SURVEY FOR THE APPLICATION OF 3D PRINTED REMOVABLE DENTURES

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Introduction: Removable dentures are still the primary treatment method used by dentists in Bulgaria. The introduction of additive technologies in the fabrication of dentures is expected to modernize and streamline the fabrication, the work process, and the materials used.

Purpose: The purpose of the survey is to determine how familiar the dentists in Bulgaria are with additive technologies, as well as whether they apply these methods in their clinical practice.

Materials and methods: An anonymous survey was conducted, and 184 general practitioners and specialists participated. The questionnaire includes 13 questions in writing and online form, which are related to 3D printing in prosthetics.

Results: A total of 184 practitioners were surveyed of which 92 (50%) were men and 92 (50%) were women. 61% of them have more than 10 years of clinical experience, and 39% have less than 10 years. Respondents who have attained a specialty in the field of Prosthetic dental medicine are 10%, while the general practitioners are 90%. 94% of respondents with less than 10 years of clinical experience, 83% of those with more than 10 years of experience, 75% of the specialists and 88% of the non-specialists are familiar with three-dimensional printing. However, 80% of the respondents believe that 3D printing is becoming more popular, while only 37% believe it will replace conventional methods and be more precise.

Conclusion: According to the obtained results, it can be claimed that Dentists in Bulgaria are familiar with 3D printing, but most of them are still skeptical and do not find 3D printing a good enough alternative to conventional methods.

Key words: 3D printed dentures, Additive manufacturing, Survey

Introduction

Despite the development of preventive dentistry and numerous innovations in this field, a large part of the adult population suffers from partial or complete edentulism (1,2) and removable dentures are still widely used by the dental practitioners in Bulgaria (3-5).

The development of new technologies in dentistry in response to improving the quality of life for patients with removable prostheses also stimulates the development of new materials and methods (6-8). The introduction of CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing) technologies in the rehabilitation of patients with removable dentures is expected to overcome some disadvantages associated with conventional methods and to simplify the overall process of their production - clinical and laboratory stages (9-11). 3D printing has the potential to modernize and streamline conventional manufacturing technologies, the materials, and the workflow (12). Unquestionable advantages are the reduction of clinical and laboratory time (13), quality control and reduction of the subjective factors (14). Although there is an increasing use of additive technologies in dental medicine, certain disadvantages of the materials and the production process are also reported (15).

Purpose

This survey aims to determine how familiar the dentists in Bulgaria are with additive technologies for the production of removable prostheses, as well as whether they apply these methods in their clinical practice.

Materials and methods

An anonymous and voluntary survey was conducted, and 184 general practitioners and specialists participated of which 168 were general practitioners and 16 were specialists in Prosthetic Dentistry. The questionnaire included 13 questions related to 3D printing in prosthetics and responses were collected both on paper and electronically through an online dental medicine forum.

Results

After analysing the collected data some conclusions can be made about the knowledge of dental practitioners on additive technologies and their opinion of the advantages and disadvantages.

A total of 184 dental practitioners were surveyed, of which 92 men (50%) and 92 women (50%) (Fig.1). According to age, they are divided into three main groups - under 30 years, between 30 and 60 years and over 60 years. The largest group is 30-

60 years old - 75%, under 30 years old - 15% and the least are the respondents over 60 years old - 10%.

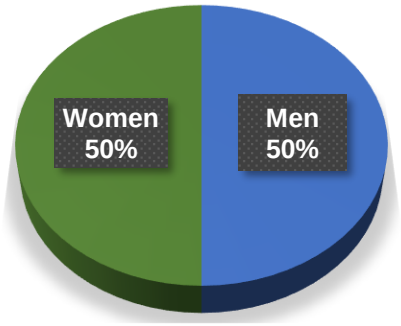

Figure 1. *Distribution of respondents by gender*

According to clinical experience, dentists are divided into two groups - with clinical experience over and under 10 years. Dentists with more than 10 years of clinical practice are 112 (61%), compared to those with less than 10 years of experience – 72 (39%) (Fig.2).

