Journal of IMAB
ISSN: 1312-773X
https://www.journal-imab-bg.org

Review article

APPLICATION OF DIGITAL TECHNOLOGIES FOR COMPLETE DENTURES

Yordanka Donkova, Desislava Konstantinova, Delyan Georgiev.
Department of Dental Material Science and Prosthetic Dental Medicine, Faculty of Dental Medicine, Medical University - Varna, Bulgaria.

ABSTRACT

Introduction: The daily practice shows that the patients prefer treatments that require fewer visits and low cost. The technology of conventional complete dentures follows several subsequent stages – clinical and laboratory. The search for alternative methods has led to the more and more successful development of digital technologies that could also be used for complete dentures. The conclusions of their use include higher quality, simplification of the laboratory technologies, and creation of functionally fit prosthetic structures.

Purpose: The purpose of this research is to systematically review the up-to-date information available in the scientific databases in regard to the implementation of CAD/CAM technologies for the complete prosthesis.

Materials and methods: A search was carried out in the period from January 2022 to October 2022 in the electronic databases PubMed, Google Scholar and ScienceDirect, using the following keywords: CAD/CAM, digital prosthesis, complete dentures, planning of complete dentures, edentulous patients, in English, German, Turkish and Bulgarian language.

Conclusion: The individual anatomic and morphological particularities, age and functional changes occurring after the complete loss of teeth create conditions for the prosthesis that cannot be unified according to the scientific literature. Most probably, this is the reason why there is no straight protocol and straight technology for producing complete dentures using the digital method.

Keywords: CAD/CAM, Digital dentures, Complete denture, Denture design, Edentulous patient,

BACKGROUND:

The CAD/CAM technology is increasingly successfully integrated into producing unremovable prostheses and total dentures. [1] According to Nadim, the entire design and production using this method increases the quality of the dentures and optimizes the time-consuming laboratory procedures. [2]

The first information about CAD/CAM technologies can be found in the literature from the mid-80s of the XXth century. [3] It states that the inclusion of the digital component demonstrates an increase in the predictability of the result from the treatment decrease in the clinical time and number of patient visits. [4] Together with the development of technologies, more and more biocompatible materials are used in the production process for the fabrication of digitalized dentures. [5]

Additional security when using the CAD/CAM technologies also comes from the possibility for visual assessment of the dentures and the creation of electronic registers with patient files containing all clinical and paraclinical data, photos and treatment plan. [6]

The use of CAD/CAM technologies allows the production of complete dentures based on the information received through intraoral scanning of the prosthesis area or indirectly – through a laboratory scanning of the conventional impression or model. Additive or subtractive methods [6, 7].

PURPOSE:

The purpose of this research is to systematically review the up-to-date information available in the scientific databases in regard to the implementation of CAD/CAM technologies for the complete prosthesis.

MATERIALS AND METHODS:

A search was carried out in the period from January 2022 till October 2022 in the electronic databases PubMed, Google Scholar and ScienceDirect, using the following keywords: CAD/CAM, digital prothesis, complete dentures, planning of complete dentures, edentulous patients, in English, German, Turkish and Bulgarian language. The total number of publications accessible was 326. In the way of adding an additional criterion – the period of issuing after 2000, the selection covered 158 publications. With the use of another additional indica-

tor – the keyword „complete denture with cadcam“ 26 publications were selected and analyzed.

