary, the possibility of interrupting therapy conducted with bisphosphonates should be considered in order to prevent BRONJ. It must be done with the doctor's consent at least three months before and three months after surgery.[2] In the case reported herein, such recommendation was not followed before the first intervention, given that the patient did not inform her dental surgeon that she made use of alendronate sodium. Furthermore, the patient decided to stop using the medication without proper medical advice, since she believed that taking too much medication was the cause of the alterations. In spite of stopping the medication, she presented no regression of infection.

BRONJ therapy, whether conservative or radical, varies from author to author. Conservative treatment includes oral or intravenous antibiotic therapy, mouthwashes or wound irrigation to reduce bacteria and colonization in cases associated with infection; as well as surgical removal of bone sequestrum in symptomatic cases in which the painful bone necrosis area is a source of ongoing infection and does not respond to local and systemic antibiotic therapy. Should conservative treatment not be effective, some authors suggest bone resection with a safety margin, for which a more aggressive surgery is necessary.[2] In the present case, an attempt at conservative treatment was made, with oral and topic antibiotic therapy, in addition to two debridement interventions. Since conservative treatment was rendered unsuccessful, en bloc resection of the affected bone was carried out.

Conclusion

Based on the results of the present study, it is reasonable to conclude that osteonecrosis of the jaw associated with bisphosphonates is a severe complication, difficult to be managed at a dental clinic and that may cause severe morbidity and sequelae to the patient.

Therefore, prevention is of paramount importance, and so is the dental surgeon, given that he will advise the patient who uses bisphosphonates with regard to oral hygiene and elimination of any potential infectious focus, establishing criteria for dental evaluation similar to those applied to patients undergoing head and neck radiotherapy. Furthermore, it is essential that the dental surgeon be aware of the risks of BRONJ, its consequences and treatment methods, so as to conduct his cases as satisfactory as possible.

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Evaluation of the influence of compression (megapixels) in the diagnosis of alveolar bone loss in digitized radiographs using digital cameras

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Abstract

Introduction: This study aimed at evaluating the required digital camera resolution used for radiograph digitalization. **Material and Methods:** Periapical radiographs were selected from the undergraduate dental clinics at Ingá University (UNINGÁ) and digitalized with three different amateur digital cameras which were set at different megapixel resolutions. **Results:** Sony W110 digital camera showed similar acceptability results in all evaluated resolutions, which were VGA, 3, 5 and 7 megapixels (96.6%, 94.7%, 97. 3% and 97.3% respectively). Fujifinepix 2800HD digital camera presented a 100% of acceptability when set at 7 megapixels resolution. Sony T110 digital camera showed acceptable results when set at 5 megapixels resolution or higher. **Conclusions:** The best results were obtained with Fujifinepix 2800HD digital camera when set at a 7 megapixels resolution. The three brands evaluated, when set at a 5 megapixels resolution or higher, showed adequate results for diagnosis.

Keywords: Digital radiograph. Resolution. Scanning.

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Introduction

Fast technological development aids all professionals in planning, executing and completing their services. Countless documents are currently being digitized, databases are being created and, as a result, statistics arise in a simple click. The use of digital imaging has increased among dentists, however, due to the lack of proper knowledge, the results have been unsatisfactory, since distorted images are produced with little or no sharpness.[1]

There are several methods for digitizing a radiographic image, and the advent of computers has contributed to increase the use of digital imaging in Dentistry. Digitizing an image means converting it into numeric data and storing it into a computer hard drive. This is done through a process called sampling. Sampling means to divide the original image into small squares (samples) and assign to each one of them a number that represents the color of that part of the image. This allows the image to be represented by a set of numbers that can be stored in a computer. There are several options that can be used for digitalization, namely: scanners, digital cameras, digital radiographs, and video cameras.[2]

The current use of digital imaging is a result of scientific advancements that allow professionals to use what had been once unconceivable. Digital imaging has aided the diagnosis of malocclusions and the communication between professionals and patients. In addition, it has served as an excellent tool for prospectively and retrospectively evaluating the evolution and the outcomes of periodontal treatment. Moreover, it is also an excellent option for professionals who have a significant amount of records and want to digitize them, so that the documents that take a large amount of space can be converted into digital files and stored into medias such as CDS (compact disks) or USB drives.

