FULL DENTURES REALIZATION -CONVENTIONAL VS DIGITAL TECHNOLOGIES

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Abstract:

The technologies for full dentures realization are almost the same for more than fifty years despite their being associated with many risks of error. In recent years, digital technologies have been increasingly used in dental practice, due to the many advantages it offers. The CAD / CAM technologies, are moving constantly in new directions, to provide exciting, innovative products and systems, with the highest quality standards. Thanks to CAD/CAM technologies, perfect clinical restorations can be achieved, with no secondary reactions and excellent esthetic appearance, through a digital cooperation between dentists and dental laboratories. CAD/CAM technology allows the realization of a well-fitting, aesthetic, and durable prosthetic appliances.

Conventional technologies also have a number of advantages and disadvantages that must be known, and computerized methods have not only advantages but also disadvantages. We cannot notice that there is an ideal technology, but that we can choose, knowingly, the most appropriate method for each clinical case.

The present paper aims to comparatively analyze a series of clinical parameters of conventional complete and CAD-CAM complete dentures.

Keywords: full dentures, conventional technologies, digital subtractive technologies, digital additive technologies

INTRODUCTION

Full dentures is still frequently used in the treatment of complete edentulism because it has a relatively low price and ensures a satisfactory functional restoration. The technologies for removable acrylic dentures realization are the same for more than fifty years despite their being associated with many risks of errors [1,2, 3]. In recent years, digital technologies have been increasingly used in dental practice, due to the many advantages it offers. The CAD / CAM technologies, are constantly moving in new directions, to provide exciting, innovative products and systems, with the highest quality standards.

Thanks to CAD/CAM technologies, perfect clinical restorations can be achieved, with no biological secondary reactions and with excellent esthetic appearance, through a digital cooperation between dentists and dental labs. CAD/CAM technology allows the realization of a well-fitting, aesthetic, and durable prosthetic appliances [3].

A great advantage of digital technologies is a reduced working time and for this reason, it is an increasingly used treatment solution, as most patients want to minimize the number of visits to the dentist's office. CAD / CAM technology has brought the possibility of using new types of biocompatible materials, new dental treatment concepts and a mental and physical comfort for the patient. Also, these new systems allow the elimination of human errors, have very good mechanical strength, ensure an excellent recovery from an aesthetic point of view and have good longevity over time.

The main computerized methods used in practice today are subtractive and additive systems; both technologies offer clinically acceptable results faster than the traditional process. The additive manufacturing technique is more recent and has the advantage that a 3D printer is more affordable than a milling machine [4].

Furthermore, the 3D printing technology is advancing rapidly, with applications in many fields, including dental laboratories. A range of materials are available for the manufacturing of a plethora of products, such as models, parts and complete restorations [5].

Additive manufacturing methods are more efficient than the subtractive ones and are available for a range of tasks, output volumes and laboratory sizes. Selection of the appropriate 3D printer is a complicated task that includes considerations about software compatibilities, printable materials and services provided by the manufacturer. The milling machines, on the other hand, have been on the market for a longer period and the customers are more likely to be familiar with the available options.

Accuracy for both techniques seem to be acceptable, however 3D printing might present a higher variance [6]. The additive manufacturing technique is evolving and several parameters that seem to affect accuracy need to be addressed. The orientation of the printed denture base, for instance, seems to affect the accuracy of the resulting product with some additive techniques [7].

The main disadvantage of these digital technologies is that the initial cost of equipment and software is still very high, and practitioners who are unable to achieve a sufficient volume of restorations will need a long time to recover the investment. An important goal includes reducing unit cost and making affordable restorations and appliances that otherwise would have been prohibitively expensive.

Conventional technologies also have a number of advantages and disadvantages that must be known, and computerized methods have not only advantages but also disadvantages. We cannot say that there is an ideal technology, but that we can choose, knowingly, the most appropriate method for each clinical case.

