FIXED CERAMIC PROSTHETIC RESTORATIONS WITH METAL INFRASTRUCTURE - TECHNOLOGICAL FEATURES AND CERAMIC MATERIALS

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ABSTRACT

Aim of the study The metal-ceramic fixed restorations is a reliable method of rehabilitation of the dental arch, offering effective morphological and functional aspects, which ensures resistance, biocompatibility with dental tissues and aesthetic harmony in a unitary work, as ceramics have the ability to imitate the appearance of natural teeth. **Materials and methods** Our study aimed to highlight the particularities of performing mixed restorations, with an aesthetic ceramic component system, applied on metallic infrastructure, in the lateral area of the mandibular dental arch. The workflow presented elements specific to each stage, by combining the classic steps of the algorithm with digital technologies for the design and development of infrastructures, and then the application of ceramic mass systems and sintering stages. **Results** The use of digital technologies both in the clinic, for the scanning stage, and in the laboratory - ExoCAD software, for the design of the metal infrastructure, in combination with analogue techniques for the application and sintering of ceramic masses for the aesthetic component, led to obtaining the optimal parameters of mixed metal-ceramic restorations. **Conclusions** Laboratory CAD/CAM systems involve a more extensive technological process, often utilizing advanced materials, typically employed for complex cases requiring high precision and durability, such as full-arch restorations or fixed prosthesis.

Key words: Metal-ceramic restorations, Digital technologies

INTRODUCTION

Ceramics solve the issues of dental aesthetics due to their ability to imitate the appearance of natural teeth, both for restorations applied to compromised teeth and for bridge restorations as a result of reduced partial edentulism, benefiting from metal or zirconia infrastructures, which thus ensure the strength and durability of the restorations. [1]

Research conducted in various studies in the specialized literature presents various types of materials comparatively in terms of physical properties and biocompatibility, in order to achieve a classification, and has consistently demonstrated that ceramic materials have superior strength, hardness, and modulus of elasticity, a more biocompatible nature, and outstanding aesthetics.

Thus, for a long period of time, ceramics were classified according to their microstructure. A commonly used classification system, developed by Kelly and Benetti [2], classifies ceramic materials according to their glass content - as follows:

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(1) predominantly glassy materials, (2) glass-filled particles, and (3) polycrystalline ceramics that do not contain glass.

However, this classification system, along with many others, does not take into account resin matrix materials that are heavily filled with ceramic. These materials have recently been designated as “Ceramic Materials” by the American Dental Association. In light of this, Gracis et al. proposed a new classification system for ceramic materials.[3]

A. Glass matrix ceramics: ceramic materials that contain a glass phase.

B. Polycrystalline ceramics: ceramic materials that do not contain any glass phase.

C. Resin matrix ceramics: polymer matrices consisting predominantly of inorganic refractory compounds, which may include porcelains, glass, ceramics and glass-ceramics.

Feldspathic: Glass matrix ceramics belong to the traditional group, are based on a ternary material system consisting of clay/kaolin, quartz and natural feldspar. These ceramics are known for their high brittleness, limiting their use as veneering material on metal alloys and ceramic substrates. Examples include IPS Empress Esthetic, IPS Classic, Vita VMK 68 and Vitablocks.[4]

Fluorapatite glass-ceramics: exhibit a phase of fluorapatite crystals during processing, which gives them good shaping properties, high strength and excellent firing behavior. They are recommended for use as materials for characterizing and veneering conventional lithium disilicate and zirconium oxide glass-ceramics. An example is IPS e-max Ceram, a nano-fluorapatite glass-ceramic.[5]

MATERIALS AND METHODS

Our study aimed to highlight the particularities of performing mixed restorations, with an aesthetic ceramic component system, applied on metallic infrastructure, in the lateral area of the mandibular dental arche. The workflow presented elements specific to each stage, by combining the classic steps of the algorithm with digital technologies for the design and development of infrastructures, and then the application of ceramic mass systems and sintering stages.

