Chairside and Labside CAD/CAM Workflow for Esthetic and Functional Smile Design Rehabilitation

Dragos Adam¹, Andrei Faur¹, and Anca Jivănescu¹

¹University of Medicine and Pharmacy Victor Babes Timisoara

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Case Report
Chairside and Labside CAD/CAM Workflow for Esthetic and Functional Smile Design Rehabilitation
Dragos Andrei Adam¹, Andrei B. Faur¹,² and Anca Jivănescu¹,²

¹Department of Prosthodontics, University of Medicine and Pharmacy “Victor Babes”, B-dul Revolutiei 1989, No. 9, 300580 Timisoara, Romania; adam.deagos@umft.ro (D.A.); andrei.faur@umft.ro (A.B.F.); jivanescu.anca@umft.ro (A.J.)
²TADERP Research Center, Department of Prosthodontics, University of Medicine and Pharmacy “Victor Babes”, B-dul Revolutiei 1989, No. 9, 300580 Timisoara, Romania

* Correspondence: adam.dragos.andrei@gmail.com; Tel.: +40-744765857

Abstract: Esthetic restorations that mimic the patient’s individual naturalness must be shaped and guided by the patient’s complex facial features and physiognomy. CAD/CAM protocols allow us to communicate treatment options with the patient, enabling us to understand the patient’s aesthetic preferences and to convey to the dental technician a viable, functional, physiognomic, and yet patient-accepted treatment option.

This case report presents a case of aesthetic frontal rehabilitation based on a fully digital workflow on a young female patient with Kennedy class IV frontal edentulousness. The workflow consisted in a digital smile design protocol, 3D-printed diagnostic wax-up, multiple 3D-printed provisional restorations and a CAD/CAM zirconia fixed dental prostheses.

Complex cases of frontal rehabilitation can be functional and aesthetically solved using digital methods and predictable CAD/CAM protocols, by establishing a good communication of the whole team, accurately and thoroughly transmitting all the details related to the aesthetics and natural anatomy of the patient and performing several stages of provisional treatment before the final restoration.

Keywords: CAD/CAM, zirconia fixed dental prostheses, 3D-printed provisional restorations, 3D-printed diagnostic wax-up, frontal rehabilitation, digital workflow.

1. Introduction

A person’s smile is influenced by the size, shape, and color of the teeth, the position, texture, color and lines of the lips and gingiva, as well as the shape of the jaws. The most appealing, fulfilling, and fascinating component of dentistry is creating aesthetically pleasing smile design [1,2]

Fulfill the patient’s expectation is a key goal of the aesthetic treatments, and the result be improving the appearance of his or her face and smile. By achieving a simulation and previsualization of the outcome of the suggested therapy, Digital Smile Design (DSD) is a digital tool that aids in the creation and projection
of the new smile. A digital mockup of the patient’s new smile is created and presented to them before the actual treatment process begins. This allows for careful examination of the patient’s facial and dental characteristics that play a crucial role in determining the treatment plan [3–5].

The development of simplified and predictable protocols in the field of restorative dentistry has been made possible by the advancement of digital technology in dentistry. CAD software can be used to create the temporary and permanent prosthesis as well as the master die model, which can then be produced using 3D printing or milling.

Additive procedures have recently been used in restorative dentistry in order to give the dental professional more restorative alternatives. As printing methods are becoming more accurate, the doctor can use digital design (CAD) to create initial diagnostic models, full removable dentures, surgical guides, and temporary restorations. Due to its reproducibility, low cost, and speed of treatment, utilizing a three-dimensional (3D) printed coping to assess the marginal adaptation of the final prosthetic restoration is a solid option. Fixed dental prosthesis using printed materials and techniques may become quite popular in the near future [6,7].

Zirconia was initially employed in dentistry at the beginning of the 1990s and has since become widely accessible through the use of CAD/CAM technology. According to recent surveys, dentists frequently propose ceramics, particularly lithium disilicate and zirconia, for both front and back single crowns [8].