The present paper aims to comparatively analyze a series of clinical parameters of conventional total prostheses and total prostheses made by additive and subtractive CAD-CAM methods.

MATERIAL AND METHODS

In the present study we compared the characteristics of full dentures made by conventional and digital methods. For this

purpose, we realized, in a first stage, 10 complete bi-maxillary dentures from Superacryl Plus heat-curing acrylic resin (Spofa Dental), following the classic algorithm of realization: preliminary impression, preliminary model, custom tray and functional impression registration. (fig.1)

Fig.1 Functional impression

Based on the functional impressions, the secondary model cast were made, on which the dental technician realized the occlusal rims; after the intraoral recording of the inter-maxillary relations, the models are mounted in the articulator and the wax-up of the full denture are made. (fig.2).

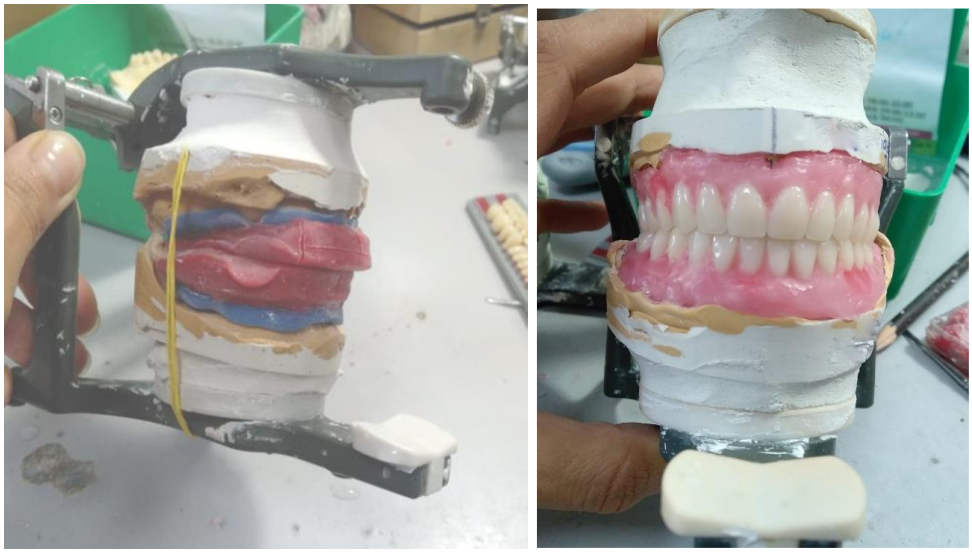

Fig. 2 The wax-up of the full dentures

After final wax contouring, the next steps consisted of flasking and packing; the resin paste was prepared by mixing the powder with liquid and it was introduced into the mold; the metal ring were placed in a water bath at a temperature of 65 ° C, where they were kept for 60 minutes, the temperature being controlled with a thermometer and staggered in time; after

60 minutes, the water temperature rose to 100 ° C, where the rings were kept for 60 minutes. After slow cooling, the prostheses are removed from the mold, finished and polished.

Fig.3 the finishing and polishing step

The technician will make a final check of the prostheses, after which they are decontaminated and sent to the office for intraoral verification and adaptation (fig.4).

Fig.4 Intraoral verification

The next step was to make 10 prostheses using digital methods; 6 prostheses being made by the 3 D Printing method and 4 by the subtractive CAD-CAM method

For the additive technology, the clinical-technological flow of making the complete dentures involves several stages: scanning, designing, STL file output, printing and post processing, assembly, final post cure and finishing.

A preliminary impression was registered, and the technician made the custom tray, used for the functional impression. After the secondary model was realized, it was scanned in a scanning chamber (fig.5).

