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DOCTORAL THESIS (ABSTRACT)

Modern methods used for raising predictibility in dental implants and bone grafts body integration.

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CONTENTS

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INTRODUCTION

Oral implantology is a branch of dentistry that deals with the rehabilitation on implant and prosthetic support of clinical situations of edentations in the oral cavity. It is a special discipline, regulated as a right of limited practice in Romania for dentists who have an official competence called "competence in oral implantology", acquired after graduating from postgraduate studies lasting 3 semesters. Also, oral implantology can be practiced in Romania by any dentist with limitations of competence when inserting implants, without performing other operations and related interventions.

Oral implantology is a field that is constantly evolving and at an accelerated rate, unlike other branches of dentistry, this evolution being in line with technological progress in the field, with the emergence of increasing possibilities of implant and prosthetic treatment, with the discovery of new methods of bone augmentation.

During this study we identified as modern methods used to increase the rate of predictability of the integration of bone implants and grafts, several technologies that greatly facilitate the work of the clinician and increase the quality of the medical act.

These technologies are related on the one hand to high-performance imaging, which is constantly evolving, cone-beam computer tomography (CBCT) being the best method of acquiring imaging data in order to achieve implant-prosthetic rehabilitation; on the other hand, this radiological information is used to its full potential only by its integration into treatment simulation software and other methods of digitization and information transfer, in order to plan clinical cases as thoroughly as possible in the achieving the highest possible success rate.

The contribution of oral scanning technologies, facial scanning, CAD-CAM systems, the possibility of pre-designing surgical guides and temporary and definitive prosthetic restorations are some of the elements that will be analyzed in this study and that contribute as modern treatment methods to increase the rate. predictability of the integration of implant and bone rehabilitation in the patient's body.

The current research is a study to identify, quantify and calculate the impact of all modern technical possibilities created in order to evaluate and design the best implant-prosthetic treatment plan for oral and general rehabilitation of the patient.

During the research, for about 3 years, the evolution of technology has been very accelerated, so we have managed to cover a large part, but not all, of modern methods of treatment and simulation. These were represented by the technologies we had access to during the treatment of patients whose implants were included in the statistical evaluation. Also, in order to clarify and include most of the technologies available on the European continent, the research being one with clinical involvement and collaboration with doctors and practitioners from abroad, we conducted a study on the effectiveness of simulation methods and the possibility of acquiring imaging information available during the course of scientific research.

This doctoral study is structured in two main parts. The first part contains general notions relevant to the field of modern implantology, including notions of anatomy, implant risk areas, autologous bone graft collection spaces, auxiliary implant insertion spaces. Notions of digitization in the field of implantology are also presented, and during the scientific research we will detail and effectively apply the way of working in order to obtain data of statistical importance.

The second part of the doctoral research consists of two studies. The first study is a descriptive and statistical one about the current modern technologies used in oral implantology to increase the predictability of the integration of implant-prosthetic rehabilitations. The second study includes statistics of historical research of its own database, which contains a significant number of implants and bone grafts inserted with the contribution of modern technologies available at the time of intervention, thus allowing the development of a statistical process to track the effect of modern technologies used in oral implantology. to increase the predictability of implant-prosthetic rehabilitation integration. The historical study of this database is made according to the legislation in force and is not an experiment or an elective method of treatment, but is represented by implant surgery and grafting performed using modern technologies available at the time of performance.

The final conclusions are presented in each study and will show us the effect of using modern technologies in oral implantology to increase the predictability of the integration of implants and bone grafts in oral rehabilitation.

THE GENERAL PART

The general part of the thesis consists of two chapters of generalities related to the approach of modern implantology in the current anatomical and technological context. The first chapter refers to the brief presentation of the notions of topographic and regional cervio-cephalic anatomy, in which all the elements interested in implant practice and bone grafting are highlighted, with special attention being paid to risk areas and reserve bone spaces in implant rehabilitation. prosthetics. Another important part of this chapter is dedicated to the peri-oral bone collection spaces, as well as to the maxillary auxiliary spaces for the insertion of strategic endo-bone implants.

The second chapter refers to the digitization and computerization in implant-prosthetic therapy, a space dedicated to new imaging technologies and to the design and simulation of implant treatment and bone grafting conditions. An important part is dedicated to guided implant surgery, which is currently the standard of execution of these types of oral rehabilitation. In this chapter we find the preamble of the scientific research carried out in the personal part.