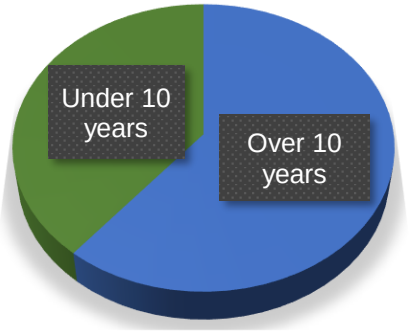

Figure 2. *Distribution of respondents by clinical experience.*

Practitioners who have attained a specialty in the field of Prosthetic dental medicine are 16(10%) while the general practitioners are 168 (90%)(Fig.3).

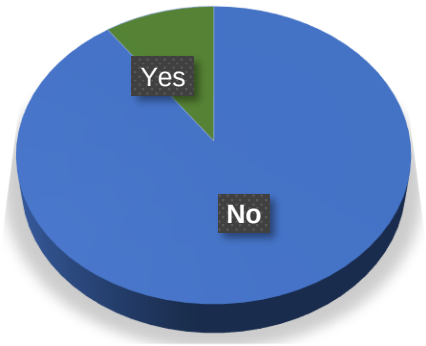

Figure 3. *Distribution of respondents by specialty*.

Figure 4 shows the respondent's responses to how familiar they are with 3D printing (Question №1). A total of 87% of respondents said that they have some knowledge about three-dimensional printing, 94% of respondents with less than 10 years of clinical experience, 83% with more than 10 years of experience, 75% of specialists and 88% of doctors without a specialty are familiar with this technology.

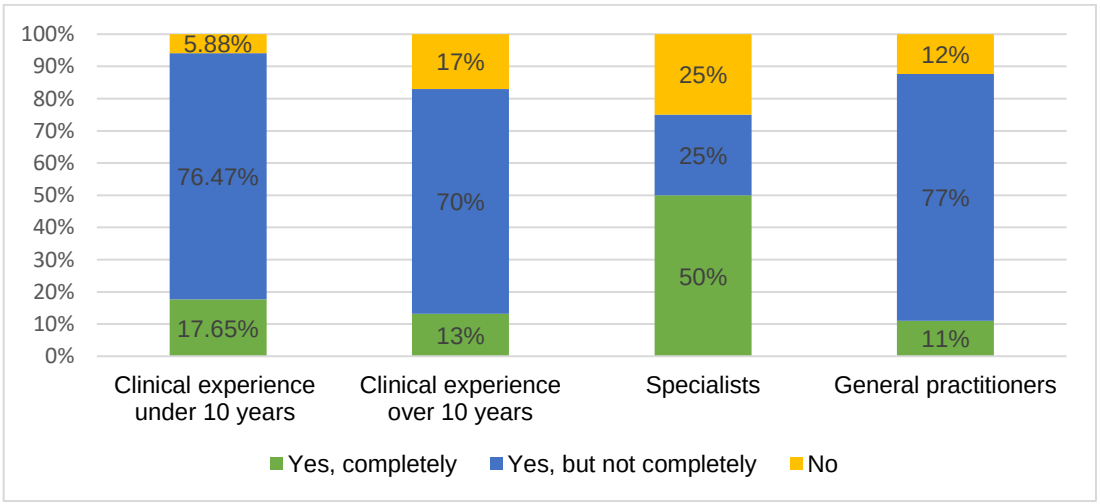

Figure 4. *How familiar are the respondents with 3D printing.*

As for question №2 - "Apart the University, from where did you get information about 3D printing in dentistry?" 48% of respondents answered that they were familiar

with 3D printing from seminars, presentations, and courses in Bulgaria, 23% from seminars, presentations and courses abroad, 16% from clinical practices and 13% from colleagues (Fig. 5).

Figure 5. *Sources of information about 3D printing in dental medicine according to the respondents.*

Figure 6 shows the answers to questions №3, 4 and 5.

To question №3, whether they think 3D printing is becoming more popular, 80% of the respondents answered yes, 14% said they cannot answer, and 6% said no.

A total of 39% of dentists do not think that 3D printing will replace conventional manufacturing methods, 37% said that it will replace them, and 24% cannot answer (Question №4).

When asked if they believe that 3D printing is more accurate than conventional methods of manufacturing dentures, 40% answered no, 37% yes, and 23% cannot answer (Question №5).