The patient presents 3 dental units requiring restorations on the right mandibular arche (4.5, 4.6, 4.7), dental structures that were prepared, and the proposed prosthetic solution was a fully physiognomic metal-ceramic restoration. The impression recording was performed digitally, using the intraoral scanner, Trios 5 (3Shape), and the images taken were sent to the laboratory in STL format (Fig. 1). The digital files resulting from the scan were imported into the Exocad software for prosthetic case configuration. At this stage, information regarding the type of restoration and the dental structures involved in the treatment were entered. Correct case configuration is an essential step in the digital workflow, as it allows the parameters of the prosthetic work to be established and constitutes the basis for subsequent virtual design stages (Fig. 2)

The digital casts were then prepared for 3D printing and exported in a 3D printer-compatible format. The use of 3D printing offers the possibility of quickly obtaining physical models with a high degree of fidelity. (Fig. 3)

After obtaining the digital casts, they were exported to the 3D printer to create the physical casts, and the printing was done using photopolymerizable resin, a material frequently used in dental technology due to its dimensional accuracy and ability to faithfully reproduce anatomical details. The printing process was carried out by successive polymerization of thin layers of liquid resin, until the filled three-dimensional models were obtained. Support structures were used to stabilize the parts during printing, which were subsequently removed. (Fig. 4)

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Figure 1. Intraoral scanning image

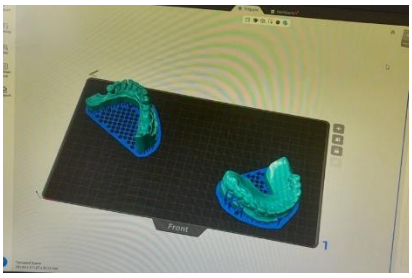

Figure 3. Digital casts ready for printing.

Figure 4. Casts during the 3D printing process.

After printing, the models were post-cured in a special ultraviolet light chamber, to complete the resin polymerization reaction and improve the mechanical properties of the material.

The casts were used for the digital design of the metal framework in the Exocad software. At this stage, the general shape, the dimensions of the infrastructure, the positioning of the aggregation elements and the characteristics of the connectors were established. (Fig. 5)

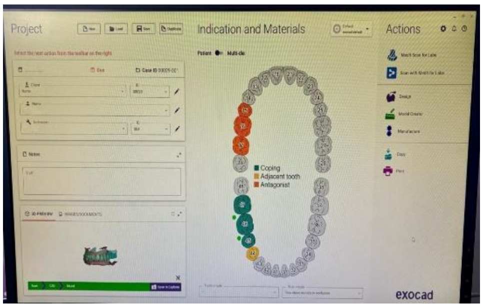

Figure 2. Case configuration in Exocad software.

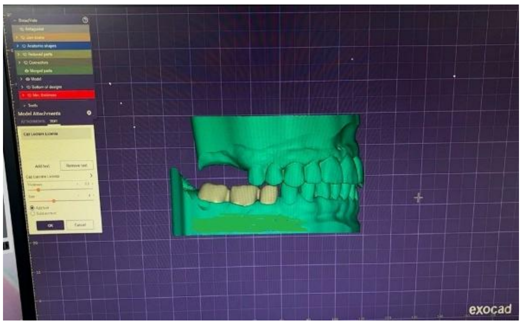

Figure 5. Designing metal infrastructure in Exocad

The metal infrastructure obtained with CAM machine by milling, it was subjected to the sandblasting process - an essential step for metal-ceramic restorations, in order remove impurities and residues from the metal surface. The process is performed with aluminum oxide particles (granulation of 250 μm) projected under controlled 4 bars pressure onto the metal surface (Fig. 6)

Figure 6. Infrastructure after blasting and its verification on the cast.

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In the case of metal-ceramic restorations in the lateral area, the design of the infrastructure is of particular importance, since this region is subject to increased masticatory stresses. For this reason, the aim was to create a metal framework capable of providing adequate support to the ceramic and evenly distributing the functional forces.

After preparing the metal infrastructure, the opaque layer was applied - the main role is to mask the metallic colour of the infrastructure and create an adequate chromatic base for the application of subsequent ceramic masses.

At the same time, the opaque contributes to the bonding between the metal and the ceramic and influences the final appearance of the restoration. The material was applied uniformly over the entire surface of the metal framework, avoiding excessive accumulations or insufficiently covered areas. After application, the restoration was placed in the oven to perform the firing cycle according to the manufacturer's instructions.

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Once the opaque was sintering, the ceramic layering applying step started. This is one of the most important phases of the realization of a metal-ceramic restoration, since the shape, volume and morphological characteristics of the future prosthetic work are built.

RESULTS AND DISSCUSIONS

After sandblasting and cleaning the infrastructure, the bonding agent was applied, with a role in optimizing the adhesion between the metal alloy and the ceramic masses applied subsequently. The material was applied in a thin and uniform layer on the surface of the metal infrastructure, subsequently subjected to a firing cycle according to the manufacturer's recommendations.

Ceramic sintering - after the first layering was completed, the restoration was placed in the ceramic furnace for the sintering cycle. During the process, the ceramic particles gradually approach and fuse, resulting in a compact and resistant structure. This process also causes a certain shrinkage of the material, which is why the layering was made slightly oversized.