The digitizing process with the use of scanners is slower and high-end equipment tends to be expensive. On the other hand, digital cameras can perform the same process in a faster way, yielding satisfactory results. The main advantages of the digital system is that it enables immediate display of the images, eliminates the cost of films and photo development, and allows simplified systematic management of images in the dental practice. Another advantage is the possibility of manipulating and editing the images, which significantly facilitates interpersonal communication and produces better results.[3-9]

According to Lemos et al[10] the photographic image has some disadvantages depending on the equipment chosen. Lens, flash light, batteries, proper lighting and focal point can affect the final quality of the image. However, little is known in the literature about how to properly use photographic equipment, and there are no standard guidelines for digitizing radiographs.[10]

Initially, it is necessary to clarify some terms so as to facilitate understanding throughout this article. Digitizing an image means to turn it into a computer file: physical and palpable material (slides, dental casts and radiographs) become virtual (displayed on a computer screen).

Various devices, including video cameras, digital cameras, scanners, digital radiograph machines, electronic microscopes, radars and ultrasound machines, can produce these digital images. Thus, it is important to differentiate "digital image" from "digital photograph".

Digital photograph is a type of digital image that is strictly obtained by the use of digital cameras. All digital files are essentially a series of binary digits, 0 and 1, which form tiny frames. Each frame is named pixel (the short form of "picture element", or the elements of an image) which is the basic unit that forms digital images.[2]

Image resolution is directly proportional to the amount of pixels. As previously described, the measurement unit of image resolution is the pixel, and the more pixels an image has, the greater its resolution will be. However, the main drawback is that images with high resolution produce large digital files, taking up a lot of computer memory space, which can hinder its performance, especially when using these images in multimedia presentations. Thus, the ideal is to obtain digital images as simply and fast as possible, with satisfactory quality and with the smallest size necessary for its purposes.

The resolution of an image is also commonly measured by DPI (dots per inch). In fact, every image is formed by PPI (pixels per inch) when it is digitally captured. Only when the image is printed it can be defined by DPI, because it ceases to be virtual and becomes physical. Therefore, it is correct to say that an image was printed in DPI, but if it is seen on a computer screen, it should be defined in PPI. This concept frequently causes confusion, even within the scientific community. Some journals erroneously require that scientific authors submit digital photographs with maximum resolution, others even specify values such as “minimum 8 megapixels resolution."

Unfortunately, this is a serious mistake, since the image resolution for printing is defined in DPI and not in megapixels. The Dental Press Journal of Orthodontics, for instance, requires that authors submit 300DPI images. These images can have 3, 5, 7, 10, 15 megapixels or more, but when printed on paper, their resolution must be of 300 dots per inch.[11]

Among the many technological innovations associated with new digital cameras, manufacturers have focused their attention on better resolutions, releasing products with “more and more megapixels!". Nowadays, there are digital cameras with 28 megapixels, which enables users to print images with high resolution (300 dpi) and in sizes up to 52 x 39 cm. This feature is of utmost importance for professional photographers who constantly work with large sized images.

Some manufacturers, following the “megapixel fever”, launch new products on the market without previous adequate testing. In addition to the number of pixels, other factors will influence the final quality of images, namely: the shape, size and layout of the pixels in the CCD digital sensor of the camera. This leads us to conclude that in order to obtain digital photographs with quality, it is important to use appropriate equipment with satisfactory resolution, excellent optical quality lens and ideal lighting systems.[12]

The subject of this research is of paramount importance, since digitizing radiographs by means of digital cameras is an effective and practical way to store data. In general, there is always an unstoppable quest for the most accessible and practical method and the fact that digital images can be shown to the patient on computer screens helps dentists build trust and credibility. This is a quick method that can be used on a daily basis in dental practice. Furthermore, we aimed at assessing the use of amateur digital cameras, since they are closer to the reality of most dental offices.

For these reasons, this study aimed at evaluating the required amount of megapixels that is necessary to obtain adequate quality of digital images when digitizing radiographs for alveolar bone loss assessment.

Material and Methods

The research project was approved by the Institutional Review Board of Ingá University, under nº 0075/10. Ten periapical radiographs were selected from the archives of the Undergraduate Dental Clinics of Ingá University (UNINGÁ), Maringá, Paraná, Brazil.

