Implementation of alternative technological options for processing ceramic masses in current practice

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Abstract

Considering the evolution of current technologies, this study aims to assess the implementation of alternative digital technologies in dental medicine for student's education and for practicing doctors.

Materials and Methods: This primary study evaluated a heterogeneous group of doctors and students through a questionnaire. The questionnaire, conducted on the Google Forms platform, consisting of 12 open-ended questions, analysed the level of implementation of traditional technologies versus the digital workflow for processing ceramic masses. The responses were statistically interpreted using the R statistical software version 4.3.1.

Results and Discussions: The statistical analysis of the questionnaires showed that digital alternative technologies are a viable method in dental practices, and it is recommended for students, being included among their specific skills.

Conclusions: The implementation of the digital workflow for processing ceramic masses, compared to the traditional one, will represent a more significant proportion in the immediate future, in generating diagnoses, developing treatment plans, and applying them in clinical practice.

Keywords: Digital workflow; traditional workflow; statistical processing

INTRODUCTION

Full ceramic systems currently used in dental prosthetics have modified compositions that allowed wide usages and indications in prosthetics. The advantages of full ceramic systems include superior aesthetics, biocompatibility, low thermal conductivity, chromatic and chemical stability [1,2]. These materials are recommended for patients' who desire natural and aesthetic restorations, coupled with the high precisions offered by digital workflows [2]. Practitioners, in addition to the optical behaviour of the restorations, have sought to improve their mechanical properties and explore new processing perspectives [3,4]. The longevity of full ceramic prostheses is multifactorial, with material selection, design, and processing procedures being of great importance [1,4].

The psychological impact of dental trauma in the anterior region is significant, and by using CAD/CAM milling systems in the clinic, we can rehabilitate the dental arches with a natural appearance in the same session, meeting both aesthetic and mechanical expectations [5,6]. Digitization in medicine has become a reality, and its implementation depends not only on understanding the digital workflow but also on the financial implications [1,7,8].

By implementing digitalization in dental practice beyond the high accuracy, time saving and efficiency in the technologic process, cross-contamination between the dental office and the dental laboratory can be prevented [7, 8]. The current trend is to use more monolithic full ceramic prosthetic restorations. Multi-layered prosthetic restorations have proven to be more prone to failures such as layer fracture or delamination [7,9]. Single-unit and partial fixed full ceramic prostheses can be successfully created using CAD/CAM technology, restoring disrupted functions through additive or subtractive processing technologies [9,10,11].

The disadvantages of using CAD/CAM systems include high costs for the devices and their maintenance [12,13]. The milling process can be either hard or soft, depending on the choice of the material that must later be sintered or not, bringing with it advantages and disadvantages [1].

Aim and objectives

The aim of this study is the assessment, through questionnaires, of the digital workflow for processing ceramic masses in prosthesis technology implementation in current dental practice in the western part of Romania. The hypotheses formulated at the beginning of the study should provide clarification regarding the need to achieve the necessary skills for students and doctors of this technological procedure. To carry out this evaluation, initially, a systematic review of data from the specialized literature has been done in order to create the design of the assessment questionnaire.

MATERIAL AND METHODS

This primary study is a questionnaire, whose results, were statistically interpreted. The digital questionnaire, created using the Google Forms platform consists of 12 questions. It was sent on email addresses for two target groups after informing them about this study and obtaining the informed consent.

The two groups included were: one represented by 50 dental practitioners and one represented by 50 final-year students from the Faculty of Dental Medicine,"Victor Babeş" University of Medicine and Pharmacy of Timişoara. The null hypothesis was that there are differences in the perspective of choosing alternative options for processing ceramic masses between experienced dental practitioners and recent graduates. The number of questionnaire

participants was chosen to be equal for each group to have balanced data. The types of questions in the questionnaire included multiple-choice, short-answer, paragraph-answer, selection, and drop-down questions. After completing the questionnaire by both groups using the Google Forms platform, the results were organized into an Excel table and use for statistical analysis.