THE PERSONAL PART

The personal part includes 2 statistical studies on modern methods used in the predictability of implant therapy and bone grafting. In the first study, the research topic was CBCT and digital planning and simulation software-methods of use and digital workflow, as well as a comparison between the CBCT units available during the study and the performances, advantages and difficulties of use.

Chapter 1 is entitled MODERN METHODS USED IN THE PREDICTIBILITY OF IMPLANT AND BONE GRAFT THERAPY - CBCT AND DIGITAL PLANNING AND SIMULATION SOFTWARE - COMPARATIVE STUDY AND DIGITAL WORKFLOW - and it covers all aspects of the logistical and statistical research of the CBCT units and simulation software that were used during this study. In this chapter in the introductory part we talked about the importance of using digital workflow in the practice of modern implantology, and in the material and methods section we will describe absolutely all aspects of this way of working. Respectively, the material and methods part contains information about CBCT resources such as:

1. Hardware
2. Algorithmics and realization of the final image
3. CBCT exposure optimization
4. Software, planning, simulation

a. Clinical digitization of radiological images - the landmarks considered in the clinical study regarding the personalization of the treatment are presented

b. The effective simulation of the insertion of implants and bone grafts with the digital evaluation of the procedure - a very well represented chapter and with presentations of the real clinical cases made by integral digital workflow.

5. Comparative study of the CBCT units used and of the planning software-final stage of the first study after which we obtained various results which are presented in the next chapter.

The purpose of this study was to highlight a comparison of specifications between devices, for the rational reason that each company advertises its own brand without relating to competition in the market. The clinician who is faced with the decision to use CBCT to its full potential must document comparative studies to obtain with minimum resources, results at full potential to use modern techniques to increase the predictability of successful integration of implants and grafts. bone in the complex treatment of oral rehabilitation. Also, another purpose of this study was to highlight a digital workflow in the practice of dentistry, specializing in advanced oral implantology. The statistical results are presented in detail in the content of the thesis and offer those interested a broad perspective on the current technological offer in terms of CBCT imaging in the current practice of oral implantology.

During the data comparison we managed, within the limits of specialized physical and literary resources, to identify the best methods to integrate digital capabilities in current practice to define the topic of this study thesis, respectively, modern methods used in predictability and acceptance of dental implants. and bone grafts. Long-term and very long-term predictability is the key to success in the field of advanced implantology and in the practice of complex oral rehabilitation.

Chapter 2 is entitled STATISTICAL STUDY OF STANDARD TREATMENT METHODS VS DIGITALIZED TREATMENT METHODS, and includes the retrospective, quantitative clinical study on an extensive batch of dental implants applied using 3 types of clinical approach over 5 years. The study is based on the evaluation of a significant number of implants applied to patients receiving advanced implant-prosthetic therapy, which were inserted using different digital techniques, namely the classic radiological evaluation technique, digital evaluation and planning technique and advanced implantology technique, based on measurements. multiple, virtual simulations, virtual planning of prosthetic restoration.

The subchapter on materials and methods describes how to work as follows:

1. A number of 556 viable two-piece implants, consisting of titanium implant screw and secondary prosthetic abutment, made of various materials, consistent with the prosthetic restoration performed, were studied and completed with constant evaluation at 1, 3,6, 12, 18 and 24 months from the time of implantation. The working groups were divided into three and named suggestively according to the clinical approach of each.

2. Thus, the first group, referred to during the exhibition as "classical", is composed of 328 implants that were inserted by the classical method. This method involved the use of classical imaging investigation techniques - orthopantomography, dental computed tomography and free-hand surgical approach, using data from radiological exposures and clinical evaluation at the operative time with adaptation to given conditions.

3. The second group, referred to as “digital” during the exposure, is composed of 113 implants that were inserted using basic digital techniques, respectively imaging type dental tomography computer, CBCT, data acquisition through exposure software. The insertion method was free-hand, with adaptation and adjustment at the time of the operator protocol.

4. The third group, referred to in the exposition as 'digital advanced', is the group that benefited from the highest standards of investigation and simulation at the time of implant insertion. It is represented by 115 implants that have benefited exclusively from advanced CBCT imaging techniques, image processing and rendering software, surgery simulation software, CAD-CAM transposition software and making surgical guides, integrated guide making service surgical

and prosthetic rehabilitation by digital methods exclusively, without using classical methods of fingerprinting and transfer to the dental laboratory.

