Ref: Ro J Med Pract. 2022;17(3)
DOI: 10.37897/RJMP.2022.3.3

Comparative study on metal versus zirconium dioxide infrastructure manufacturing in prosthetic rehabilitation in the maxillary frontal zone

Sergiu DRAFTA[1], Viorel PERIEANU[1], Radu COSTEA[1], Oana EFTENE[1], Mihai BURLIBASA[1], Raluca Maria MANEA[2], Florentina CAMINISTEANU[2], Mircea CARABELA[2], Ioana-Cristina NEAGOE[3], Raluca COSTEA[2], Irina Adriana BEURAN[1], Nicoleta MARU[1]

[1]"Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania
[2]Private practice Bucharest, Romania
[3]University of Pitesti, Romania

Abstract

Prosthetic rehabilitation of the maxillary front teeth is an extremely laborious problem for the dental team, consisting of the dentist and the dental technician. If for the physiognomic component the most recommended materials are the ceramic masses, for the resistance substrate there are several variants. Conventional technologies using dental alloys and modern ones involving the use of zirconium dioxide can be used successfully in performing fixed prosthetic restorations in the maxillary frontal area, both options having both advantages and disadvantages, as we will describe in this material.

Keywords: prosthetic restorations, infrastructure, dental alloys, zirconium dioxide

INTRODUCTION

The purpose of dental medicine is the care, recovery and maintenance of dental health and the entire dental-maxillary system (DMS), with all its structures. Extremely important for dental practitioners is the aesthetic component, so we can not talk about dental health or the restoration of DMS structures, without taking into account elements and rules of aesthetics and beauty. Dental health care, prevention of diseases in the DMS area and restoration of dental health meet the needs of the individual for security, comfort and personal care, as well as the aesthetic requirements of him or her community. Thus, dental medicine actively contributes to the development of human civilization, bringing its significant contribution to scientific progress through its research and achievements [1-7].

OBJECTIVES

Dental practice requires the choice of materials that meet the needs of the patient both aesthetically and functionally, as well as their strength. Following the scientific research in the technical and dental field in the last decades, new biocompatible materials have appeared, which satisfy the demands of dentists, dental technicians and patients.

The variety of dental materials has diversified the technologies for performing prosthetic restorations,

Corresponding authors:
Viorel Perieanu
E-mail: viorelperieanu@yahoo.com

Article History:
Received: 13 July 2022
Accepted: 20 July 202

knowing the particularities of each method with their advantages and disadvantages or limitations, allows choosing the right therapeutic solution and solving the most difficult clinical situations, in optimal conditions [8-15].

At this moment, in Romania, the most used materials to obtain the resistance infrastructure of some fixed prosthetic restorations covered with ceramic masses in the maxillary frontal area with the aim of physiognomic rehabilitation of this area, are represented either by chromium-based metallic alloys obtained by casting or milling (nickel-chromium - Ni-Cr and cobalt-chromium - Co-Cr), either of materials such as zirconium dioxide or zirconia obtained by computerized milling technology CAD – CAM [1-15].

Restoring ADM functionality should be viewed differently depending on the position of the tooth on the arch. For the lateral area, the emphasis is on the restoration of the mastication, while in the frontal area, the emphasis is on the aesthetic restoration. Even if both options mentioned above can restore the morphology and functionality of the dental arches in the frontal area with results that can be categorized from satisfactory to spectacular, we must not neglect the fact that the restorations made on metal support have the impediment of the coloristic aspect given by the alloy, which must be compensated by opacifying substances. On the other hand, zirconia has a matte appearance that blocks unpleasant colors from the dental abutments and at the same time makes it easier to obtain aesthetics by applying ceramic masses [1-15].

Specifically, both chromium-based dental alloys (Co-Cr, Ni-Cr) and zirconium dioxide (Zirconia) are recommended in current prosthetic practice, for making the strength structures of fixed prosthetic restorations in the frontal area. In our case, we are in fact discussing a comparative study on some technological aspects of performing fixed prosthetic restorations, which aim at the physiognomic rehabilitation in the frontal area with maxillary location by restorations based on metal or zirconia.

MATERIAL AND METHODS

In order to be able to make a correct evaluation of the two types of restorations, it is good to know the technological workflows for obtaining totally physiognomic fixed prosthetic restorations (covered with ceramic masses) with metal infrastructure or with dioxide infrastructure, which can be described as follows [1-15].

