ORIGINAL ARTICLE

DIGITAL DESIGN OF THE METAL COMPONENT OF METAL-CERAMIC PROSTHETIC RESTORATIONS

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Abstract: *Background*: Dental prosthetics is the specialization with the greatest technological advances, which leads to the most natural, durable, comfortable and efficient restorations. Despite these advantages, there is a risk that new methods will evolve faster than they can be implemented in everyday practice. The purpose of this study was to highlight the particularities of digital design of the metal component of metal-ceramic prosthetic restorations, depending on the morphological area, but also on changes that occurred on the potential prosthetic space. *Methods*: For this study, a total of 25 cases were analyzed for which designs for this metal component were made. Only cases involving single metal-ceramic crowns fabricated based on intraoral scanning were selected. For each case, a laboratory paper was prepared in which the patient's initials, gender and age, the arch on which the restoration was performed, the anterior or posterior morphological area, were noted. It was evaluated the potential prosthetic space which was assessed as being of reduced, normal or increased dimensions both in the vestibular and occlusal areas for each clinical situation. *Results*: The analyzed cases were distributed relatively equally according to gender, age group and the arch concerned, but we encountered mostly cases in which the posterior area was of interest, while the changes in the potential prosthetic space were mainly related to its vertical dimension. The digital design allowed us to carefully follow each stage of creation and evaluate the prosthetic space in order to properly adapt the thickness of the two components of the metal ceramic restoration. *Conclusions*: The design of the metal framework of the metal-ceramic restoration using the digital method has multiple advantages over its implementation using the conventional method. The level of precision, planning and reproducibility of the results obtained using the EXOCAD software are superior to any classic alternative.

Keywords: Digital dentistry, Metal-ceramic restoration, CAD/CAM technology, Restorative dentistry, EXOCAD

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1. Introduction

The rapid advancement of digital technologies has brought major changes to many areas of dentistry, particularly in prosthodontics. Traditional methods of designing and fabricating dental prostheses are increasingly being replaced or enhanced by digital tools that offer greater accuracy, speed, and consistency. Intraoral scanners, CAD (computer - aided design), and CAM (computer - aided manufacturing) systems have become essential components of modern dental practices, transforming the way prosthetic restorations are planned and produced. This article explores how these digital workflows improve clinical outcomes and reshape the future of dental prosthetics [1]. The evolution of current systems and the implementation of new systems demonstrate a decrease in the difficulty of their use, expanded capabilities, and improved quality through a variety in complexity and use. Nowadays more aesthetic materials have also been introduced that behave similarly to enamel with increased strength. [2]

Currently, the most widely employed restorative materials in chairside CAD/CAM applications include resin-based ceramics, feldspathic porcelains, glass ceramics, and zirconia-based ceramics. Owing to their excellent translucency and high abrasion resistance, these materials have become integral to contemporary restorative dentistry. Their utilization reflects the growing demand for dental restorations that fulfill both aesthetic expectations and functional performance criteria. [3]

The purpose of this study was to highlight the particularities of digital design of the metal component of metal-ceramic prosthetic restorations, depending on the morphological area, but also on the potential prosthetic space changes.

2. Materials and method

The activity took place within the Fixed Dental Prosthesis Technology discipline at the University of Medicine and Pharmacy Craiova, Faculty of Dental Medicine, in the period January 1st - June 1st 2023 where we created the digital design of the metal component of metal-ceramic prosthetic restorations using the software dedicated to this purpose, EXOCAD (Exocad GmbH, Germany).

For this study, a total of 25 cases were analyzed for which designs for this metal component were made. Only cases involving single metal-ceramic crowns fabricated based on intraoral scanning were selected.

For each case, a laboratory order note was prepared in which the patient's initials, gender and age, the arch on which the restoration was performed, the anterior or posterior morphological area, were noted. We also evaluated the potential prosthetic space which was assessed as being of reduced, normal or increased dimensions both in the vestibular and occlusal areas for each clinical situation.

Analyzing the data obtained, they were entered into an Excel (Microsoft ,USA) spreadsheet and then the results were expressed in the form of suggestive graphs.