REVIEW RESULTS:

The CAD/CAM technology for complete dentures fabrication

The first scientific report on this topic was issued by c, who, in 1994, described the technology for the fabrication of complete dentures from photopolymerizing composite resin through fast prototyping. [8]

A few years later, in 1997, Kawahata et al. examined for the first time the possibility of digital doubling of already existing dentures and their subsequent milling. [4]

In 2013 Kattadiyil MT, et al. described two methods for the fabrication of complete dentures using the CAD/CAM technologies (AvaDent and Dentica). For the creation of the virtual maxillary and mandibular model, on which the base is formed, and teeth are arranged. Dentica uses its own software. The so fabricated structure is finished using conventional techniques. For AvaDent, the dentures are milled by polymerized rollings from ÐÌÌÀ after scanning and processing using suitable software. [9]

Infante et al. (2014) describe a different technique for the fabrication of CAD/CAM dentures. Using the anatomic measuring device (AMD) – a thermoplastic tray, which is placed in hot water (77!), the model is formed, and the dentist can make clinical records in one room. AMD allows the clinician to gather the whole clinical information necessary using an intraoral device. The virtual denture is fabricated without the use of conventional gypsum models. The dentures described by the AvaDent company are produced in the way of machine processing of prepolymerized rollings from plastic. The process is carried out under high pressure and high temperature, thus preventing a subsequent shrinkage of the final milled prosthesis. The result of using the ready-made ÐÌÌÀ blocks is that the quantity of the free monomer is decreased, as well as the porosity of the polymer, in comparison to the conventionally processed dentures; and prevents the holding of Candida albicans on the denture's base. Teeth of acrylic plastic are used, which are not fabricated using the ÑÀD/CAM technology but are chemically joined to the base using a special bond under pressure and high temperature. [10]

Two modern methods for the fabrication of complete dentures – milling and 3D printing, were described by Bilgin SM, et al. in 2015m with the following sequence: after taking an analogue impression and determining the vertical size of the occlusion, the occlusion patterns are scanned using a digital machine. The dental arches are fabricated through milling or 3D printing. The next stage includes wax fixing to the base, and they are finished using conventional technology. According to the authors, these methods allow the achievement of good aesthetic design with improved firmness of the teeth, accuracy, and the working time is reduced. [11]

Kattadiyil MT, et al., in 2015, compare the results obtained during a prosthetic treatment carried out by dental medicine students on edentulous patients. The complete dentures are fabricated using conventional and digital technologies. The digital process appeared to be shorter in comparison to the conventional method for denture fabrications. The digital prosthesis is a preferred method by the dental medicine students at Loma Linda University School of Dentistry, California. [12]

Two digital techniques for the fabrication of complete dentures are compared in research carried out in 2016 by Schwindling et al. The first technique is milling of the polymethylmetacrylates block, and the other one – injection moulding. After taking the polyvinylsiloxane impressions and digitalization, the comparison analysis is carried out about the following indicators – aesthetics, compliance with the prosthesis area through overlaying of the image, accuracy of the intermaxillary relation, retention on the area and optimal occlusion. The results reported by the authors do not show significant differences in functional and aesthetic aspect of using both techniques. [13]

According to research carried out in 2016 by Goodacre BJ et al., the process of the fabrication of denture bases using CAD-CAM is the most precise and reproductive technique for fabrication in comparison to the other techniques for packing and pressing, casting and injecting of the denture base. Loma Linda University School of Dentistry, Loma Linda, California[14]

Kattadiyil MT, et al., in 2017, reported improved retaining and reduction of the clinical time for the complete milled dentures in comparison to the conventional ones. The additional advantage is the possibility of digital archiving of data. [15]

Ohkubo et al., in 2017, reported the use of CAD software for designing complete dentures, based on the concept of neutral area, after piezography. Using the printed piezography tray, the particularities of the prothesis area are recorded using the polyvinylsiloxane impression materials in three viscosities. The first stage uses the dough consistency of the impression material placed in the area from premolars to molars. The patient pronounces several sounds audibly, and the base of the piezography tray is formed. Then, the impression material of average liquidity is placed in the area of the canine teeth and on the preliminary formed area. Pronouncing the same sounds follows. Using the already prepared tray, the final impression is taken with silicon of creamy consistency. Using CAD software, the artificial teeth are arranged, and the denture edges are modelled. The fabricated complete dentures are physiologically adapted to the muscle movements in the mouth cavity, the tongue and lips. [16]