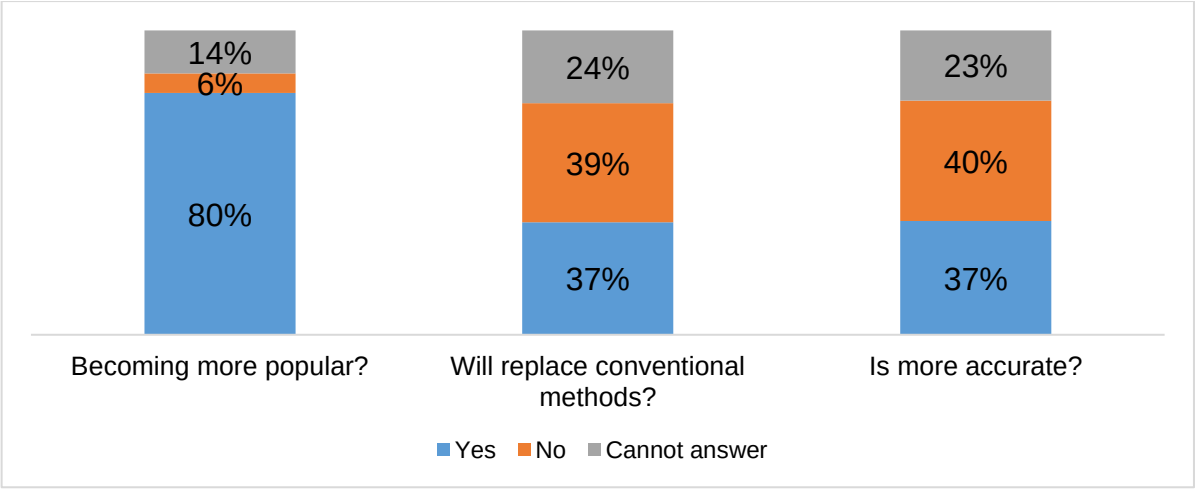

Figure 6 *Do respondents think that 3D printing is becoming more popular, will replace conventional methods and is more precise*

The respondents were asked for the manufacture of which prostheses 3D printing can be used (Question №6) (Fig.7). According to 92% of them, 3D printing can

be used for fabrication of fixed prosthetic devices, and according to 57%, removable partial or complete dentures.

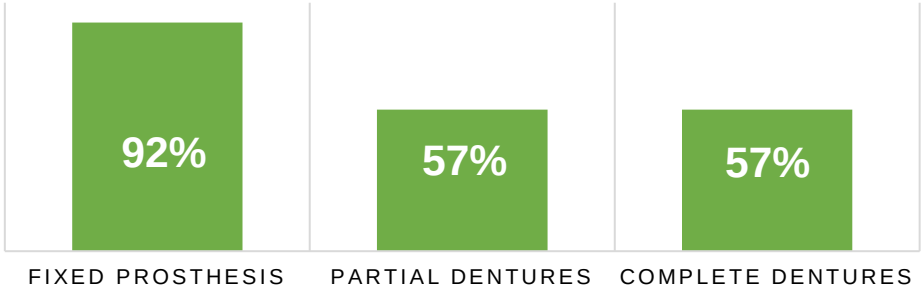

Figure 7. *What type of protheses can be fabricated with 3D printing.*

Question (№7) concerns respondents' preferences for different production technologies of removable dentures. Most practitioners (55%) prefer and use conventional fabrication methods, 22% use CAD/CAM milled removable prostheses, 16% - 3D printed and 11% prefer injection methods (Fig.8).