The radiographs were digitized by three different amateur digital cameras (Sony Cyber-Shot DSC-W110, Fuji FinePix 2800HD, Sony Cyber-ShotDSC-T110) set at different megapixel resolutions. The cameras were statically positioned in front of a light box, with a standard distance of 60 cm.[4] The digitized images were imported into the Power Point XP for Windows software and the same radiographs were photographed by different digital camera models (Sony Cyber-Shot DSC-W110, FujiFinePix 2800HD, Sony Cyber-Shot DSC-T110) and in different megapixel resolutions, such as; VGA (Video Graphics Array), 3 megapixels, 5 megapixels and 7 megapixels (Fig 1).

All images were viewed by examiners in an Intel Dual Core 2.2Ghz, 2Gb of RAM, 320GB of memory and a 19-in LCD screen computer, with calibrated brightness, contrast and distance.[13] The images were examined by five dental surgeons who classified their quality as good or poor for the evaluation of alveolar bone loss. The examiners assigned a numeric grade than ranged from 1 to 5 to the images, in which: 1 = Appropriate for diagnosis; 2 = Probably appropriate for diagnosis; 3 = Uncertain if appropriate for diagnosis; 4 = Probably inappropriate for diagnosis; 5 = Inadequate for diagnosis. Subsequently, the data were submitted to statistical analysis performed by the chi-square test (χ^2) with a significance level set at 5%. The software Microsoft Excel and Minitab 5.0 for Windows were used.

Results

According to the methods adopted in this research, the following results were obtained:

The Sony W110 digital camera showed similar acceptable results, remaining constant for the studied resolutions: VGA, 3 megapixels, 5 megapixels and 7 megapixels (96.6%, 94.7%, 97.3% and 97.3% respectively) (Table 1). Moreover, the chi-square test at a significance level of 5% showed statistically significant differences between yes and no evaluations at all the studied resolutions. As for the Fuji FinePix camera, the highest values of acceptability started from a 3 megapixels resolution (96.6%) and the 7 megapixels resolution presented a 100% of acceptance. The Sony T110 digital camera started to present acceptable results at a 5 megapixels resolution (81.5%) (Table 1).

Figure 1 - Radiographs digitized at 5MP with (**A**) Sony DSC-W110; (**B**) Fuji FinePix 2800HD and (**C**) Sony DSC-T110.

Table 1 - Results of the examiners' answers to the question on whether or not the observed image is appropriate to assess alveolar bone loss.

Digital Camera	VGA		3 megapixels		5 megapixels		7 megapixels	
	Yes	No	Yes	No	Yes	No	Yes	No
Sony DSC W110	*96.6%	3.4%	*94.7%	5.3%	*97.3%	2.7%	*97.3%	2.7%
Fuji FinePix 2800HD	51.3%	49.7%	*96.6%	3.4%	*82%	18%	*100%	0
Sony DSC T110	*40.7%	59.3%	50%	50%	*81.5%	18.5%	*92%	8%

*Statistically significant difference at 5% between answers on the same resolution.

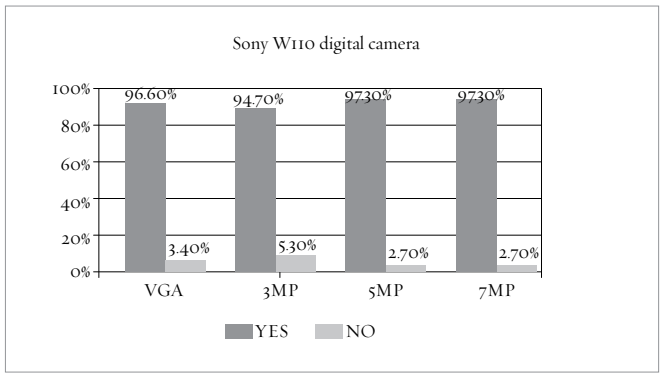

Figure 2 - Results of evaluation with Sony W110 digital camera.