I. Clinical and technical stages of obtaining ***porcelain fused to metal*** prosthetic restorations (obtaining the metal infrastructure through classical casting technology): clinical examination; establishing the diagnosis and the treatment plan; preparation of the abutments; impression of the prosthetic field; casting the working model; creating wax pattern of the metal component; investing the wax pattern; obtaining the mould; casting the metal framework; de-vesting the metal framework; trimming and finishing of the metal framework; trying in the metal framework in the dental office; fusing the ceramic component on the metal framework; examination on the model and in the oral cavity of the porcelain fused to metal crown; cementing the prosthetic restoration on the dental abutment.

II. The technological workflow for obtaining prosthetic restorations on the support of ***zirconium dioxide (Zirconia)*** (obtaining the Zirconia framework through the CAD - CAM computerized milling technology): the clinical examination; establishing the diagnosis and the treatment plan; preparation of the abutments; impression of the prosthetic field; casting the working model; preparing the working model for scanning; scanning the working model; creating the virtual model; designing the framework of the future prosthetic part with the help of specialized software; milling the Zirconia framework from a zirconium dioxide disc; trying in of the framework in the oral cavity; application of ceramic mass on Zirconia; trying in of the prosthetic restoration in the oral cavity; applying the glaze; cementing the prosthetic restoration.

OUTCOMES

Starting from the theoretical description of the technological workflow for the two types of restorations previously described, in the following will exemplify two clinical situations of restoring the morphology and functionality of the frontal area of the maxillary arch by complete aesthetic restorations on metal or zirconia substrate.

Case 1

Total physiognomic prosthetic rehabilitation, porcelain fused to metal, with framework made of nickel-chromium (Ni-Cr) alloy.

FIGURE 1. *The appearance of the maxillary prosthetic field (teeth were restored with the help of cast post and cores made of Ni-Cr dental alloy)*

FIGURE 2. *Final modeling of the wax pattern (see also the sectional working model)*

The investing of the wax pattern was made using Bego Rapid Wax sprue with runner bar system. Sprue bars are prefabricated cylinder wax bars. On each element, a 5 mm rod with a diameter of 2.5 mm, for the secondary flow channels of the alloy, is applied in the incisal third of the palatal face, at a maximum angle of 45°. At the free end of these rods, a rod with a diameter of 5 mm is applied (running bar), parallel with the wax patterns from the working model. This rod represents wax pattern of the intermediate flow channel for the liquid alloy. A 3.5 mm diameter rod is attached to this rod so that the ends are interposed between two secondary channels.

The investing of the wax patterns is done in one time [16]. The mixing of the investment material is done with the help of the vacuum-mixer, and the casting of the material in the investment ring with the help of vibrating table in order to ensure a better homogeneity and density, by eliminating the air bubbles [16].

FIGURE 3. *Rapid Wax system (Bego) attached to wax patterns prepared for investment [8]*

FIGURE 4. *Metal framework after de-vesting*

FIGURE 5. *Working models mounted in articulator, the final aspect of metal framework after sandblasting and trimming*

FIGURE 6. *Prosthetic restorations after applying of ceramic masses*

FIGURE 7. *Total physiognomic prosthetic rehabilitation, porcelain fused to metal*

Case 2

Aesthetic prosthetic restoration with zirconium dioxide (Zirconia) infrastructure.

In this case, the dentist opted for a prosthetic restoration with Zirconia infrastructure both in order to obtain a prosthetic piece with a more natural look, but also to ensure its longest lasting resistance. The Zirconia infrastructure was obtained through CAD - CAM technology.

FIGURE 8. *Sectional working model*

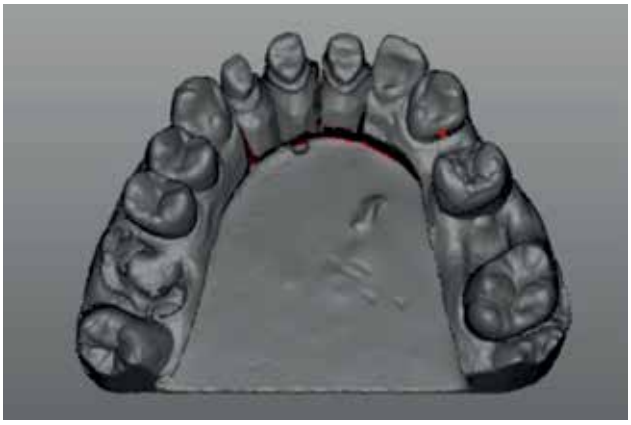

FIGURE 9. *Scanning of the working model.*

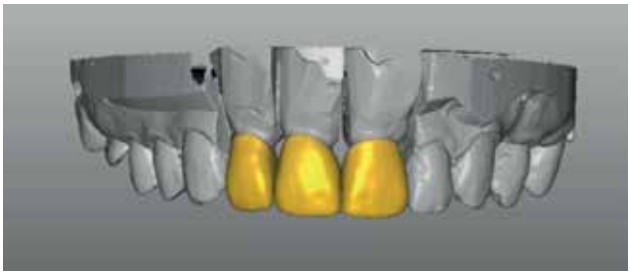

FIGURE 10. *Creating the design of the virtual framework*

FIGURE 11. *Trying in of Zirconia copings obtained by CAD-CAM technology on working model*