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Figure 7. HeraCeram System

Figure 9. First ceramic layering – rendering the morphology

Figure 8. HeraCeram Layers

Figure 10. Sintering stage and restoration after processing

Figure 11. Second ceramic layering

Second ceramic layering - Following the evaluation carried out after the first sintering, additional ceramic masses were applied in the areas that required completion. The aim of this stage was to finalize the morphology and optimize the functional and aesthetic characteristics. The coronal volumes, occlusal relief and the transition areas between the different surfaces of the restoration were

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adjusted. This stage aims to compensate for the changes that occurred as a result of ceramic shrinkage and to obtain the final shape of the work.

Second sintering - After the application of the additional ceramic, the restoration was subjected to a new sintering cycle, to allow the stabilization of the changes made and the final shape of the restoration to be obtained.

After the completion of the thermal cycle, the morphology, volume and adaptation on the working cast were evaluated again.

Glazing the restoration - the final step, consisted of applying the glaze and performing the final sintering cycle. Glazing is the procedure by which the surface of the ceramic acquires its final appearance, characterized by smoothness and gloss. In addition to its aesthetic role, the glaze contributes to reducing surface roughness and decreasing the retention of bacterial plaque, and also provides the ceramic better chromatic stability.

Figure 12. Final metal-ceramic restoration

To keep up with the rapidly evolving of the technological field, ceramic processing has undergone significant transformations from the traditional powder-liquid suspension method. Modern techniques such as CAD-CAM processing and 3D ceramic printing allow the possibility to elaborate creation of faster and more precise restorations. Innovative processing methods such as hot ceramic pressing and bubble casting have been specifically adapted for different ceramic microstructures. [6]

The integration of digital technologies has fundamentally changed the workflow for fixed prosthetic restorations and has provided increased predictability and efficiency [6-9]. The frequent use of digital workflows is further driven by the growing demand for simplified, cost-effective, and outcome-oriented treatment approaches [6, 8, 9].

An important advantage of the inclusive application of digital workflows is accurate patient-specific prosthesis design, which contributes to enhanced prosthesis durability [10-12].

As concerning the ceramic system HeraCeram, this is a versatile metal-ceramic veneering system developed by Kulzer for rapid and highly aesthetic prosthetic restorations. It includes a complete range of powders, such as Dentin, Incisal, Glaze and Universal Stains. The material is distinguished by its unique composition: multi-granular structure based on pure quartz glass and stabilized leucite, which ensures translucency and a natural appearance. Also, it has a thermal flexibility: coefficient of thermal expansion between 13.5 and 14.9 \mm\mK\), making it compatible with a wide variety of conventional dental alloys.

In a study published in 2020, the authors founded that from 45 metal-ceramic restorations, as regarding the type of ceramic used, correlated with the observance of esthetical and functional standards, the VITA Ceramic was used in a percentage of 35%, HERA Ceram in a proportion of 40% and the IPS d.SIGN ceramic in 25% of the restorations (Grădinaru I. et al., 2020) [13]

The manufacturing procedure for the metal component of a metal–ceramic system can have a significant impact on the strength of the bond of the system. Based on the studies that were carried out, the most appropriate manufacturing procedure for the Co–Cr alloy, to ensure the compatibility of metal–ceramic systems for dental restorations, was casting, although each of the methods studied had its advantages and disadvantages. The choice of method should be based on the specific

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requirements of a particular restoration, as well as on the properties of the materials used.[14]

CONCLUSIONS

1. Dental aesthetics imposes the requirement of materials that satisfy the physiognomic, morphological and functional, biological, prophylactic and mechano-prosthetic requirements of patients. One such material is dental ceramics, which are very frequently used in prosthetic fixed restorations, solving a series of shortcomings of aesthetic materials.
2. Deciphering the aesthetic code of natural teeth determines a new, modern approach to developing the physiognomic component from ceramic masses, and the chosen tones and color shades will be obtained through successive, layered applications of ceramic masses, in a precise and perfectible manner. The chromatic richness, very close to that of a vital tooth, the brightness and the illusion of depth, will allow, step by step, the guidance towards a natural integration of aesthetic (ceramic) fixed restorations.
3. The CAD/CAM systems for the labs, involve a more extensive manufacturing process, often use new, advanced ceramic materials. These systems are typically employed for complex cases requiring high precision and durability, such as fixed prosthesis mainly in aesthetic areas.
4. Improving digital workflows represents an important possibility for future development in CAD-CAM technology. The integration of artificial intelligence (AI) into CAD-CAM systems will assure the best design workflow and will improve the precision of fixed prosthetic restorations.

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