5. The data were centralized in SPSS 19.0 databases and processed with the statistical functions for which they are suitable. Both descriptive and analytical methods were used in the statistical analysis. The significance threshold was set at $p < 0.05$.

6. The data taken as a comparison and used to delimit the effectiveness of these methods were:

a. diameter

b. Length

c. Type of prosthetic load

d. Presence or not of concomitant bone grafting

e. Stability factor immediately and at 6 months

The data obtained are extensive and demonstrate the efficiency of using modern methods in predicting the integration of implants and bone grafts. We will briefly present some of these data, their detail being found in the content of the thesis.

A. The classical group It consists of 328 implants that were inserted by the classical method. This method involved the use of classical imaging investigation techniques - orthopantomography, dental computed tomography and free-hand surgical approach, using data from radiological exposures and clinical evaluation at the time of surgery, with adaptation to given conditions.

Implants with an average size of 4 mm in diameter and an average length of 9.5 mm were used in the group. This is within the normal limits given by the physiological limitations of clinical cases.

In this group, out of a total of 328 implants, we chose to prosthetically load only a third of them, mainly for aesthetic reasons, most of these cases belonging to restorations in the frontal group. Late loading was the method of choice because at that time the implantology guides offered as a time of osseointegration, adapted to the implant leaflet, a period of at least 6 months. The immediate prosthetic loading was performed with elastic materials such as acrylate or PMMA and without occlusal contact, so as not to affect in any way the osseointegration process.

Regarding concomitant bone grafting, this was done by choice for situations of increased unilocular postextractional and dimensional defects at the time of implantation. In this group only a very small percentage, 8.23%, benefited from concomitant bone augmentation. This also has the explanation related to the moment of implant therapy, which did not allow through the current available techniques the correct evaluation of the bone defect, but rather the adaptation of the implant size to the existing bone supply. The guides present at that time mentioned as the moment of execution of the bone additions during the implant preoperative period, with a distance of at least 6 months between the procedures. The clinician's choice to augment at the same time comes from simply adapting to the clinical situation existing at the time of implant insertion. Most often they coincide with tooth extraction and post-extraction implantation, at which point the space between the implant and the remaining alveolus must be increased in order to ensure the integration of the implants. It should be noted that most implants used at that time had only a physically and chemically treated surface to increase the degree of bone adhesion. Modern implants have certain substances such as hydroxyapatite, hyaluronic acid and other molecules impregnated on its treated surface.

Despite all the difficulties given by the lack of modern simulation and investigation methods used in current practice, the primary ISQ assessing primary implant stability had the sum of values between 128 and 344, with an average of 256.93, above the average considered in this study as being an indicator of excellent stability. We mention here that a percentage of 93.6% of the implants in this group had an ISQ higher than 200 in the cut-off analysis, which means an excellent percentage. The prediction of this percentage is also maintained by the ISQ measured at the time of prosthetic loading, which was only 5 implants located below the threshold of 200 at the cut-off. So the percentage of stability increased at a rate of 98.47% implants with an average of over 200 at the secondary evaluation of ISQ, the rest of the percentage being represented by implants with poor stability, which were considered implant failure and were replaced.

B. The digital group It is composed of 113 implants that were inserted using basic digital techniques, respectively computer tomography, dental tomography, CBCT, data acquisition through exposure software. The insertion method was free-hand, with adaptation and adjustment at the time of the operator protocol. Implants with an average size of 4 mm in diameter and an average length of 9.5 mm and 11.5 mm were used in the group. These dimensions are within the normal limits given by the physiological limitations of clinical cases, but also by the possibility to analyze a bone volume with the help of CBCT. The greater variation of lengths and the use of longer lengths is an aspect gained by the contribution of the insertion of the modern examination method offered by CBCT. In this group, out of the total of 113 implants, we chose to load only 44 prosthetically, mainly for aesthetic reasons, most of these cases being restorations from the frontal group. Late loading was the method of choice only for cases that required osseointegration, especially in the lateral areas, where the masticatory forces are definitely higher. The possibility of immediate loading, higher than the classic group, is given by the possibility of a minimum simulation using the acquisition software within the CBCT examinations. The immediate prosthetic loading was performed with elastic materials such as acrylate or PMMA and without occlusal contact, so as not to affect in any way the osseointegration process.