After the computer design of the prosthetic restorations, the virtual image was transferred to the milling machine for processing. actual milling was carried out, with all the related maneuvers (according to the clinical-technical stages presented in Materials and methods). The obtained Zirconia coping are shown in Figure 11.

FIGURE 12. *Prosthetic restorations on zirconia support before trying in on dental abutments*

FIGURE 13. *Prosthetic restoration after applying the glaze layer*

DISCUSSIONS

Regardless of the treatment plan chosen, prosthetic restorations must restore the morphology and functionality of the dental arches affected by various lesions. At the level of functionality in the lateral area, the emphasis is mainly on the masticatory function, while in the frontal area the emphasis is on restoring the aesthetic function [17-19]. Dental alloys have been used for a long time in the frontal area as infrastructure for mixed restoration. With the development of processing technologies, the way has been opened for the use of other materials for infrastructure of mixed restoration such as zirconia [20-22].

Fixed porcelain fused to metal prosthetic restorations combine the advantages of metal infrastructure, such as tensile strength, with those offered by ceramic masses - esthetics, biocompatibility, etc. [23,24].

Porcelain fused to zirconia restorations have a special aesthetic and can faithfully reproduce the texture, translucency and natural shades of the teeth, these being the materials of choice, in the case of prosthetic restorations in the frontal area [25, 26].

The classic technology for obtaining the metal structure by melting / casting is the most often used in current practice, being perfected over time to reduce errors that may occur in the technological workflow. Wide use also automatically involves lower production costs [23,24].

Modern milling technologies have made it possible to replace metal alloys in mixed restorations with more aesthetic materials that could not be obtained by classical techniques [25, 26].

This technological evolution, which comes with a multitude of advantages related in particular to the precision and aesthetics of prosthetic restorations, is accompanied by an increase in production costs that is felt directly on the patient [27, 28].

CONCLUSIONS

The two categories of materials used for infrastructure of mixed restoration of the maxillary frontal area have both advantages and disadvantages.

The metal alloys benefit from a well-developed and very accessible technology, but they have a major color impediment that makes difficult to obtain a superior aesthetic, especially in the cervical area, where the restorations have a reduced thickness.

On the other hand, zirconium dioxide has mechanical properties similar to dental alloys and also has a color similar to hard dental tissues, which makes it easier to obtain restorations with a high degree of aesthetics. The major disadvantage of zirconia is the cost of production due to the complex equipment required to obtain it.