In 2018 Wimmer et al., reported that for digitally fabricated dentures, the manual arrangement of teeth on the denture base could result in deviations from the planned arrangement. Five sets of wax prototypes are fabricated (upper and lower denture) using digital and the conventional method. For conventionally fabricated dentures, a silicon key is used from the milled prototype dentures for standardizing the wax quantity. After scanning and overlaying of images, the deviations between the den-

ture bases, fabricated as per the different technologies, are measured. [17] The deviations are bigger in the area of the denture bases for the conventional technology in comparison to those fabricated using the combined conventional and digital stages. The milled wax bases show better linear and volume stability in comparison to the conventionally fabricated wax patterns.

In 2019 Fang et al., describe a digital system for generating edentulous models with the correlation between the jaws in the way of direct intraoral scanning. It also includes the virtual registration of the bite. The method and the models created using this system may be used for the fabrication of complete dentures for edentulous patients. [18]

Srinivasan et al., based on a randomized study in 2021, compare the differences between the milled and the 3D-printed whole teeth dentures. The results show that both types of dentures are suitable for the treatment of complete edentulism, but the 3D-printed ones have disadvantages in regard to the duration of the fabrication and the costs required for the subsequent care of the denture. [19]

In 2021 Lucio Lo Russo et al., describe a comprehensive digital protocol for the fabrication of complete dentures. They include intraoral scanning, without physical models; with integrated partial and complete registrations of the soft-tissue profile of the person at the design process. The goal is to achieve the optimal arrangement of teeth. [20]

Aboheikal et al., in 2022, carried out research that compared the patients' satisfaction in regard to retaining their complete dentures during the follow-up examination after six months. The dentures are fabricated using three methods – printing, milling and the conventional method. The analysis of the results does not show statistically significant differences in satisfaction regarding the retaining of complete dentures depending on the fabrication technique. [21]

In 2022 Mubaraki et al., assess the qualities of the digital and conventionally fabricated complete dentures about the following criteria: fitting and retention to the denture area, clinical and laboratory time and satisfaction of patients of the three medical and biological criteria – preventive, functional and aesthetic. The authors report the various advantages of the CAD-CAM dentures, including a smaller number of visits, the possibility for data archiving, improved mechanical qualities of the materials used. [22]

Goodacre et al., 2022 describe the advantages of the dentures fabricated as per the additive technologies: lower prices of the 3D printers in comparison to the expensive milling machines,the possibility for sophisticated design, decreased quantity of waste products and option for fabrication of several dentures, simultaneously. The disadvantages in comparison to the milled and conventional ones include reduced bend and break strength, colour instability and adapting of the denture base. [23]

In 2022 Maniewicz et al., carry out clinical research and also compare bases of complete dentures fabricated using the CAD-CAM technology and the conventional method. The authors report that there is no significant difference in regard to the retention and fitting of denture bases produced conventionally and digitally. The testing of denture bases in artificial saliva again does not show statistically significant differences in regard to denture retention and stability. [24]

In 2022 Schubert et al., in their research report, the fitting of dental bases for complete dentures fabricated through additive, subtractive and conventional technologies. The physical bases of the complete dentures are fabricated after scanning 12 doubled gypsum models using different technologies: milling, ink-jet print, selective laser sintering, stereolithography and injection molding. The results achieved through digital overlaying of bases on the surface of the scanned models and the statistical analysis show significantly better fitting to the denture area of the milled bases in comparison to the other methods. [25]

Soeda et al., in 2022, described a different technique for the fabrication of complete dentures. A self-polymerizing resin is placed in a factory disk, used as a frame. The artificial teeth are affixed through chemical polymerization under pressure and high temperature. After polymerization of the resin in the disk, with included teeth, the denture is milled. Thus, the fabricated dentures have a rigid joining of base and teeth, similar to that of conventional dentures. The same dependence is present in relation to the colour stability and accumulation of plaque. The fitting to the denture area is good due to the lack of polymerizing shrinkage, as the milling is done when the polymerization of the material is completed. [26]