We selected two representative cases from the analyzed ones for which the stages of creating metallic design components and their particularities are presented in this article. For this, we made screenshots for the stages of creating the design of the metal component, paying special attention to the stages of

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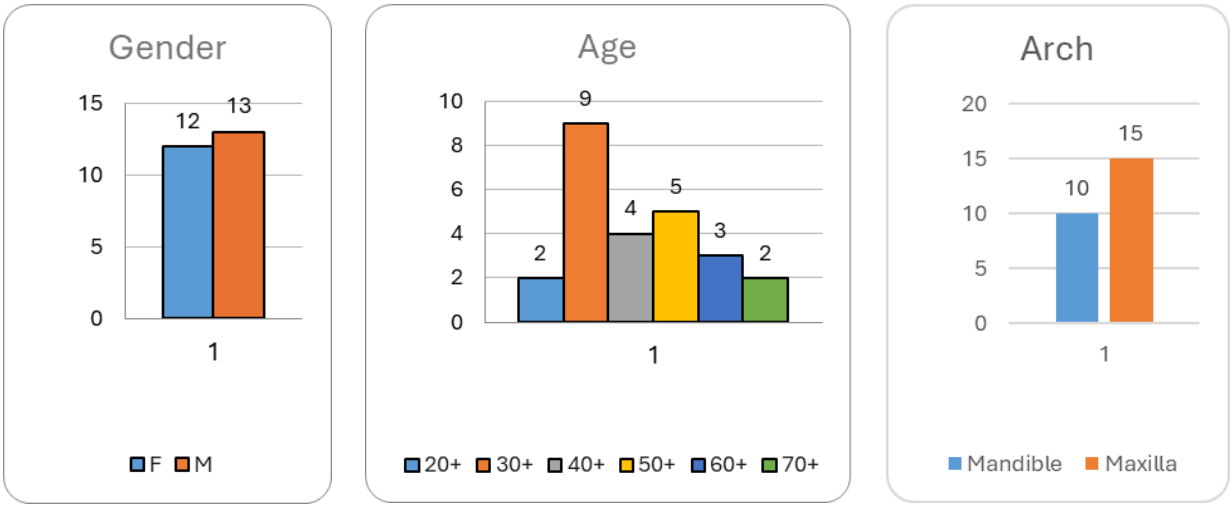
creating the space for the ceramic component. For this stage, we simulated several technological possibilities with the provision of a different space for the ceramic mass both in terms of dimensions and distribution on the morphological areas.

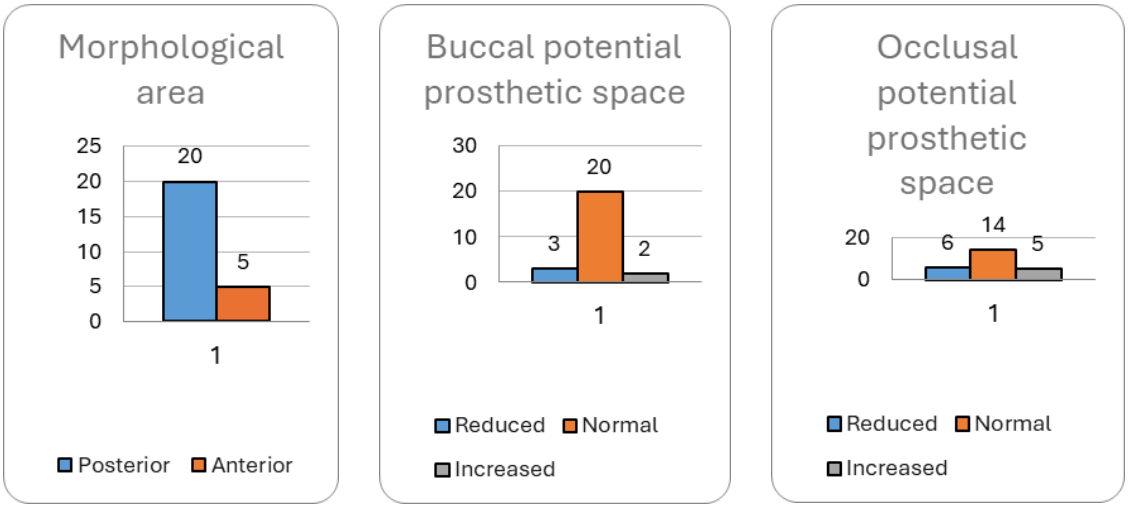
3. Results

Our results showed that from the total of 25 cases, gender distribution was almost equal and regarding the distribution by age groups, the highest number of cases belonged to the 30+ group (Graph 1, 2).