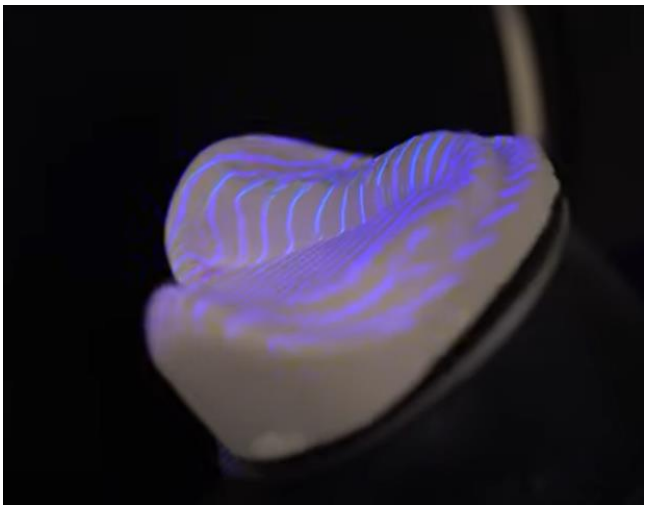

Fig.5 The virtual model

Thus, a virtual model was obtained on which the design of the future complete denture was elaborated. The teeth area is selected for the digital denture, depending on the desired morphology, size and color; also, the shape and color of the false gingiva will be chosen. Then, it was selected the option to produce the base and teeth as separate manufacturing files, because this is ideal for 3D printing full dentures (fig.6).

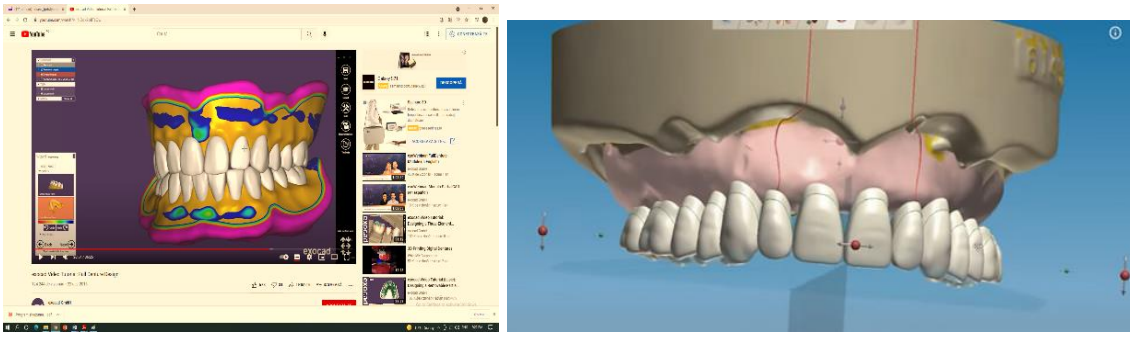

Fig.6 The design of the denture

After STL File Output, follows the stage of printing and Post processing. Once the STL files for denture design are exported, it can be imported the file into the software that contains files for printing and the material for printing denture -teeth or denture base- can be selected.

After the resin is inserted in to a resin tank, printing can be started. 3D printing consists in inserting a platform for making the proposed prosthetic works in a bath with light-

curable liquid resin, on which a uniform layer of micrometric-sized resin is deposited, according to the CAD program 3D design. Once this first layer of material has been polymerized, the procedure is continued by the successive layered deposition and polymerization of fluid resin until the final form of the prosthetic appliance is realized. The 3D printed device is connected to the manufacturing platform by some support elements of the same type of resin; thus, the post-processing stage follows, which involves washing under running water and removing the support structures (fig.7).