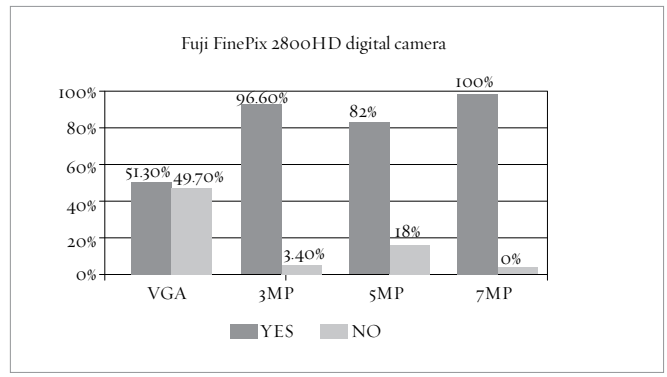

Figure 3 - Results of evaluation with Fuji FinePix 2800HD digital camera.

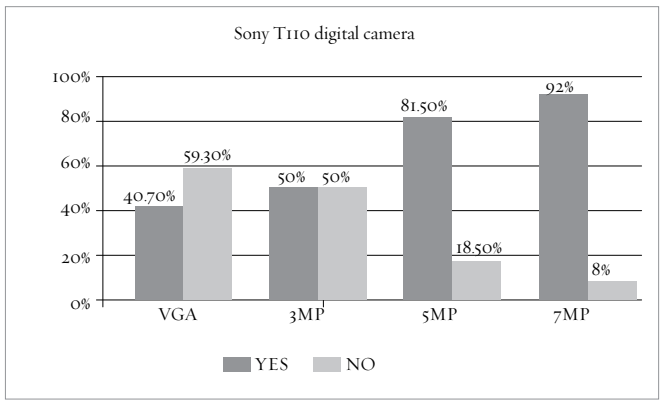

Figure 4 - Results of evaluation with Sony T110 digital camera.

Discussion

The current use of digital imaging is a result of scientific advancements that allow professionals to use it in previously unconceivable ways; assisting the diagnosis of malocclusions, the communication between professionals and their patients, and serving as an excellent tool to prospectively and retrospectively evaluate the evolution as well as the outcomes of periodontal treatment. It is also an excellent option for professionals who have a significant amount of records and want to digitize them so that documents that take a large amount of space can

be converted into digital files and stored in medias such as CDs (compact disks) or USB drives. The digitizing process with the use of scanners is slower and high-end equipment tends to be expensive. Digital cameras can perform the same process in a faster and adequate way, enabling immediate display of the images, which eliminates the cost of films and photo development.[3]

With this in mind, the present study aimed at evaluating the required amount of megapixels that is necessary to obtain adequate quality of digital images when digitizing and storing radiographs for alveolar bone loss assessment.

This study corroborates previous study results published by Machado et al[11] who suggest that the higher the image resolution, the higher is its detail definition, and consequently, the better tone, brightness and contrast it will have. Image resolution is directly proportional to the amount of pixels. That is, the greater the number of pixels (number of dots in the image), the better the image quality. This statement was proven correct in this study of which best results were obtained at highest resolutions. Machado et al[11] found that the versatility of digital cameras is unquestionable. Additionally, they claim that digital cameras are an excellent tool to digitize photographs, radiographs, dental casts and book pictures, replacing the use of scanners.[11]

According to the Webopedia,[18] the terminology "tone depth" is used to define the amount of distinct tones that a certain image features. This feature is often called "bit depth", because it is directly related to the number of bits used for each pixel to generate the tones. Therefore, the greater the number of pixels in an image, the greater the number of bits, and consequently, the greater the number of shades of gray that will favor the quality of the image. The results of the present study showed that the best images for alveolar bone loss[9] assessment were obtained by the Fuji FinePix digital camera, set at a 7 megapixels resolution.

This study showed that at a 5 megapixels resolution or higher, all evaluated digital cameras had adequate results for diagnosis (Fig 1). However, radiographs digitized at a VGA resolution were not adequate for diagnosis for the Sony T110 and Fuji FinePix 2800HD digital cameras (Figs 2, 3 and 4). According to the examiners, the Sony W110 digital camera presented adequate images for diagnosis in all studied resolutions; therefore, in addition to the resolution, the quality of the lens, the type of flash light, and the camera digital sensor may contribute to the final quality of a digital image (Fig 2).