For the statistical evaluation was used the R statistical software version 4.3.1. Bar charts were employed for visual analysis using the R package ggplot2, Wordcloud and Wordcloud2 packages were used for text analysis. To test the statistical dependence between categorical variables, the Chi-Square test was used. The Chi-Square test in R is a statistical method used to determine whether two categorical variables have a significant correlation.

The first two questions aimed to determine group affiliation: practitioner or student, and age distribution in the group. Question 3 aimed to establish the level of knowledge of the digital processing protocol for ceramic masses, while question 4 quantify the percentage of level of digital workflow usage in dental prosthetics.

As metal-free fixed prostheses are more commonly used in recent years, question 5 aimed to identify the proportion of choosing traditional versus digital technologies in the current processing of ceramic masses and question 6 assessed the use of intraoral scanning in the dental office. Considering that full ceramic systems generally require knowledge about indications, contraindications, advantages, and disadvantages, questions 7 and 8 evaluated these aspects for the traditional additive protocol in processing ceramic masses.

The working time required to obtain metal-free prostheses using CAD-CAM systems is an essential variable evaluated with question 9, along with the benefits brought by digital workflow that was assessed through question 10. Questions 11 and 12 aimed to analyse respondents' opinions regarding the difficulty of implementing the digital workflow for processing ceramic masses in Romania and the percentage they believe digital full ceramic prostheses will occupy in the coming years.

RESULTS

Initially, visual analyses were conducted for the questionnaire responses. Questions 1 and 2 highlighted the heterogeneity group. For question 3, "Are you familiar with the digital protocol for full ceramic prostheses? Yes/No," the majority of the medical practitioners answered "Yes", while among the students, only half are familiar with the digital protocol, and the other half is not familiar with it. For questions 2 and 3 regarding the knowledge of the digital workflow, based on respondents' age, the analysis showed that those, aged between 30-40 years are familiar with the protocol, most respondents aged 20-24 do not know the protocol and those aged 24-30 mostly know it. The majority how are older than 40 are familiar with the protocol (Figure 1).
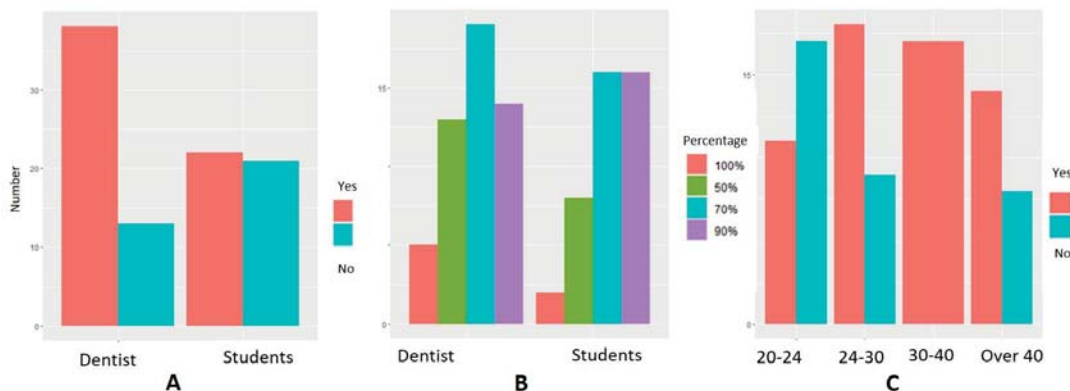
Figure 1. A- graphic representation of question regarding the knowledge about digital protocol for full ceramic prostheses 3; B-graphic representation of questions 2 and 3; C-graphic representation of age and familiarity with digital protocol