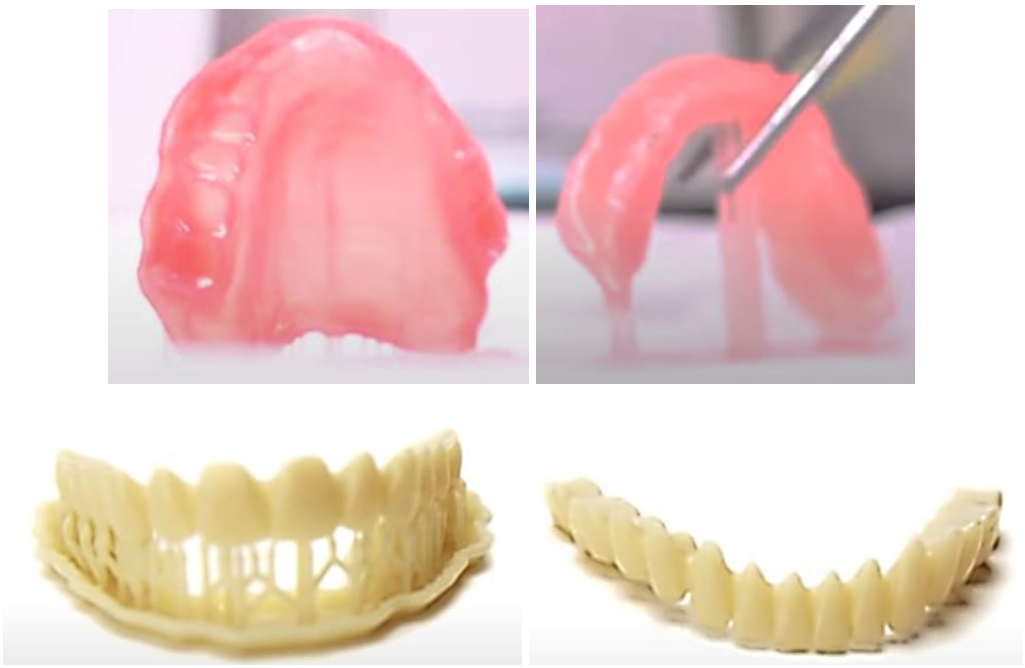

Fig.7

For printing we used the Form 3B printer (Formlabs), which uses an advanced printing process called Low Force Stereolithography, which drastically reduces the printing process. In the subsequent assembly step, the teeth are inserted and bonded into the saddles. At this point, the denture is ready for the final post-cure, at 80 ° C for 30 minutes. For post-cure we used the Form Cure equipment; after post-curing procedure is complete, the finishing step follows, in the same way as for a conventional denture (fig.8).

Fig.8 3D Printed full denture after finishing

The prostheses are disinfected and sent to the dental office for adaptation into the oral cavity (fig.9)

Fig.9 Intraoral adaptation

The third digital technology used for this study was the subtractive CAD-CAM method; the working flow consisted in scanning the functional model, creating a virtual model and establishing the design of the full dentures. The information was sent to the milling unit, where the base of the prostheses and the artificial dental arches are made. (fig.10).

Fig.10 The Milling step

For milling we used Polident Pink CAD-CAM discs, which allow obtaining highly aesthetic and functional dentures. At the end of the stage, the prostheses are polished, disinfected and sent for adaptation in to the dental office (fig.11).