According to Lemos et al[10] the photographic image has some disadvantages depending on the equipment chosen. Lenses, flash light, batteries, proper lighting and focal point can affect the final quality of the image. However, little is known in the literature about how to properly use photographic equipment, and there are no standard guidelines for digitizing radiographs.[10]

As reported by Bockert et al[14] the lens of a camera can produce image distortions, of which the most common are "barrel" and "cushion" distortions. The barrel distortion is a lens effect that causes images to seem inflated and it typically occurs at short end zoom lenses, in which the focal length is shortened. The cushion distortion is a lens effect that causes images to seem compressed at their center, and it is associated with long end zoom lenses, in which one focal length is greater. On both scenarios, the use of converters often amplifies the distortion. These defects can be better observed in images of perfectly straight lines, particularly when they are located close to the edge of the image. To most digital cameras, cushion distortions are less frequent than barrel distortions. The Adobe Photoshop[14] software can easily correct distorted images. The characteristics aforementioned may have influenced the results obtained by the three different digital cameras, despite having the same megapixel resolution.

Many studies approach image resolution subjects. Machado et al[15] described that the basic measurement unit of an image resolution is the pixel and the more pixels an image has, the greater its resolution will be, which was confirmed by this study.

The resolution of an image is also commonly measured by DPI (dots per inch). However, when digitally captured, every image is formed by PPI (or pixels per inch). Therefore, only when the image is printed it can be defined by DPI, because it ceases to be virtual and becomes physical.

According to Albenson et al[16] it is correct to say that an image was printed in DPI, but if it is seen on a computer screen, it should be defined as PPI. Albenson[16] suggests that although these two terms are theoretically different, in practice, they are used for the same goal. Branco et al[17] explain the meaning of DPI by affirming that when digitizing a picture with 300 DPI, for example, it is implied that each linear inch image contains 300 pixels and every square inch contains 90,000 (300 x 300) pixels, which will form the digital image. Therefore, we can conclude that the greater the amount of DPI, the greater the image resolution will be, and consequently, larger size files[17] (in bytes) will be created.

According to the Webopedia,[9] the resolution of an image depends on its DPI. When an image is digitized, it is divided into various dots, named pixels. Even though they are sometimes referred to as dots, pixels have a square shape and are not round,[9] as the nomenclature suggests. Thus, when thinking about scanning an image, one must remember that the best quality (higher resolution) is closely associated with the use of a larger hard drive space. However, an image with a lower resolution has inferior quality.

With the recent shift in the digital paradigm, digital cameras have proved to be another option for digitizing and archiving radiographs. Furthermore, we chose amateur digital cameras to conduct this study with the purpose of increasing their clinical applicability in daily dental practice. However, additional studies are warranted to further investigate the use of these technologies.

Conclusion

According to the methods adopted in this study, it can be concluded:

1) The best results were obtained with the Fuji FinePix 2800HD digital camera when set at a 7 megapixels resolution.
2) The three analyzed digital cameras presented satisfactory diagnostic results when set at a 5 megapixels resolution or higher.
3) The Sony W110 digital camera showed similar results for all three analyzed resolutions.

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

Dario Augusto Oliveira **MIRANDA***

Effect of the timing of restoration on implant marginal bone loss: a systematic review

Suarez F, Chan HL, Monje A, Galindo-Moreno P, Wang HL

J Periodontol. 2013 Feb;84(2):159-69

Background: The advancement in implant dentistry has allowed shortened treatment time by restoring the implants earlier. Whether the timing of restoration has an impact on implant marginal bone level has not been systematically analyzed. The aim of this study is to compare marginal bone loss (MBL) between implants that were restored with the following protocols: 1) immediate restoration/loading (IR/L); 2) early loading (EL); and 3) conventional loading (CL). **Methods:** An electronic literature search from three databases (until November 2011) and a hand search in implant-related journals were conducted. Clinical human studies in English language that had reported a comparison of MBL between implants with IR/L, EL, or CL with ≥12-month follow-up were included. In addition, the minimal number of implants had to be 10 for each group. Implants with both immediate placement (IP) and delayed placement (DP) were included and analyzed separately. An assessment of the publication bias for the included randomized clinical trials (RCTs) was performed. **Results:** The initial search resulted in 1,640 articles, of which 27 articles in full text were further evaluated for eligibility. Finally, 11 studies (eight RCTs, two controlled clinical trials, and one retrospective study) were qualified and classified into four groups: 1) IR/L + DP versus CL + DP (n = 6 articles); 2) IR + DP versus EL + DP (n = 2 articles); 3) EL + DP versus CL + DP (n = 1 article); and (4) IL + IP versus CL + IP (n = 2 articles). A meta-analysis performed for group 1 showed 0.09 mm (95% confidence interval = -0.27 to 0.09 mm) difference in the mean MBL, favoring the IR/L protocol but without significant difference (P = 0.33). No significant difference in MBL was found for groups 2 through 4 after adjusting for the implant placement level. The eight RCTs were determined to be at moderate-to-high risk of publication bias. **Conclusions:** This meta-analysis does not show an effect of the timing of restorations on implant MBL. The selection of restoration protocols should be based on factors other than MBL.