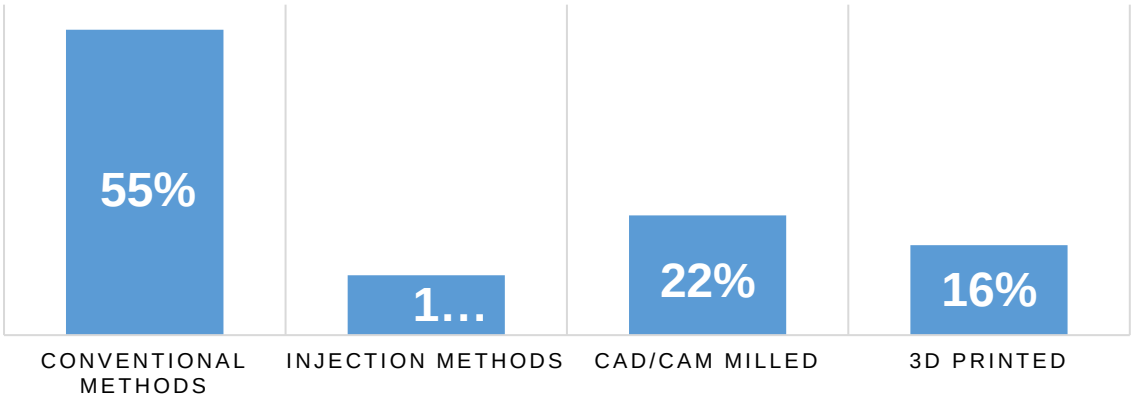

Figure 8. *What are respondents' preferences for different production technologies of removable dentures.*

Question №8 is related to the recommendations that doctors give to their patients regarding the hygiene of the dentures. Most respondents (76%) recommend the use of cleaning tablets, followed by brush and soap (54%), 33% answered “brush and toothpaste" and 3% answered "other".

To the question "How often do you observe denture stomatitis in your practice?" 69% answered "rarely", 24% - "often" and 7% - "quite often"(question №9).

Question №10 is related to the reason why respondents do not use 3D printing in their daily practice. The largest part of them answered that this is due to the high cost of the equipment (42%), 13% claimed that there is a lack of sufficient information

about the technology, 6% believed that special knowledge is needed, and 39% agreed with the three responses (Fig.9).

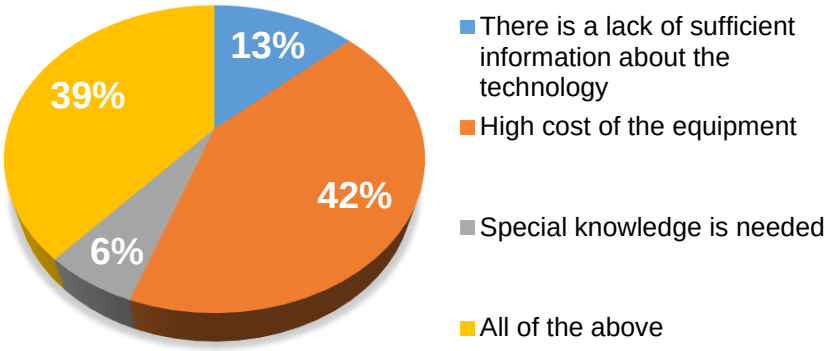

Figure 9. *Reasons why respondents do not use 3D printing for fabrication of dentures.*

Regarding the disadvantages of three-dimensionally printed dentures (question №11), 23% of the practitioners answered, "Poor mechanical properties", 18% - "Appearance of cracks, defects and breakage", 14% - "Other", 12 % answered "Change in color and low aesthetic properties", and 9% - "Denture stomatitis and inflammation of the mucosa" (Fig.10).

Figure 10. *Disadvantages of 3D printed dentures.*

Question №12 is about the advantages of 3D printed dentures and is directed to respondents who use 3D printing in their daily practice. Of the respondents, 24% answered that the reason is that they want to use the latest technologies, 17% believe that these prostheses are more accurate. Ulcers are less often observed, 14% answered that they have better mechanical properties, 12% said that they have better retention and stability, and 10% that they have better aesthetic properties (Fig.11).