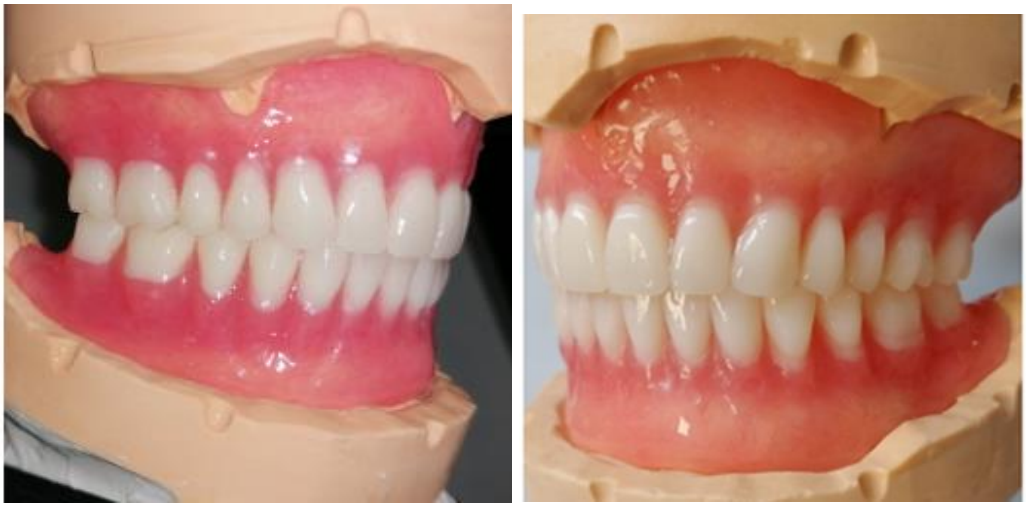

Fig.11 Prosthesis final check

In order to comparatively analyze these prostheses realized by these technologies, we monitored the surface quality, intraoral adaptation, maintenance and stability, static and dynamic occlusion parameters and the degree of functional recovery, immediately after applying prostheses into the oral cavity, six months after treatment and 12 months after treatment.

Patients were trained on oral hygiene measures as well as on complete denture hygiene and maintenance measures. They were also asked to report to the dentist any changes on the prostheses or prosthetic area or any inconvenience in wearing the device.

For the analysis of the followed criteria we established a scale of appreciation and we noted with:

A = Very good -no negative findings
B = Good (1 negative finding)
C = Satisfactorily (2 negative findings)
D = Poor (3 or more negative findings; clinically satisfactory)
E = Clinically unsatisfactory

RESULTS AND DISCUSSION

After the application of prostheses in the oral cavity, absolutely all patients who benefited from prostheses made by digital methods were extremely satisfied because the treatment sessions in the dental office have been greatly reduced. Full dentures realized by conventional methods presented excellent characteristics, both in the initial stage and in the control stage at six months; instead, after 12 months of application; there were a series of changes in the parameters, which did not require the restoration of these prosthetic devices (fig.12)

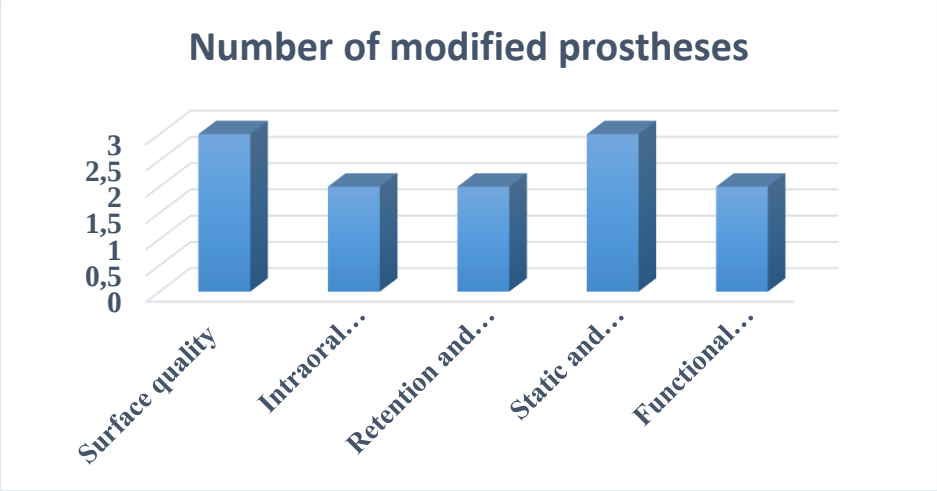

Fig.12 Prosthesis parameters made by conventional methods

Systematizing the clinical results of conventional prostheses, we can see that over a period of about a year, the properties of complete dentures have not changed substantially and the functional recovery is still good (Table I).