In the present dental industry, there are several different zirconia materials, and the level of yttrium oxide significantly affects the mechanical and optical capabilities of the restoration. High biological stability and biocompatibility, as well as excellent mechanical qualities, are all characteristics of zirconia. The main drawback of this material is its opacity, which makes it less aesthetically pleasing than other ceramic materials, but can be overcome by stabilizing it with yttrium. While zirconia with 3 mol% yttrium oxide (3 Y-TZP) exhibit high flexural strength, it is not the same for case zirconia with 5 mol% yttrium oxide (5 Y-TZP). Although it is not advised to fabricate fixed dental prostheses larger than three units from 5 Y-TZP, greater translucency may also result in superior aesthetics [9–12].

This case report presents a smile design rehabilitation for a young female patient with Kennedy class IV frontal edentulousness, based on a fully digital workflow. The workflow consisted in a digital smile design protocol, 3D-printed diagnostic wax-up, multiple 3D-printed provisional restorations and a CAD/CAM zirconia fixed dental prostheses, in order to restore the smile design considering the facial characteristics, in an accurate and predictable way.

2. Case Presentation

The patient was a 26-year-old Asian woman who came to the Department of Prosthodontics Clinic at the University of Medicine and Pharmacy “Victor Babes”, Timisoara, Romania, in February 2023, with a chief complaint regarding her old prosthetic. The patient presented a Kennedy class IV frontal edentulousness, restored with an eleven years old removable partial denture (Figure 1).
A thorough clinical and radiological examination of the dental and periodontal status was performed, as well as the photographic setup (Figure 2). The patient signed the informed consent alongside the additional documents of study participation in accordance with the ethical standards of the Helsinki Declaration and its later amendments.

The patient requested a fixed restoration solution that would be fully functional and aesthetically integrated into her physiognomy and facial features.

Figure 1. Kennedy class IV frontal edentulousness: (a) the old Kemeny removable partial denture; (b) edentulous space central view; (c) edentulous space left view(d) edentulous space right view.

Figure 2. Frontal pictures of the patient in: (a) physiologic rest position; (b) smile position without the prosthesis; (c) smile position with the Kemeny prosthesis inserted.

The patient was offered the alternative of a surgical treatment including implants and augmentations of soft and hard tissues. However, the patient rejected any surgical treatment.

The first step was to take digital impressions, for both the mandible and maxilla with an intraoral scanning device (Medit i700, Medit Link v3.0.4, Medit, Seoul, South Korea, 2021). Additionally, a face scan was acquired with same device (Figure 3). It is necessary and advantageous to digitally design and previsualize
the new smile, which is the best way to communicate with the patient and facilitate the treatment planning of the case. The initial 2D smile design was made using Medit Smile Design (Medit Link v3.0.4, Medit, Seoul, South Korea, 2021) (Figure 4). Once the diagnostic design was finalized, it was presented to the patient as a before and after picture.

Figure 3. IOS scans: (a) intraoral scan in occlusion; (b) face scan with the patient in smile position.

Figure 4. Medit Smile Design.

The shade of the patient’s teeth was determined by using the Vita Shade Guide (Vita Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany) alongside the Vita Easy Shade spectrophotometer (Vita Zahnfabrik H. Rauter GmbH & Co. KG, Bad Säckingen, Germany) and analyzed with the help of Digital Shade Assistant on the Programat CS6 furnace (Ivoclar Vivadent, Schaan, Liechtenstein, 2021) resulting in the shade A2 (Figure 5).
The next step was to generate a 3D digital wax-up starting from the 2D digital smile design using a CAD software (DentalCAD, Exocad GmbH, Germany) which was also used for all the subsequent laboratory steps. The digital diagnostic wax-up including the frontal maxillary area was designed for creation of an additive mock-up over the existing patient smile, and the digital model was printed using a 3D printer (Prusa SL1S 3D, Prague, Czech Republic) (Figure 6). The digital mock-up is an essential step that allows the patient to evaluate the esthetics and to give the consent for the proposed treatment.

One of the greatest challenges in a smile makeover restoration is to reproduce exactly what has been digitally planned, previsualized and presented to the patient. In this case, conservative crown preparation with vertical finish line were made, ensuring the minimum necessary thickness of the material and limiting the volume of the pontic of the future fixed dental prostheses.