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Association of periodontitis with the risk of oral leukoplakia

Meisel P, Holtfreter B, Biffar R, Suemnig W, Kocher T

Oral Oncol. 2012 Sep;48(9):859-63

Background: Oral leukoplakia is an oral lesion suspected to be of premalignant character. Besides smoking and alcohol, the risk factors for the development of this oral lesion are still less identified. The purpose of this study was the search for a possible influence of periodontitis on the risk of leukoplakia. **Methods:** We used data from 4233 subjects (2116 women and 2117 men) who were recruited for the population-based Study of Health in Pomerania (SHIP) and finished a standard medical and dental examination. One hundred two-three cases with oral leukoplakia were 1:2 age and sex-matched with 246 healthy control subjects. Measures of bleeding on probing and clinical attachment loss were related to oral leukoplakia. **Results:** We found increased periodontal measures in subjects with leukoplakia. Adjusting for risk factors and possible confounders revealed a periodontitis-related dose-dependent increase in the probability of having oral leukoplakia. Odds ratios adjusted for socioeconomic factors and smoking computed for the second, third and fourth quartiles of clinical attachment loss were OR=1.7 (0.6-5.0), 3.3 (0.8-13.1) and 5.3 (1.2-22.7), respectively. For bleeding on probing the respective odds ratios were OR=2.0 (0.8-4.90), 2.9 (1.1-7.8) and 3.8 (1.5-9.8), respectively. Measures of systemic inflammation and of lipid metabolism were important cofactors attenuating these figures. While smoking is a risk factor of leukoplakia, oral hygiene is protective. In a follow-up survey, the leukoplakia subjects had lost more teeth than their counterparts (p=0.043). **Conclusion:** Periodontitis increases the risk of oral leukoplakia and, therefore, the risk of mucosal lesions predisposing to oral cancers.

Periodontal disease, Porphyromonas gingivalis serum antibody levels and orodigestive cancer mortality

Ahn J, Segers S, Hayes RB

Carcinogenesis. 2012 May;33(5):1055-8

Periodontitis, the progressive loss of the alveolar bone around the teeth and the major cause of tooth loss in adults, is due to oral microorganisms, including Porphyromonas gingivalis. Periodontitis is associated with a local overly aggressive immune response and a spectrum of systemic effects, but the role of this condition in orodigestive cancers is unclear. We prospectively examined clinically ascertained

periodontitis (N = 12,605) and serum IgG immune response to P.gingivalis (N = 7852) in relation to orodigestive cancer mortality among men and women in the National Health and Nutrition Examination Survey III. A detailed oral health exam was conducted from 1988 to 1994 in survey Phases I and II, whereas serum IgG for P.gingivalis was measured from 1991 to 1994 in Phase II only. One hundred and five orodigestive cancer deaths were ascertained through 31 December 2006. Periodontitis (moderate or severe) was associated with increased orodigestive cancer mortality [relative risks (RR) = 2.28, 95% confidence interval (CI) = 1.17-4.45]; mortality risks also increased with increasing severity of periodontal disease (P trend = 0.01). Periodontitis-associated mortality was in excess for colorectal (RR = 3.58; 95% CI = 1.15-11.16) and possibly for pancreatic cancer (RR = 4.56; 95% CI = 0.93-22.29). Greater serum P.gingivalis IgG tended to be associated overall with increased orodigestive cancer mortality (P trend = 0.06); P.gingivalis-associated excess orodigestive mortality was also found for healthy subjects not exhibiting overt periodontal disease (RR = 2.25; 95% CI = 1.23-4.14). Orodigestive cancer mortality is related to periodontitis and to the periodontal pathogen, P.gingivalis, independent of periodontal disease. Porphyromonas gingivalis is a biomarker for microbe-associated risk of death due to orodigestive cancer.