Table I The characteristics of conventional prostheses

Conventional prosthesis characteristics	**Initial**	**Clinical examination at 6 months**		**Clinical examination at 12 months**
Surface quality	**A**	**A**		**A**
Intraoral adaptation	**A**	**A**		**B**
Retention and stability	**A**	**A**		**B**
Static and dynamic occlusion	**A**	**A**		**B**
Functional restoration	**A**	**A**		**B**

Of the 4 prostheses made by subtractive technologies, two had problems of immediate intraoral adaptation step, which could be remedied in the dental office; at 6 months and 12 months of control we also found problems with retention, stability and changes in occlusal contacts. Absolutely all prostheses have kept their surface characteristics (fig.13).

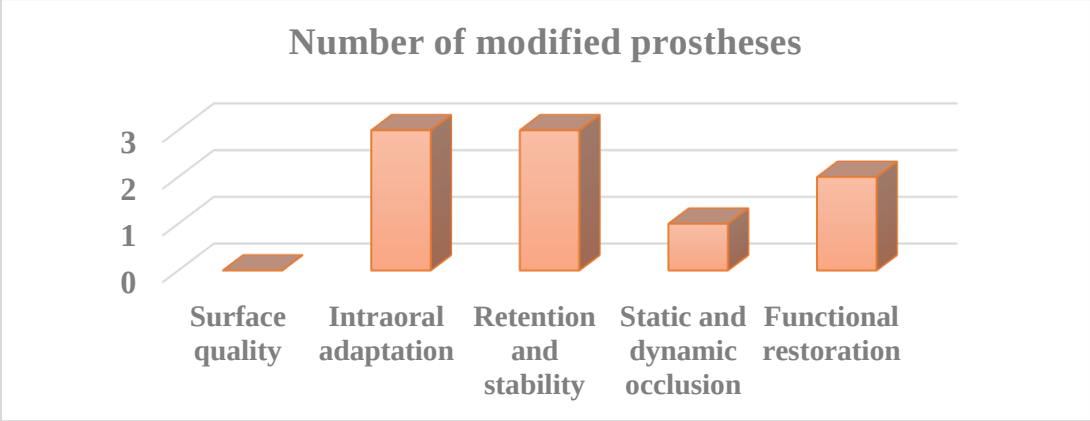

Fig.13 Prosthesis parameters made by CAD/CAM subtractive method

The results of clinical examinations during the study are systematized in the tablel II.

Table II The characteristics of CAD/CAM subtractive prostheses

Dentures made by the subtractive method	**Initial**	**Clinical examination at 6 months**	**Clinical examination at 12 months**
Surface quality	**A**	**A**	**A**
Intraoral adaptation	**B**	**A**	**A**
Retention and stability	**A**	**B**	**B**
Static and dynamic occlusion	**A**	**B**	**B**
Functional restoration	**A**	**A**	**A**

The complete dentures made by 3 D Printing technologies had excellent characteristics both in the initial adaptation stage and in the clinical examination 6 months after treatment. Clinical examination one year after prosthesis application revealed minor changes in retention and stability,
in 2 of the 6 prostheses and changes in dynamic occlusion in one prosthesis. (fig.14)