CONCLUSIONS:

The successful fabrication, retention and stabilization of functionally fit complete denture is a challenge for the digital methods for the treatment of edentulous patients. The individual anatomic and morphological specifics, age and functional changes occurring after the complete edentulism create conditions for prosthesis, which cannot be unified according to the modern scientific literature. Probably, this is the reason why there is no straight protocol for work and straight technology for the fabrication of complete dentures using a digital method. The lack of sufficient experience in this field and the overcoming of various differences in the fabrication of complete dentures through digital technologies leads to uncertain and unpredictable final results.

REFERENCES:

1. Gruber S, Kamnoedboon P, Özcan M, Srinivasan M. CAD/CAM Complete Denture Resins: An In Vitro Evaluation of Color Stability. *J Prosthodont*. 2021 Jun;30(5):430-439. [PubMed]

2. Baba NZ. Materials and processes for CAD/CAM complete denture fabrication. Current Oral Health Rep 2016;3:203-8. [Crossref]

3. Prajapati A, Prajapati A, Mody, Choudhary A. Dentistry Goes Digital: A Cad-Cam Way- A Review Article. *IOSR- JDMS*. 2014; 13(8):53-59. [Crossref]

4. Bidra AS, Taylor TD, Agar JR. Computer-aided technology for fabricating complete dentures: systematic review of historical background, current status, and future perspectives. *J Prosthet Dent*. 2013 Jun;109(6):361-6. [PubMed]

5. Schweiger J, Güth JF, Edelhoff D, Stumbaum J. Virtual evaluation for CAD-CAM-fabricated complete dentures. *J Prosthet Dent*. 2017 Jan; 117(1):28-33. [PubMed]

6. Zhou YS, Sun YC, Wang Y. Clinical application and research progress of digital complete denture. *Hua Xi Kou Qiang Yi Xue Za Zhi*. 2021 Feb 1;39(1):1-8. [PubMed]

7. Wang C, Shi YF, Xie PJ, Wu JH. Accuracy of digital complete dentures: A systematic review of in vitro studies. *J Prosthet Dent*. 2021 Feb; 125(2):249-256. [PubMed]

8. Maeda Y, Minoura M, Tsutsumi S, Okada M, Nokubi T. A CAD/CAM system for removable denture. Part I: Fabrication of complete dentures. *Int J Prosthodont*. 1994 Jan-Feb;7(1):17-21. [PubMed]

9. Kattadiyil MT, Goodacre CJ, Baba NZ. CAD/CAM complete dentures: a review of two commercial fabrication systems. *J Calif Dent Assoc*. 2013 Jun;41(6):407-16. [PubMed]

10. Infante L, Yilmaz B, McGlumphy E, Finger I. Fabricating complete dentures with CAD/CAM technology. *J Prosthet Dent*. 2014 May;111(5):351-5. [PubMed]

11. Bilgin MS, Erdem A, Aglarci OS, Dilber E. Fabricating Complete Dentures with CAD/CAM and RP Technologies. *J Prosthodont*. 2015 Oct;24(7):576-579. [PubMed]

12. Kattadiyil MT, Jekki R, Goodacre CJ, Baba NZ. Comparison of treatment outcomes in digital and conventional complete removable dental prosthesis fabrications in a predoctoral setting. *J Prosthet Dent*. 2015 Dec;114(6):818-25. [PubMed]

13. Schwindling FS, Stober T. A comparison of two digital techniques for the fabrication of complete removable dental prostheses: A pilot clinical study. *J Prosthet Dent*. 2016 Nov; 116(5):756-763. [PubMed]

14. Goodacre BJ, Goodacre CJ, Baba NZ, Kattadiyil MT. Comparison of denture base adaptation between CAD-CAM and conventional fabrication techniques. *J Prosthet Dent*. 2016 Aug;116(2):249-56. [PubMed]