The conservative preparations were made over the mock-up to ensure maximum preservation of hard dental tissue and pulp vitality. The preparation included the right upper canine, the right upper lateral incisor and the left upper canine. The teeth preparation was performed based on the evaluation of the teeth alignment and angulation and the need to create a path of insertion for the monolithic zirconia fixed dental prostheses.

Following the teeth preparation and digital impression phases, the dental technician designed a new set of restorations based on the mock-up, and produced a 3D printed provisional restoration prototype to test drive esthetics, function, and patient perceptions. Two 3D printed restorations were made during the three weeks test drive phase. The first provisional restorations focused on the conformation and development of the soft tissues for ovate pontic design, while the second one brought changes and improvements of the size and shape of the frontal teeth (Figure 7).
After the healing period of the soft tissues and the patient’s confirmation of the aesthetics, the final digital impression was made. The final fixed dental prostheses were designed by the dental technician using DentalCAD 3.1 (Exocad GmbH, Darmstadt, Germany), by using the option to copy the design of the latest 3D printed provisional restoration within the CAD software.

The final restorations consisted of a milled monolithic zirconia fixed dental prostheses (Katana Zirconia YML, Noritake, Japan) that was cemented with the help of an adhesive resin luting system (RelyX Universal, 3M, U.S.A.) (Figure 8). The choice of Katana Zirconia YML as the final monolithic restoration material was based on the features of this material that presents a well-balanced combination of mechanical strength and esthetics.

### 3. Discussion and Conclusions

Novel technologies have been widely used in dentistry for diagnosis, treatment planning, and execution [13–15]. The implementation of the digital workflow aims to provide a faster and more predictable treatment.

A successful smile makeover has a positive impact on a patient’s life, and this should be the goal of any dental restoration. Careful planning, tooth preparation according to a minimally invasive approach, and the
correct choice of materials for both the restoration and the luting are essential to ensure a successful and long-term restorative outcome.

The digital workflow provides numerous advantages, these can be summarized as improved communication, more efficient treatment and predictable outcomes.

Digital dental processes have become more user and patient-friendly due to their predictability, accuracy, effectiveness, and reduced need for multiple appointments [16]. Additionally, 3D modeling can create a virtual representation of the patient using intraoral and facial scanners, enabling the dental professional to assess the initial, proposed, and final treatment stages as frequently as necessary without the patient being physically present in the dental chair [17]. A recent systematic review and meta-analysis examined patient preferences and clinical work time for digital scanning versus conventional impressions [18]. The findings indicated that digital scanning was superior and favored by patients due to its time efficiency compared to conventional methods [17]. In the case presented, the patient also expressed a preference for digital technology over traditional techniques.

Along with the improvement of CAM procedures, new materials with improved physical and optical properties are used. Currently, zirconia-based ceramics are the most widely used materials. The current trend advocates for the use of monolithic restorations. While the traditional 3 Y(yttria) zirconia materials may compromise the esthetic outcome, the new generation of translucent 5Y zirconia materials shows improved optical properties, enhanced esthetics, but with a reduced flexural strength. Katana YML (Kuraray Noritake Dental Inc) selected in this study matches three raw materials with different yttria contents, combining a well-balanced color/translucency and flexural strength gradation (from 750 to 1100 MPa). The body layer of YML can be adjusted thinner than that of high translucency zirconia, increasing its translucency even more.

This aspect was desirable for this case to achieve satisfying aesthetics, without compromising the strength of the restoration, considering the size of the edentulous ridge and its position in a highly aesthetic area. Monolithic zirconia has the ability to achieve a restoration thickness of less than 0.8mm axially, unlike layered zirconia or metal-ceramic restorations that necessitate a greater thickness and consequently the preparation would be more invasive and might not be able to preserve the vitality of the teeth.

The surgical treatment option was not pursued in this case as in addition to the patient’s refusal of surgical treatment, the case would have raised problems related to a lack of hard and soft tissue due to the rather old edentulous area.

Adhesive cementation was essential in this case in order to increase the strength and adhesion of the fixed dental prosthesis and must be performed using a state-of-the-art protocol.

In the present case, a chairside and lab-side digital workflow was utilized from the planning phase to the milling of the fixed dental prostheses and it was able to render results in a predictable and reproducible manner, achieving satisfactory outcomes for both the dental team and the patient.


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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patient(s) to publish this paper.
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References