Concerning the arch and morphological area distribution, the cases were rather evenly distributed concerning the upper of lower level, with a slightly higher number on the mandible, and the highest number of crowns were placed in the posterior area (Graphs 3,4).



Graph 1. Gender distribution. **Graph 2**. Age distribution of cases on age groups. **Graph 3**. Distribution of cases on the maxillary and mandibular arches.



Graph 4. Cases distribution on the morphological areas . **Graph 5**. Cases distributions depending on the buccal potential prosthetic space. **Graph 6**. Cases distributions depending on the occlusal potential prosthetic space.

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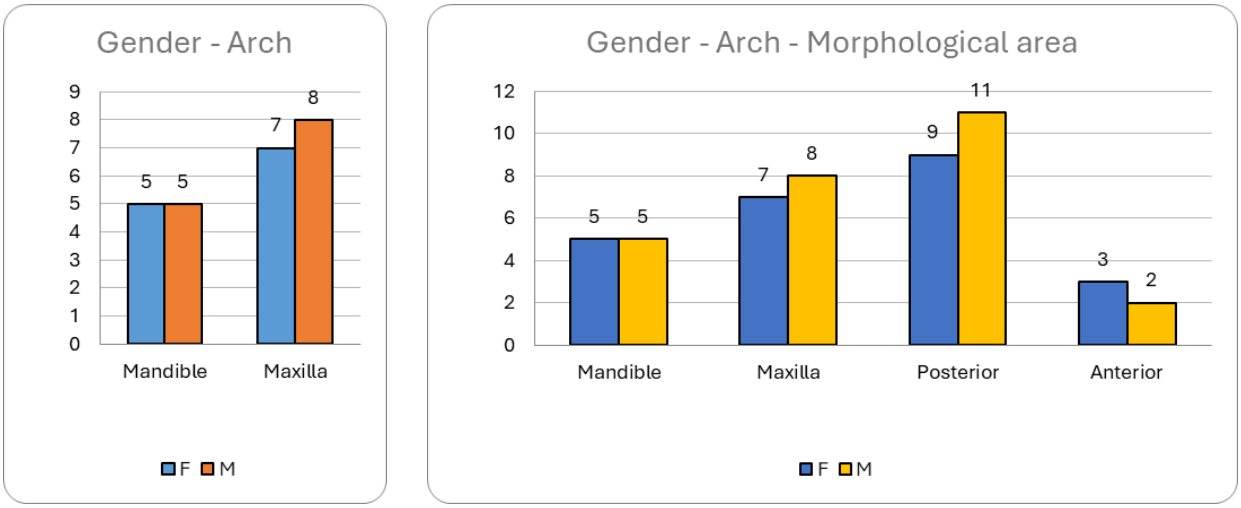
The buccal potential prosthetic space and the occlusal potential prosthetic space usually suffers some modifications, however in our study, the majority of the cases presented no modifications of these spaces (Graphs 5,6).

Some correlations are also presented, such as the correlation between the gender, the arch level, and morphological area, where we found that the gender did not affect the distribution level of the crowns (Graphs 7,8).



Graph 7. The correlation between patient gender and the distribution of cases on the arches. **Graph 8**. The correlation between the gender of the patients, the maxillary or mandibular arch and the morphological area.

In the first presented case we followed the steps for creating the digital design of the metal component of a metal-ceramic crown corresponding with tooth 2.5, starting from a real clinical case for which an intra-oral scan of the preparation was performed after its completion (Figure 1, Figure 2).

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Figure 1. Development of the design of the metal component of a metal-ceramic crown for tooth 2.5 (a) Initial menu; (b) The appearance of the scanned abutment; (c) Initial 3-point cervical design; (d) Final cervical boundary design; (e) Cervical area design; (f) Minimizing the distance from the crown edge of the cement space; (g) First placement suggested by the software; (h) The software's dental library.