Regarding concomitant bone grafting, this was done by choice because the clinical situation was more easily visible by using CBCT, which allowed a clear view of where bone augmentation is required at the same time as implant insertion. A number of 89 implants, ie 78.8% of the total number of cases, benefited from surgically guided bone grafting using primary volumetric simulation using CBCT software. The clinician's choice to augment at the same time as implantation comes from simply adapting to the clinical situation existing at the time of implant insertion. In most cases, they coincide with tooth extraction and post-extraction implantation, at which point the space between the implant and the remaining alveolus had to be increased in order to ensure the integration of the implants. It should be noted here that most implants used at that time had only a physically and chemically treated surface to increase bone adhesion. Modern implants have certain substances such as hydroxyapatite, hyaluronic acid and other molecules impregnated on its treated surface. This greatly contributed to the integration of bone grafts, the implant, through its surface, acting as an osteosynthesis screw. This phenomenon is subsequently observed by a superior integration of dental implants concomitantly with bone grafts applied at the same time as the operator. Despite all the difficulties given by the incipient development of modern simulation and investigation methods used in current practice, the primary ISQ assessing primary implant stability had the sum of values between 140 and 349, with an average of 253.02, above the average considered in this study as an indicator of excellent stability. We mention here that 100 out of 113 implants in this group had an ISQ higher than 200 in the cut-off analysis, which means an excellent percentage. The prediction of this percentage is also maintained by the ISQ measured at the time of prosthetic loading, which was only 7 implants located below the threshold of 200 at the cut-off. So the percentage of stability increased at a rate of 106 implants with an average of over 200 at the secondary evaluation of ISQ, the rest being represented by implants with poor stability, which were considered in this case for re-evaluation and could be loaded prosthetically at a distance. longer time. In this group digitized by incipient modern methods, considerable improvements can be observed, but comparable to the classical method. It was the surgical techniques that made the difference or, rather, reduced the difference between the classic and digital group, by using the same free-hand technique, but which benefited from better pre-operative planning. We cannot draw any beneficial conclusion, but only state that this was the intermediate step between the classical methods of treatment and investigation in the field of implant-prosthetic rehabilitation and the current modern methods that will be highlighted in the discussions about the advanced digital group.

C. Advanced Digitized Group

It is the group that benefited from the highest standards of investigation and simulation at the time of implant insertion. It is represented by 115 implants that have benefited exclusively from advanced CBCT imaging techniques, image processing and rendering software, surgery simulation software, CAD-CAM transposition software and surgical guidelines, integrated guidance service surgical and prosthetic rehabilitation by exclusively digital methods, without using classical methods of fingerprinting and transfer to the dental laboratory.

Implants with an average size of 4.2-4.5 mm in diameter and a length of 10 mm and 13 mm were used in the group. These fall within the upper limits given by the physiological limitations of clinical cases, but also by the possibility of analyzing a bone volume in advance using CBCT and three-dimensional rendering and reconstruction software. The greater variation of the lengths and the use of longer lengths of the implants is an aspect gained by the contribution of the insertion of the modern examination method offered by CBCT and of the rendering and three-dimensional reconstruction software. It should be noted that here, due to the much greater possibilities of simulation and creation of a surgical guide, it was possible to approach large diameters and lengths that are beneficial and indicated for prosthetic restorations with a generous and stable cantiliver over a very long period of time. . Also, the implantation capacities in terms of structure were greatly improved and the possibility of using a torque higher than 50-60 Ncm at insertion was possible. Also, the possibility to identify the details related to bone densities made possible, by three-dimensional rendering and simulation of higher force capacities, the use of larger diameters and lengths of implants, as well as implants with more aggressive coils than bone, or, conversely, more compressive, to achieve osteocondensation at densities higher than D2 or after bone grafting.

In this group, out of the total of 115 implants, we chose to load only 25 prosthetics, mainly for aesthetic reasons, most of these cases belonging to restorations in the frontal group. Late loading was the method of choice for cases that benefited from pre-operative simulation and had to be part of extensive restorations, especially in the lateral areas, where the masticatory forces are definitely higher. The possibility of immediate loading lower than the classical and digital groups is given by the chance of a simulation with the help of the acquisition software within the CBCT examinations, but also by the three-dimensional rendering and the simulation of the prosthetic works and the evaluation of the necessary supporting forces. Immediate prosthetic loading was performed with elastic materials such as acrylate or PMMA and without occlusal contact, so as not to affect in any way the process of osseointegration.