The analysis of the answers to question 6 show that 55% of the participants in the questionnaire use digital scanning, while the other 45% use the traditional method. Among those who use digital scanning, 45% scan intraoral, 4% scan the analysed model and a percentage of 6% use both variants. When asked question 12, "select what percentage you believe digital full ceramic prostheses will occupy in the coming years with options: 50%, 70%, 90%, 100%" showed that, majority of dental practitioners believe that in the coming years digital full ceramic prostheses will be produced at a rate of 70%. A smaller percentage of dentists believes it will reach 100%. On the other hand, students consider that the percentage will reach 70% or even 90% (Figure 2). For question 5, "what technologies do you use for ceramic processing? Traditional or digital?" the responses indicated that dental practitioners mostly use traditional technologies, while they use digital technologies to a greater extent. In contrast, students use traditional technologies to a higher percentage than dental practitioners, who use digital technologies more frequently (Figure 2).
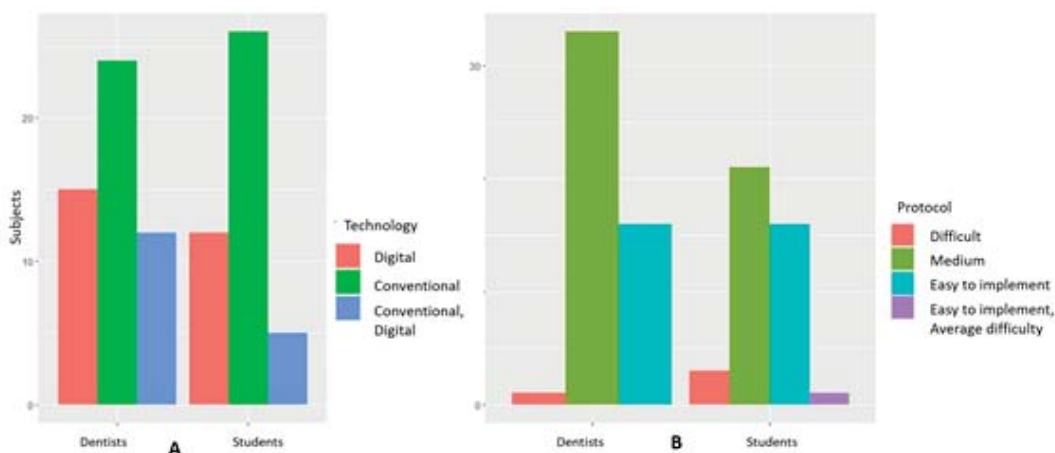

Figure 2. A- graphic representation for the answers of question 5; B - graphic representation for question 11

The majority of dental practitioners chose their response to question 11:"The digital protocol for creating full ceramic prostheses is: Difficult to implement / Easy to implement / Medium level of difficulty" (Figure 2B). This reflects that the implementation of digital technologies for processing ceramic masses is considered of medium difficulty. In contrast, students prefer a simpler implementation method. The response to question 12 had different

percentages, and the choice was influenced by the age of the respondents. Individuals between 20-24 years old believe that digitally manufactured full ceramic prostheses will occupy a percentage of 90%. Those aged between 24-30 believe it will be 70% (Figure 3).

For all age categories, the choice of response to question 11, regarding the difficulty of implementing the digital protocol for creating full ceramic prostheses, indicates that respondents consider the digital workflow need to have a medium level of implementation (Figure 3).
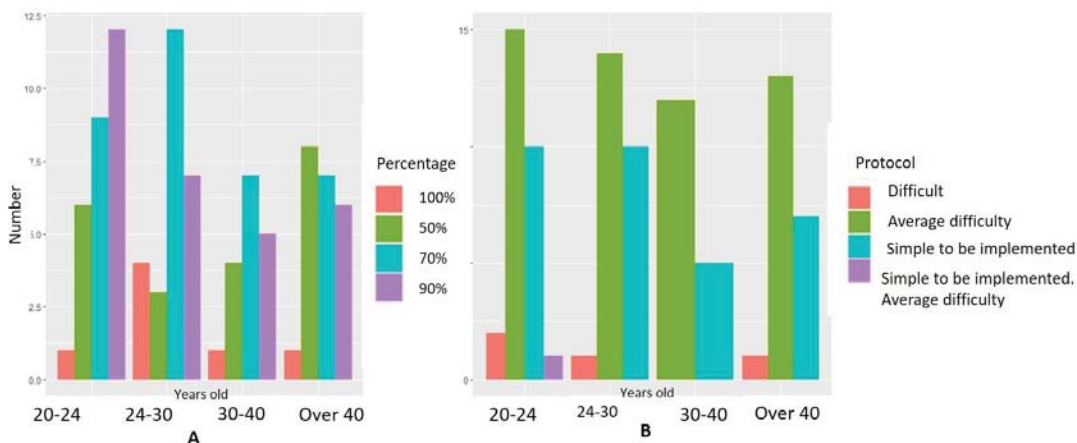