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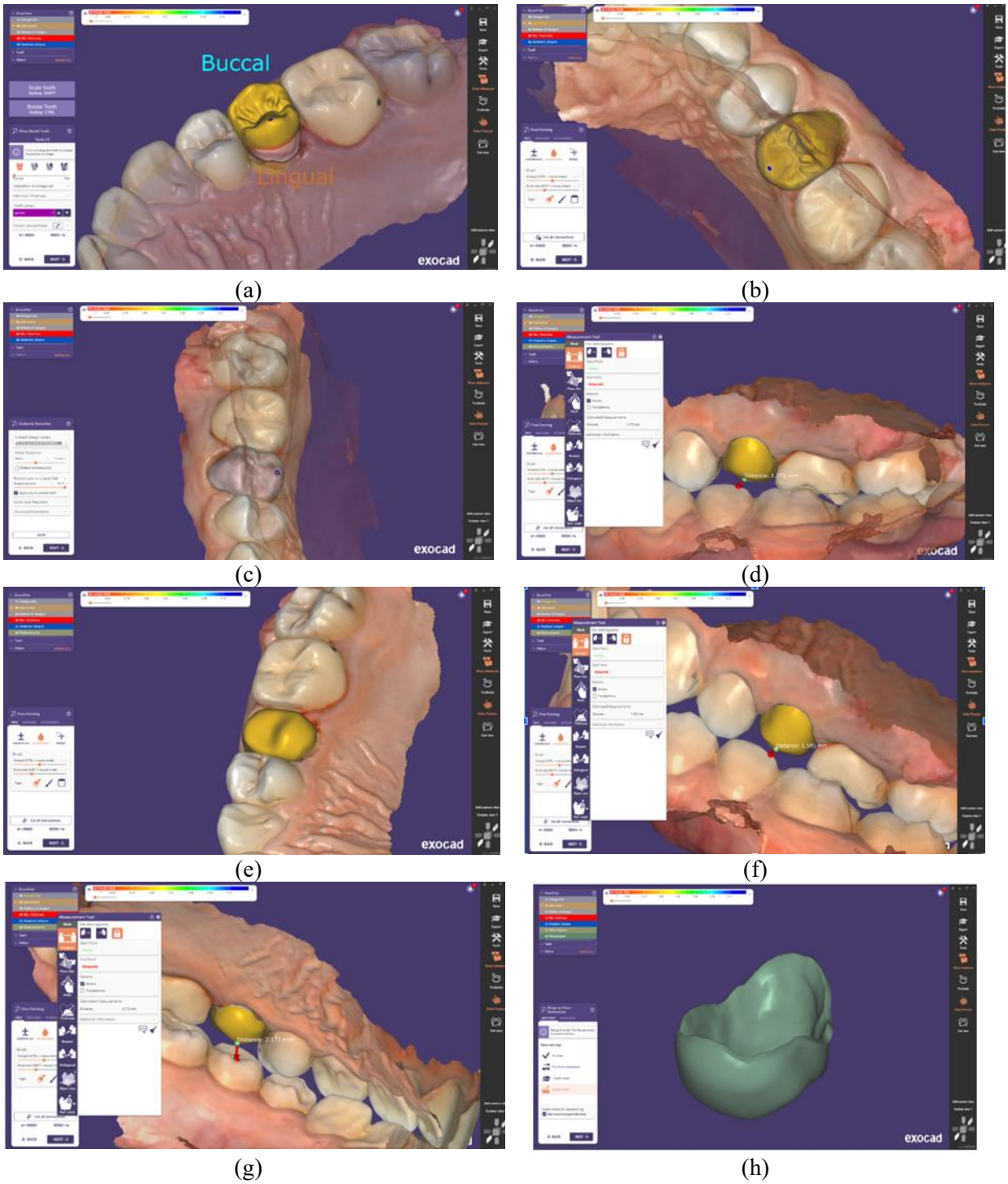

Figure 2. Creating the design of the future metal component starting from the desired shape for the future crown and reducing its volume to provide the necessary space for the ceramic application (a) Sharp occlusal relief ; (b) The initial form of the restoration; (c) Reducing the space for applying ceramic masses; (d) Creating a 1.2 mm ceramic space; (e) Final design of the metal frame with another space for ceramics; (f) Creating a 1.59 mm ceramic space; (g) Creating a 2.1 mm ceramic space; (h) The final design of the prosthetic piece ready for milling.