Conflict of interest: none declared
Financial support: none declared

REFERENCES

1. Macris A, Preoteasa CT, Iliescu AA, Luca I. Considerații statistice privind comportamentul coroanelor și punților dentare de trei elemente din ceramic zriconică. *Rev Rom Stom*. 2014;14(4).
2. Lăzărescu F. Incursiune în estetica dentară. București: SSER, 2013.
3. Ghidrai G. Infodentis: Zirconiul în stomatologie, lucrări dentare din zirconiu. Accessed April 28, 2022. https://www.infodentis.com/coroana-dentara-punte-dentara/zirconiu.php
4. Giordano R 2nd. Zirconia: a proven, durable ceramic for esthetic restorations. *Compend Contin Educ Dent*. 2012 Jan;33(1):46-9.
5. Gligor MR, Malița MA, Perieanu VS et al. Aspecte teoretice și practice în tehnologia protezelor unidentare – Parte I. În: Gligor MR, Malița MA, Perieanu VS et al. Tendințe moderne în științele biomedicale Vol 20. București: Editura Matrix Rom; 2021: p. 9-153.
6. Gligor MR, Malița MA, Perieanu VS et al. Aspecte teoretice și practice în tehnologia protezelor unidentare – Parte II. În: Gligor MR, Malița MA, Perieanu VS et al. Tendințe moderne în științele biomedicale Vol. 20. București: Editura Matrix Rom; 2021: p. 154-336.
7. Bratu D, Nussbaum R. Bazele clinice și tehnice ale protezării fixe. București: Editura Medicală; 2006: p. 353-375.
8. Cristache CM, Burlibasa M, Cristache G et al. Zirconia and its biomedical applications, *Metalurgia International*. 2011;16(7):18-23.
9. Mocuța D, Popovici IA, Burlibasa L et al. Impact of the living conditions on population health. *Metalurgia International*. 2009; 14:17-19.
10. Burlibasa L, Chifiriuc MC, Lungu MV et al. Synthesis, physico-chemical characterization, antimicrobial activity and toxicological features of Ag-ZnO nanoparticles, *Arabian Journal of Chemistry*. 2020;13(1): 4180-4197.
11. Burlibașa M, Cernușcă-Mițariu M, Cernușcă-Mițariu S et al. Theoretical and practical aspects related to biomaterials decontamination in dental medicine (with reference to dental prosthetics). *Metal Internation*. 2013;18(4):261-267.
12. Mocuta D, Popovici LR, Dumitriu AS et al. Life quality-condition of social welfare. *Metalurgia International*. 2009;14:62-64.
13. Burlibașa M, Muntianu L, Tănase G et al. Study on microbial contamination of biomaterials in medical practice. *Metalurgia International*. 2010;15(SI2):163-166.
14. Tănase G, Burlibașa M, Muntianu L et al. Testing the antibacterial potential of biomaterials in medical practice. *Metalurgia International*. 2010;15(SI2):160-162.
15. Burlibașa M, Tănase G, Muntianu L et al. Quality of life, a multidisciplinary concept with economic and social impacts in medical practice. *Metalurgia International*. 2010;15(SI4):88-90.
16. Bego. Rapid Wax system. Accessed April 17, 2022. https://www.bego.com/conventional-solutions/materials/modelling/modelling-k-b/product/Product/show/571/
17. Henriques B, Gonçalves S, Soares D, Silva FS. Shear bond strength comparison between conventional porcelain fused to metal and new functionally graded dental restorations after thermal-mechanical cycling. *J Mech Behav Biomed Mater*. 2012 Sep;13:194-205.
18. Lajnert V, Pavičić DK, Gržić R et al. Influences of age and maxillary anterior teeth status on patient's satisfaction with dental appearance and tooth color. *Gerodontology*. 2012 Jun;29(2):e674-9.
19. Peng M, Fei W, Hosseini M, Gotfredsen K. [Crown color match of implant-supported zirconia and porcelain-fused-to-metal restorations: a spectrophotometric comparison]. *Hua Xi Kou Qiang Yi Xue Za Zhi*. 2014 Feb;32(1):62-5.
20. Vigolo P, Mutinelli S. Evaluation of zirconium-oxide-based ceramic single-unit posterior fixed dental prostheses (FDPs) generated with two CAD/CAM systems compared to porcelain-fused-to-metal single-unit posterior FDPs: a 5-year clinical prospective study. *J Prosthodont*. 2012 Jun;21(4):265-9.
21. Larsson C. Zirconium dioxide based dental restorations. Studies on clinical performance and fracture behaviour. *Swed Dent J Suppl*. 2011;(213):9-84.
22. Christensen GJ. Choosing an all-ceramic restorative material: porcelain-fused-to-metal or zirconia-based? *J Am Dent Assoc*. 2007 May;138(5):662-5.

23. Appleby DC. Control of form and function for esthetics in the maxillary anterior porcelain-fused-to-metal restoration. *Compend Contin Educ Dent*. 1985 Mar;6(3):210-1, 214-21, 224 passim.
24. Singh K, Gupta N, Kumar N et al. Esthetic and functional rehabilitation of missing anterior teeth with a conservative treatment approach: a clinical case series. *Oral Health Dent Manag*. 2014 Sep;13(3):656-60.
25. Ferrari M, Sorrentino R, Cagidiaco C et al. Short-term clinical performance of zirconia single crowns with different framework designs: 3-year clinical trial. *Am J Dent*. 2015 Aug;28(4):235-40.
26. Monaco C, Llukacej A, Baldissara P et al. Zirconia-based versus metal-based single crowns veneered with overpressing ceramic for restoration of posterior endodontically treated teeth: 5-year results of a randomized controlled clinical study. *J Dent*. 2017 Oct;65:56-63.
27. Papaspyridakos P, Lal K. Computer-assisted design/computer-assisted manufacturing zirconia implant fixed complete prostheses: clinical results and technical complications up to 4 years of function. *Clin Oral Implants Res*. 2013 Jun;24(6):659-65.
28. Pozzi A, Holst S, Fabbri G, Tallarico M. Clinical reliability of CAD/CAM cross-arch zirconia bridges on immediately loaded implants placed with computer-assisted/template-guided surgery: a retrospective study with a follow-up between 3 and 5 years. *Clin Implant Dent Relat Res*. 2015 Jan;17(S1):e86-96.