Regarding concomitant bone grafting, this was done by choice for cases where a need or sufficient bone density could not be identified by simulation, as the clinical situation was more easily visible through the use of CBCT, which allowed a clear view. of the place where bone augmentation is required at the same time as the implant is inserted. A number of 36 implants, ie 31.3% of cases, benefited from surgically guided bone grafting by using and volumetric primary simulation using CBCT software. The clinician's choice to augment at the same time comes from simply adapting to the clinical situation existing at the time of implant insertion, but also from the possibility of simulating and performing a surgical guide valid for both implant insertion and bone grafting areas. Most often they coincide with tooth extraction and post-extraction implantation, at which point the space between the implant and the remaining alveolus had to be increased in order to ensure the integration of the implants.

The most important part of the discussions related to the results obtained by using modern methods in advanced implant-prosthetic rehabilitation in order to improve success rates and predictability of results is related to the factors and degrees of primary and secondary stability. The values obtained are statistically different from the first two groups and this gives us the confidence to say that using modern methods in advanced implant-prosthetic rehabilitation to improve success rates and predictability of results is the best way to approach these clinical cases.

As follows, at primary stability we obtained results of variability from 100 to 340, with an average of 288.7 at a standard deviation of 39,198. At the cut-off values, we obtained in 112 out of 115 implants an ISQ higher than 200, which means 97.4% of the total group. At the secondary ISQ measurements, the mean value increased to 318.84, with no cut-off implants below 200. We can say that 100% of the implants inserted using modern methods in advanced implant-prosthetic rehabilitation to improve success rates and predictability of results had the expected effects. The results obtained show that there are significant differences between the classical group and the one that used advanced digital technologies ($U = 10494$; $z = -7.082$; $p < 0.001$; $r = 0.336$), as well as between the digital group versus the one that used advanced digital technologies. ($U = 3588.50$; $z = -5.84$; $p < 0.001$; $r = 0.37$). Therefore, the primary ISQ value is statistically significantly higher in the advanced digitized group compared to the classical one. The same statistically significant results are found in the group that used advanced digital technologies compared to the digital one. The secondary stability index was also subjected to the Mann-Whitney

U test, corrected by the Bonferoni method, and the results showed that there were significant differences between the classical group and the one that used advanced digital technologies ($U = 6102.5$; $z = -10,332$; $p < 0.001$; $r = 0.503$), as well as between the digital group versus the one that used advanced digital technologies ($U = 2686.5$; $z = -7.655$; $p < 0.001$; $r = 0.506$). Therefore, the final ISQ-isq2 value is statistically significantly higher in the group that used advanced digital technologies compared to the classical one. The same statistically significant results are found in the group that used advanced digital technologies compared to the digital one.

The conclusions of the clinical study include a resolution that shows us that modern technologies and the good training of the clinician in this field lead to a better predictability of the integration of implants and bone grafts in implant-prosthetic therapy.

The historical study on the three groups of implants inserted by classical, digital and advanced digital methods shows us that modern implantology is a continuous learning curve based on two very important pillars. The first pillar is represented by the theoretical support, the experience of the clinician, resources that accumulate over time by adapting to all treatment possibilities and all types of clinical situations in oral implant-prosthetic rehabilitation. The second pillar is represented by logistics and technology in a broad, continuous and accelerated process of evolution, which is increasingly adapting to the preferences, knowledge and capabilities of the clinician.

The use of modern methods of investigation, simulation and treatment in order to improve predictability and success rate in osteo-implant integration is the baseline that was the basis for evaluating the implants under study.

After detailed statistical analysis, which used advanced resources and specialized tests of type t test for independent samples, One-Way Anova, Shapiro-Wilk, non-parametric equivalent test Kruskal-Wallis H, Mann Whitney U test, the main consideration, respectively that of obtaining superior results by using advanced digitization, has been demonstrated for the working sample.

The results obtained by using modern methods of investigation, simulation and treatment to improve predictability and success rate in osteo-implant integration are clearly superior to samples that have benefited from classical and digital basal treatment and show us that the increased efficiency of these methods generates guaranteed success. long-term in implant therapy.

Following this study we can conclude that by using modern digital methods the clinician has greater safety and better control of implant therapy, which provides a net improvement in medical practice.

This study can pave the way for many correlations between digital integration and the controlled and simulated development of treatments in the virtual environment and the safety of an error-free medical act.

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