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In the second presented case we followed the steps for creating the digital design of the metal component of a metal-ceramic crown corresponding to tooth 1.4, starting from a real clinical case for which an intra-oral scan of the preparation was performed after its completion (Figure 3, Figure 4).

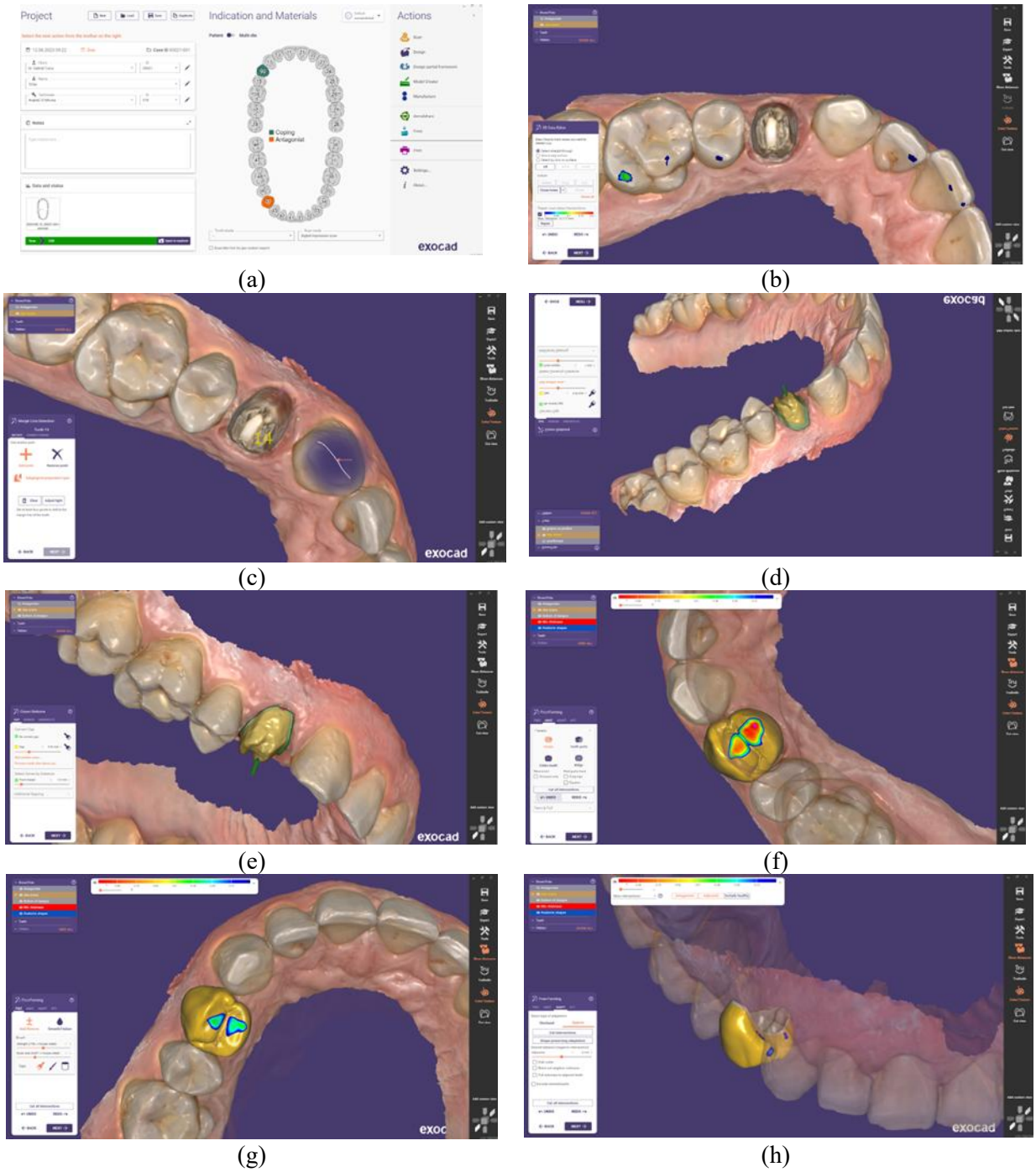

Figure 3. Development of the design of the metal component of a metal-ceramic