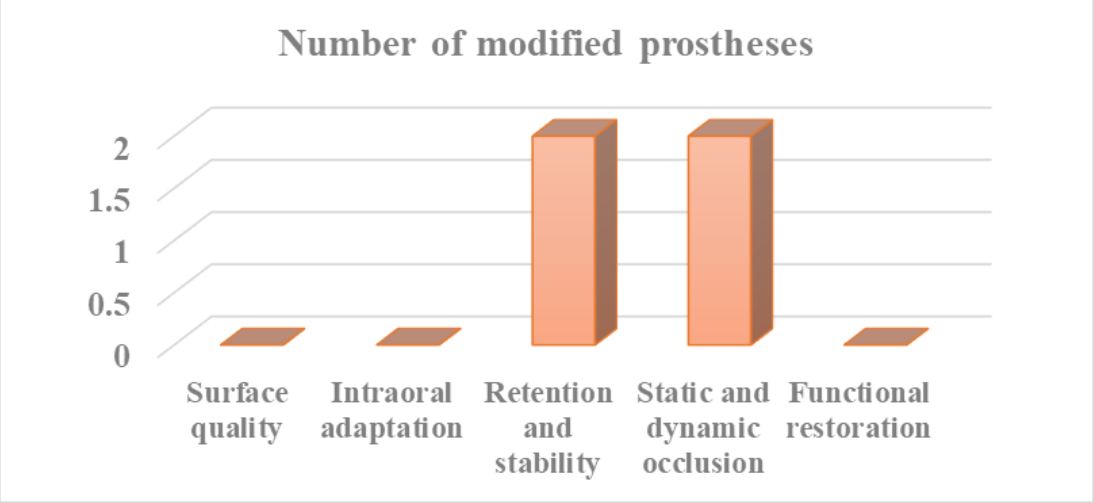

Fig.14 Prosthesis parameters made by CAD/CAM additive method

Table III systematizes the results of clinical analyzes during the study, in the case of digital prostheses made by additive methods.

Table III The characteristics of CAD/CAM additive prostheses

Dentures made by the additive method	**Initial**	**Clinical examination at 6 months**	**Clinical examination at 12 months**
Surface quality	A	A	A
Intraoral adaptation	A	A	A
Retention and stability	A	A	B
Static and dynamic occlusion	A	A	A
Functional restoration	A	A	A

The results show that all types of prostheses keep their surface characteristics, without significant alterations throughout the study. However, the resins used in computerized technologies are industrially produced, have a high resistance to impact and distortion, resistance to blanching, color stability and dimensional stability The pre-polymerized acrylic resin are produced under high pressure and heat and polymerization shrinkage does not occur, porosity is decreased, and the microbial adherence to the denture base is decreased. Also, the CAD/CAM denture base milled from poly-methyl methacrylate discs, polymerized on high temperature and pressure have been reduced the risk of residual monomer, which is responsible for local and general toxicity, inflammation of the oral mucosa, inferior mechanical properties [9,10,11] and porosity [11, 12, 13];

Prostheses made by subtractive CAD-CAM technologies have presented a poorer marginal adaptation and a lower maintenance and stability than conventional prostheses and those made by 3D Printing method.

Compared to the subtractive CAD-CAM technology for the elaboration of prosthetic appliances based on computer-controlled milling, 3D printing offers the advantage of unlimited design flexibility, the elaboration of the prosthetic device being realized in a few single steps [4]. The quality and durability is comparable to those of conventionally produced dentures, often even superior, because these technologies allow the use of modern materials, with optimized mechanical and biological characteristics [15,16,17].

In our study, the virtual models were obtained by scanning the functional models made in the dental laboratory. In future studies we propose to make an optical impression of the prosthetic field, in order to eliminate the stage of making the conventional model9 of plaster. We will be able to follow if the digital recording of the prosthetic field offers a higher accuracy and if the clinical results will be superior in this case.

CONCLUSIONS

Digital denture process represents an opportunity in the digital design and manufacture of complete removable dentures; is mandatory to know the stages of realization and the advantages of conventional prostheses, but, at the same time, it is necessary to know the benefits of modern technologies, in order to adapt the therapeutic solutions to the particularities of each clinical situation

CAD/CAM has improved the quality of prostheses in dentistry and found a way to standardize the production process. It has increased productivity and the chance to work with new materials with a high level of accuracy. It has also found a way to de-crease chair time for the patient by the use of intra-oral scanning systems which allow the dentist to send electronic impressions to the lab.

Although clinical studies presented patient satisfaction using this technique, further groundwork is required with regards to the stability and comfortable design of the 3D-printed prosthetic restorations

The treatments can be done in conditions of comfort and total safety for the patient, with more precision and in a very short time; overall patient satisfaction will increase significantly [7].

Given that the three categories of total prostheses have a similar behavior over time, we can conclude that digital methods become a viable alternative to conventional methods in making full dentures

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