Figure 3. A. Graphic representation for questions 2 and 12. B. Graphic representation for questions 2 and 11

For question 5, if age has influenced the choice of response differently, specifically, for the age group of 20-24, the predominantly used technology is traditional, while for the age group between 24-30, digital technology predominates. For those over 40 years old, traditional technology is still predominant. Question 6 aimed to establish a very important aspect of the digital workflow represented by collecting data about the prosthetic field through various scanning methods: intraoral or analogue model. The presented results are a conclusion of the cascade questions (Figure 4).
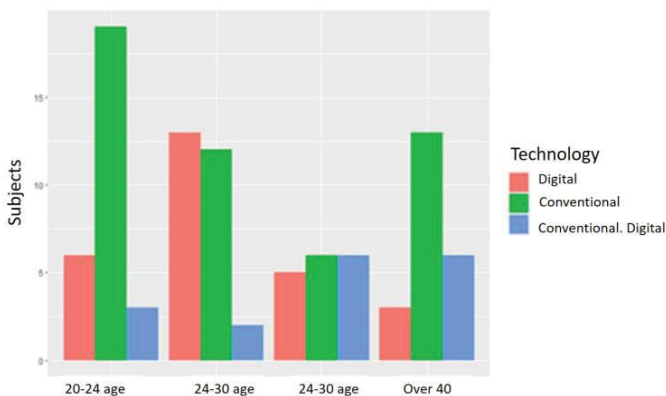

Figure 4. Graphic representation for answers of questions 2 and 5

For questions with short-answer or paragraph-type responses was made a text analysis and followed to analyze which are the benefits of traditional full ceramic prostheses. The most frequently used words were identified and the most relevant characteristics were aesthetics, working time adaptation of prosthetic restorations made through a digital protocol.

For question 10, "What are the benefits of digitally produced full ceramic prostheses?" the most frequently found responses were: reduced/shorter working time, better adaptation. The responses to question 8, "What disadvantages/difficulties have you encountered regarding the adaptation of ceramic prostheses?" most frequently were represented by difficulties in cementation and brittleness.

Among young individuals aged 20-24, a higher percentage of students still do not know the digital protocol for full ceramic prostheses. After the age of 24, the percentage of knowledge about this protocol increases. All dental practitioners come to know this protocol between the ages of 30-40, and after the age of 40, there is a percentage similar to that of students aged 24-30 who either do not know or do not wish to implement new technologies in dental offices. The reasons are the lack of opportunity to learn and practice since their studying years and the costs of the technology.

Despite the expectation that modern technology would be the most used one, the reality is different. Traditional technology is the mostly used among both students and dental practitioners in 2023. Having more experience, dental practitioners use modern ceramic processing technology to a higher percentage compared to students. This percentage could become at least equal in the future among students and dental practitioners if the mandatory use of new ceramic processing methods could be implemented in the university curriculum, bringing benefits not only to medical professionals but also to patients.

Regarding the difficulty level of the digital protocol for creating full ceramic prostheses, all age categories consider that the digital protocol for ceramic prostheses has a medium level of implementation difficulty.

The benefits of digitally manufactured full ceramic prostheses are presented from the perspective of both dental practitioners and students. Among the most frequent mentioned benefits are reduced/shorter working time, improved adaptation to the natural or artificial abutments, the possibility of milling and fixing the restoration in the same day and patient comfort during impressions.

The disadvantages/difficulties encountered by both students and dental practitioners regarding the adaptation of ceramic prostheses are: occlusal adaptation and proximal contact areas which are more challenging for designing an free interference occlusion and proximal contact areas. Materials dedicated to full ceramic prostheses are prone to brittleness, have a high risk of fracture, sensitive adaptation at the threshold level, laborious luting and higher expenses.

Using the Chi-Square statistical test, we compared the relationship between the variables "You are" and "You know", and the p-value was 0.01377 (less than 0.05). It can be concluded that transitioning from the student group to the doctor group will change knowledge regarding technology.