crown for tooth 1.4. (a) EXOCAD initial menu; (b) Occlusal surface of the prepared tooth; (c) Detection of the subgingival cervical margin; (d) Adjustment of the cement space; (e) Reducing the cervical contact area; (f) Initial morphology suggested by the software; (g) Adjustment of the occlusal surface relief; (h) The mesial contact areas suggested by the software.

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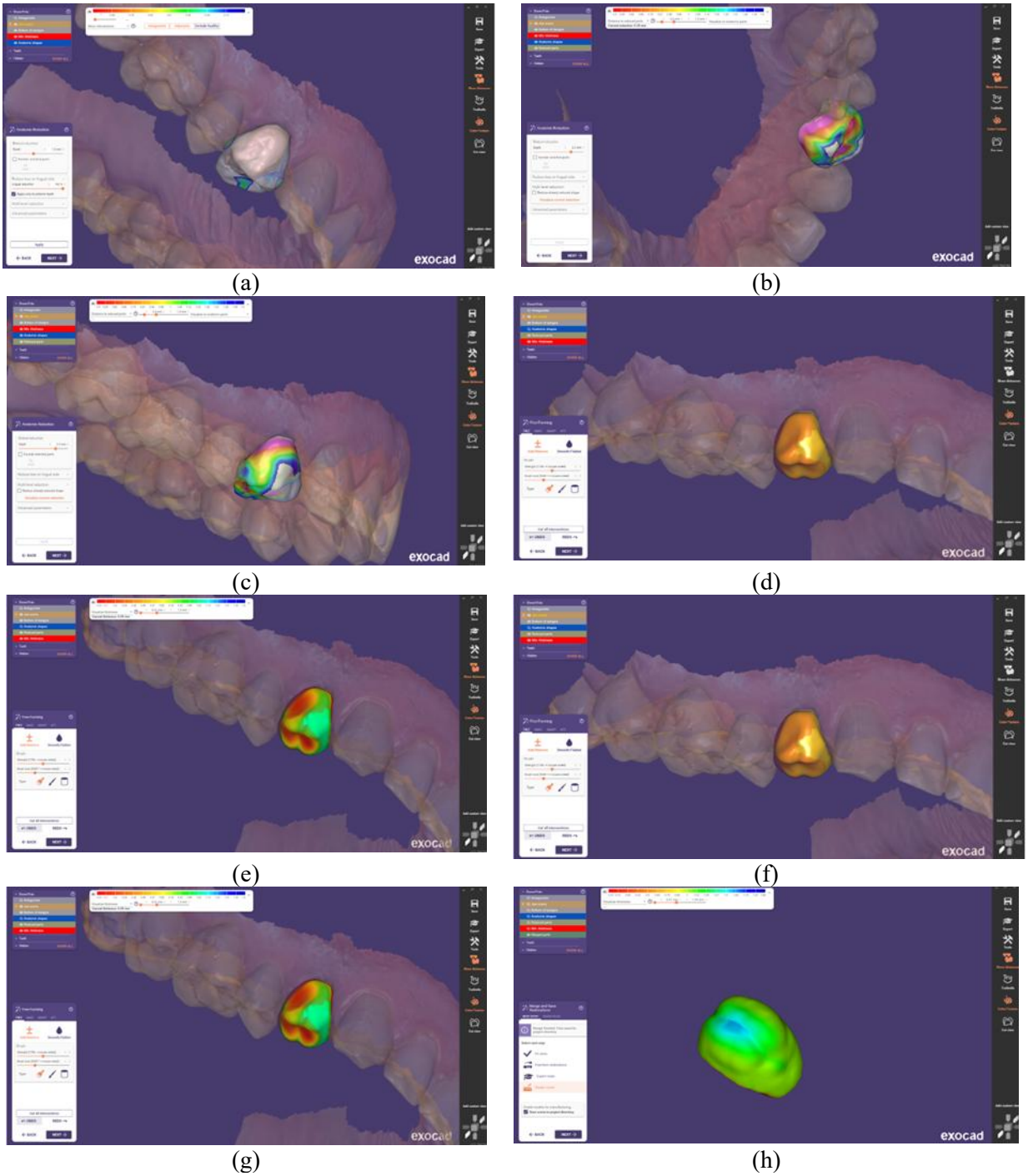