15. Kattadiyil MT, AlHelal A. An update on computer-engineered complete dentures: A systematic review on clinical outcomes. *J Prosthet Dent*. 2017 Apr;117(4):478-485. [PubMed]

16. Ohkubo C, Shimpo H, Tokue A, Park EJ, Kim TH. Complete denture fabrication using piezography and CAD-CAM: A clinical report. *J Prosthet Dent*. 2018 Mar;119(3):334-338. [PubMed]

17. Wimmer T, Eichberger M, Lümkemann N, Stawarczyk B. Accuracy of digitally fabricated trial dentures. *J Prosthet Dent*. 2018 Jun; 119(6):942-947. [PubMed]

18. Fang Y, Fang JH, Jeong SM, Choi BH. A Technique for Digital Impression and Bite Registration for a Single Edentulous Arch. *J Prosthodont*. 2019 Feb;28(2):e519-e523. [PubMed]

19. Srinivasan M, Kalberer N, Fankhauser N, Naharro M, Maniewicz S, Müller F. CAD-CAM complete removable dental prostheses: A double-blind, randomized, crossover clinical trial evaluating milled and 3D-printed dentures. *J Dent*. 2021 Dec; 115:103842. [PubMed]

20. Lo Russo L, Salamini A, Troiano G, Guida L. Digital dentures: A protocol based on intraoral scans. *J Prosthet Dent*. 2021 Apr;125(4): 597-602. [PubMed]

21. Abo Heikal MM, Nabi NA, Elkerdawy MW. A study comparing patient satisfaction and retention of CAD/CAM milled complete dentures and 3D printed CAD/CAM complete dentures versus conventional complete dentures: a randomized clinical trial. *Braz Dent Sci.* 2022 Jan-Mar; 25(1):e2785. [Crossref]

22. Mubaraki MQ, Moaleem MMA, Alzahrani AH, Shariff M, Alqahtani SM, Porwal A, Al-Sanabani FA, Bhandi S, Tribst JPM, Heboyan A, Patil S. Assessment of Conventionally and Digitally Fabricated Complete Dentures: A Comprehensive Review. *Materials (Basel)*. 2022 May 28; 15(11):3868. [PubMed]

23.Goodacre BJ, Goodacre CJ. Additive Manufacturing for Complete Denture Fabrication: A Narrative Review. *J Prosthodont*. 2022 Mar; 31(S1):47-51. [PubMed]

24. Maniewicz S, Imamura Y, El Osta N, Srinivasan M, Muller F, Chebib N. Fit and retention of complete denture bases: Part I e conventional versus CAD/CAM manufacturing methods: A clinical controlled crossover study. *J Prosthet Dent*. 2022. [Crossref]

25. Schubert O, Edelhoff D, Erdelt KJ, Nold E, Güth JF. Accuracy of surface adaptation of complete denture bases fabricated using milling, material jetting, selective laser sintering, digital light processing, and conventional injection molding. *Int J Comput Dent*. 2022 Jul 19;25(2):151-159. [PubMed]

26. Soeda Y, Kanazawa M, Arakida T, Iwaki M, Minakuchi S. CAD-CAM milled complete dentures with custom disks and prefabricated artificial teeth: A dental technique. *J Prosthet Dent*. 2022 Jan;127(1):55-58. [PubMed]

Please cite this article as: Donkova Y, Konstantinova D, Georgiev D. Application of digital technologies for complete dentures. *J of IMAB.* 2023 Jul-Sep;29(3):5031-5035. [Crossref - https://doi.org/10.5272/jimab.2023293.5031]

Received: 08/02/2023; Published online: 21/07/2023

Address for correspondence:
Yordanka Donkova
Department of dental material science and prosthetic dental medicine, Faculty of Dental Medicine, Medical University - Varna;
84, Tzar Osvoboditel str. Varna 9000, Bulgaria
E-mail: daniddonkova@gmail.com,