Periodontitis and diabetes associations with measures of atherosclerosis and CHD

Southerland JH, Moss K, Taylor GW, Beck JD, Pankow J, Gangula PR, Offenbacher S

Atherosclerosis. 2012 May;222(1):196-201

Objective: Diabetes has been linked with more severe periodontal disease and with coronary heart disease (CHD). The purpose of this study was to determine if periodontal infection was a significant modifier in the risk that diabetes poses for increased carotid artery intimal-medial wall thickness (IMT) and more advanced atheroma lesions as reflected in atherosclerotic plaque calcification measured by acoustic shadowing. **Methods and Results:** Comparisons for analyses of cardiovascular outcomes were performed based upon periodontitis and diabetes status. Periodontitis was measured using pocket depth and attachment loss at six sites per tooth. Cross-sectional data on 6048 persons aged 52-74 years were obtained from the Dental Atherosclerosis Risk in Communities Study. Participants without diabetes (n=5257) were compared to those with diabetes (n=791). Dependent variables were thick IMT (>1 mm), presence of acoustic shadowing, and prevalent CHD. All models were adjusted for the following covariates: gender, age, race/center, LDL and HDL

cholesterol, BMI, triglycerides, hypertension, smoking, income and education. For multivariate model building, all non-normally distributed variables were transformed and multivariable logistic regression analyses were performed to evaluate the relationship between periodontal infection, diabetes, and cardiovascular outcomes. Individuals with diabetes and with severe periodontitis were found to be significantly more likely to have IMT>1 mm [OR=2.2, (1.4-3.5)], acoustic shadowing [OR=2.5, (1.3-4.6)], and CHD [OR=2.6, (1.6-4.2)] compared to those without diabetes or periodontal disease. **Conclusion:** Results from this study suggest that among people with diabetes, periodontal disease may increase the likelihood of subclinical atherosclerotic heart disease and CHD.

Periodontal disease and the oral microbiota in new-onset rheumatoid arthritis

Scher JU, Ubeda C, Equinda M, Khanin R, Buischi Y, Viale A, et al

Arthritis Rheum. 2012 Oct;64(10):3083-94

Objective: To profile the abundance and diversity of subgingival oral microbiota in patients with never-treated, new-onset rheumatoid arthritis (RA). **Methods:** Periodontal disease (PD) status, clinical activity, and sociodemographic factors were determined in patients with new-onset RA, patients with chronic RA, and healthy subjects. Multiplexed-454 pyrosequencing was used to compare the composition of subgingival microbiota and establish correlations between the presence/abundance of bacteria and disease phenotypes. Anti-Porphyromonas gingivalis antibody testing was performed to assess prior exposure to the bacterial pathogen P gingivalis. **Results:** The more advanced forms of periodontitis were already present at disease onset in patients with new-onset RA. The subgingival microbiota observed in patients with new-onset RA was distinct from that found in healthy controls. In most cases, however, these microbial differences could be attributed to the severity of PD and were not inherent to RA. The presence and abundance of P gingivalis were also directly associated with the severity of PD and were not unique to RA. The presence of P gingivalis was not correlated with anti-citrullinated protein antibody (ACPA) titers. Overall exposure to P gingivalis was similar between patients with new-onset RA and controls, observed in 78% of patients and 83% of controls. The presence and abundance of Anaeroglobus geminatus correlated with the presence of ACPAs/rheumatoid factor. Prevotella and Leptotrichia species were the only characteristic taxa observed in patients with new-onset RA irrespective of PD status. **Conclusion:** Patients with new-onset RA exhibited a high prevalence of PD at disease onset, despite their young age and paucity of smoking history. The subgingival microbiota profile in patients with new-onset RA was similar to that in patients with chronic RA and healthy subjects whose PD was of comparable severity. Although colonization with P gingivalis correlated with the severity of PD, overall exposure to P gingivalis was similar among the groups. The role of A geminatus and Prevotella/Leptotrichia species in this process merits further study.

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De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res. 2005 Feb;84(2):118-32.

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