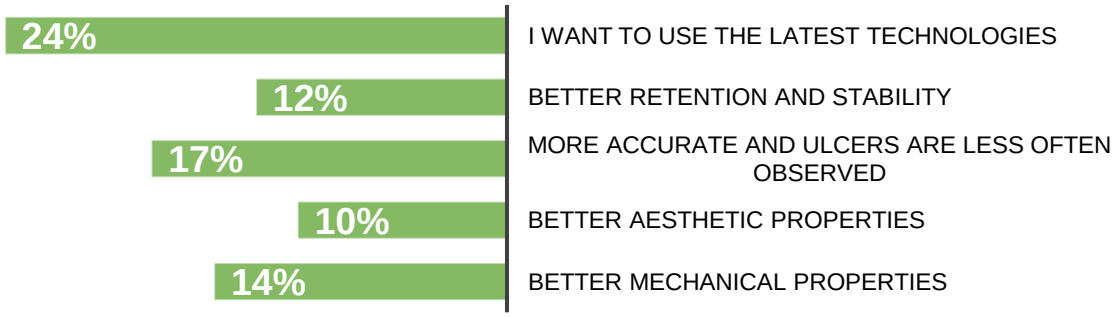

Figure 11. *Reasons why respondents use 3D printed dentures.*

Question №13 is also directed to practitioners using 3D printed dentures and is related to their most common problems. To this question, 40% of them answered that it is the separation of the tooth/s from the denture base, 35% said it is a fracture of the denture and 25% answered "other".

Discussion

Along with countless applications in mass production, additive technologies are also gaining popularity in dentistry, mainly due to the constantly improving quality of printed objects and reduced clinical time (13,16).

The results from the survey, in which dentists with clinical experience under and over 10 years, as well as specialists and general practitioners took part, show that practitioners in Bulgaria are familiar with 3D printing. Primarily the source of information are dental medicine forums, including seminars, presentations and courses in Bulgaria and abroad.

According to 80% of respondents, 3D printing is becoming more popular and used while only 6% disagree. Similar results were obtained in a survey by Jawahar and Maragathavalli among dentists in India - 82% believe that 3D printing is becoming more popular, 14% disagree and 4% answered "maybe" (17).

Another survey by Suganna M. et al. among dentists in Saudi Arabia showed that 66% of respondents believe that 3D printing is becoming widely used in dental practice (18).

According to our results, only 37% of respondents believe that 3D printing will replace conventional methods of manufacturing dentures in the next 10 years. The same number of respondents believe that 3D printing is more accurate.

In Prosthetics, the additive manufacturing is becoming an alternative to conventional methods for making removable dentures and the most commonly used technology is Stereolithography (15,19,20). Almost all respondents (92%) from our survey believe that 3D printing can be used to produce fixed prostheses as crowns and

bridges. However, only 57% believe that it is possible to be used while making removable dentures (partial and complete).

The advantages and disadvantages of 3D printed prosthetic devices are also a subject of interest while the continuous introduction of new materials requires new studies of their properties.

Alhallak notes the advantages of additive technologies are less material waste, the ability to fabricate more complex objects and the lower cost (21).

According to Russo, manufacturing complete dentures using additive technologies is the most cost-effective option, compared to conventional methods and CAD/CAM milling. However, he notes the increased number of clinical stages as a disadvantage (22).

Despite the great possibilities of digital technologies, some authors believe that more research is needed related to the chemical composition, mechanical and physical properties of printing materials to prove their clinical effectiveness (23-26).

As for the main reason why, respondents do not use 3D printing in their practices, 42% answered that the cost is high. However, there are opposite results in a study by Revilla-León et al. for ADA (American Dental Association) about the application of 3D printing in dental practices where 44% of respondents find the reduced cost as a main advantage. The survey results show that 17% of the participants own a 3D printer, and 67% have been using it for less than 2 years. Most respondents use it for diagnostic models (62%), occlusal splints (50%) and surgical guides (48%). 36% of respondents use it to make preliminary fixed dentures, and 29% for orthodontic aligners. According to 68% of respondents, the main benefit of 3D printing is improved efficiency, 44% believe it is low production cost, and 20% believe it reduces clinical time, improves patient communication, and better outcomes (27).

According to the surveyed dentists in Bulgaria, one of the main advantages of 3D printed structures is that they are more accurate compared to conventional fabrication techniques. These results are also supported by Acharya A. et al. in whose survey 87% of respondents consider the high precision of 3D printing to be the main advantage (28).

Conclusion

According to the obtained results, it can be claimed that the dentists in Bulgaria are familiar with 3D printing and believe that the technology is becoming more and more popular and used in dental practices. However, most of them are still skeptical and do not find 3D printing a good enough alternative to conventional methods for making removable dentures. The main disadvantages are believed to be the equipment's high cost and the materials' poor mechanical properties. Apart from the reduced clinical time, the main advantage is the more precise production of the printed objects.

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