The two important criteria considered in interpreting the questionnaire responses were their correlation with age groups and whether or not the participants had knowledge of the digital workflow from various perspectives.

DISCUSSIONS

The introduction of digital technologies in dental medicine has significantly altered the field of dental practices, particularly in the ceramic prostheses fabrication. The findings from our study underscore a growing acceptance and use of these technologies among dental practitioners and student's curriculum, with noticeable ease of implementation and high accuracy of prosthetic restorations.

Our results indicate a higher familiarity and implementation of digital workflows among practicing dental professionals compared to students. This discrepancy, may be

attributed to the exposure and access to digital tools in clinical settings, which is more pronounced among practitioners than in educational settings. Practitioners are likely to have direct experience with CAD/CAM systems, which offer distinct advantages such as improved precision and efficiency in creating dental prosthetics. This observation aligns with previous studies which suggest that the integration of digital technologies in dental curriculum is essential to bridge this gap [2].

The significant variance in the level of digital workflow familiarity between students and professionals, highlights the need for curriculum improvement and implementation of digital dentistry. Incorporating comprehensive training on digital dental technologies within dental curricula could enhance student competency and readiness for modern dental practices, which increasingly rely on digital techniques [10]. This approach is supported by the findings from Baroudi and Ibraheem [14], who advocate for the inclusion of digital dentistry training as a core component of dental education to meet the evolving demands of the field.

Despite the advantages, our study also highlight the challenges associated with the adoption of digital technologies in dental practices. High equipment costs and maintenance are significant barriers, as noted in several responses are supported by research from Galante et al. [12]. Additionally, the complexity of integrating new technologies into existing systems poses a notable challenge, particularly for older practitioners who may have less flexibility in adapting to new workflows [7,15,16].

Looking forward, the advancement of digital technologies, such as the integration of Augmented Reality (AR) in surgical procedures, is continuously changing dental medicine by enhancing the capabilities of dental professionals to perform complex procedures with greater accuracy and patient comfort [1, 7].

With these digital technologies in development, Augmented Reality (AR) will reinvent surgical procedures, enhance healthcare providers' ability to treat patients, and transform healthcare as a whole. The future certainly looks bright and virtual [14,15].

In the e-book published in 2021, "Digitalization in Dentistry, Clinical Applications," Jain P. and Gupta M provide readers with evidence-based guidance on the clinical applications of digital dentistry. They present the use of devices incorporating digital or computer-controlled components for dental procedures. Information about current digital procedures in various dental fields is published and presents in detail digital protocols in endodontics, orthodontics, implantology, and other dental specialties [1].

The main objective is to improve daily practice and equip practitioners with the necessary knowledge and skills to cope with innovations. In this regard, a problem-solving method is addressed, emphasizing key concepts and presenting details in a sequential and easy-to-follow manner [1,16].

AI is already present in the digital dentistry workflow, the DiagnoCat tool being already widely used and provided by dental radiology offices. These tools offer an analysis of the patient's oral cavity providing quickly an overview regarding: the presence or radio-transparency in a teeth structure, the number of root canals etc [18].

The transition toward digital workflows in dental medicine is both an opportunity and a challenge. As digital technologies become more embedded in dental practices, it is crucial for educational institutions to adapt and provide robust training in these technologies. Furthermore, addressing the barriers to adoption, particularly through cost management and training, it will be essential for the widespread acceptance and use of digital workflows in dental medicine. By overcoming these challenges, the dental industry can fully leverage the potential of digital technologies to improve patient outcomes and operational efficiency.

CONCLUSIONS

Digitalization in Medicine in general, and especially in Dentistry in the near future, will play a significant role in generating diagnoses, developing treatment plans, and their application.

In Romania, medical digitalization is currently undergoing substantial development, but there is a need to increase the level of proficiency in new technologies, both among experienced doctors and recent graduates.

The implementation of digital technologies for processing ceramic masses is becoming a reality because the advantages of these systems are proofed and the working protocols are understood. The focus of the digitalization in the curriculum in dental schools can accelerate the integration of the digital workflow in dental practice.

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