Figure 4. Reducing the volume of the restoration to obtain the space for the ceramic component in different design alternatives with highlighting the thickness of the obtained metal structure (a) Initial reduction suggested by the software; (b) Differential reduction of space for ceramics with highlighting of the dimensions of the remaining space (palatal view); (c) Differential reduction of the space for ceramics with highlighting the dimensions of the remaining space (vestibular view); (d) Changing the thickness viewing range; (e) Modification of the vestibular face of the metal structure; (f) The shape of the cape highlights that the thickness is too small; (g) Visualization of the thickness of the metal frame; (h) The final design of the metal structure.

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4. Discussion

Error testing at each stage of prosthetic construction remains relatively poorly developed for digital CAD CAM methods. Thus, the accuracy of digital design can differ depending on the type of software program used [4]. In our study we used the EXOCAD software, which is one of the most used software for digital design of fixed dental prostheses. [5,6]

The skill of a dental technician operator varies depending on the type of CAD software used to design a dental crown, but previous experience in digital design will significantly influence this skill. In addition, the use of artificial intelligence to automate design functions has the potential to greatly enhance the ability to achieve desired results with digital design software.[7]

The speed of technology development is already very high, today there are opinions according to which traditional digital design can be considered time-consuming and does not provide precision in restoring the shape [8]. Thus, artificial intelligence technologies of deep learning are developed to build a precise neural network for personalized restoration of dental defects [9].

These models can help dental technicians obtain a digital design that closely resembles the original shape of the teeth to be restored. These personalized designs can form the basis for improving the efficiency and precision of digital restorative design [10].

Over time, it has been observed that patients who underwent implant treatments using digital techniques presented fewer postoperative adjustments and had a higher degree of satisfaction with prosthetic restorations, compared to those treated using traditional working methods.[11] A digital workflow and digital impressions are perceived by patients as more comfortable and less invasive [12]. In contrast, Giachetti reported in his study that conventional impressions, made using high-precision and high-quality impression materials, demonstrated higher accuracy than digital impressions [13]. However, Tabesh [14] and Hasanzade [15] stated that there were higher values of marginal adjustment accuracy of restorations made by digital methods than those produced with conventional impressions.

A general analysis comparing digital dental impressions with conventional ones was also conducted and it was found that patients strongly preferred digital workflows. Patients reported increased comfort during impression taking, reduced stuffiness and faster work time, which significantly contributed to their satisfaction with digital prosthetic treatments [16].

5. Conclusions

The design of the metal framework of the metal-ceramic restoration using the digital method has multiple advantages over its implementation using the conventional method. The level of precision, planning and reproducibility of the results obtained using the EXOCAD software are superior to any classic alternative.

However, it is important to mention that CAD/CAM technology does not completely replace the skills and experience of dental technicians or dentists. It is only a powerful tool that helps them achieve more precise and efficient results. Although the design of the metal component remains mainly the responsibility of the dental technician also the

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dentist must be familiar with its particularities, because digital technology allows the dentist to follow in real time how the clinical requirements are implemented and to intervene even during the design phase to optimize the design according to the clinical particularities of each case. The professionalism and competence of dentists remain essential in creating an adequate treatment plan and ensuring patient satisfaction.

CAD/CAM technology has brought about a significant change, transforming the way dental prosthetics are designed and manufactured, certainly representing the future of dentistry.

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Conflict of interest statement

Define any potential conflicts of interest concerning this study.

Data availability statement

Data availability at request.

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