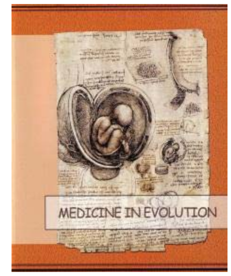
Digital vs conventional workflow in fixed prosthodontic restorations



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Abstract

Aim and objectives: This study will try to emphasize the differences between different materials and technologies currently used for dental crown manufacturing.

Materials and methods: We performed 4 different types of dental crowns, using different materials and technologies, on the same preparation, on 4 different duplicate models, and we examined the marginal adaptation and the surface quality, using a HD camera.

Results: The worst results, both in marginal adaptation and surface quality, were found to be present in the crowns manufactured in the traditional casting and waxing manner.

Discussions: The traditional procedures, which involve casting and waxing, are many times subject to human error and are also affected by many physical factors, which are harder to control.

Conclusion: Regardless on the material chosen – metal, ceramic or zirconia, the CAD-CAM technology offers better properties to the final restorations and, thus, more safety to the clinician and to the dental technician.

Keywords: Fixed restorations, digital workflow, marginal adaptation

INTRODUCTION

One of the biggest challenges in dentistry is the marginal sealing of fixed restorations. This problem not only involves clinical management and protocols, but also different technological procedures. First problem that researchers have to overcome is how to determine precisely the quality of the crown-abutment marginal interface. As Noor A. Nawafleh[1] et al. point out, in their literature review, there is a substantial lack of consensus relating to marginal adaptation of various crown systems due to differences in testing methods and experimental protocols employed. However, direct view technique was the most commonly used method of reproducible results.

Tooth preparation is very important in order to obtain a good quality prosthetic restoration, especially regarding the marginal adaptation, but also a good biological response from the surrounding tissues[2, 3, 4, 5]. From a clinical perspective, the preparation step should always be done using strict guiding protocols, such as the silicone keys[2] to obtain the best possible outcome. Regarding the type of preparation, there is a debate in the international literature, whether or not the finish line design affects the overall outcome, depending on the protocols and materials used. While some authors[6] have found little or no difference between different preparation types, there are articles who suggest that the finish line can influence the marginal fit of the crown[7, 8, 9, 10]. As Comlekoglu et al.[8] wrote in the conclusion of his study, the preparation design should always relate to the material and technology used for the final crown: „Although the feather-edge finish line resulted in lower absolut marginal opening and marginal opening values, with its proven mechanical disadvantage, it cannot be recommended in clinical applications of zirconia crowns. This type of finish line has acted solely as a control group to test the null hypothesis in the current study. For better marginal adaptation, both shoulder and mini-chamfer finish line types could be suggested for zirconia crowns."

Impression is also a very important topic when it comes to crown adaptation. When dealing with traditional impression methods, the depth and the width of the gingival sulcus play a vital role in obtaining a correct and well fitted crown[11]. When it comes to optic impression techniques, the results may vary depending on the brand and/or protocols that are being used[12].

Aim and objectives

The aim of the study is to determine the factors that can influence the overall quality of a fixed prosthetic restoration. From clinical procedures related to tooth preparation, the impression material/protocol or the technological steps, all these factors contribute to the final outcome and have to be taken into consideration, but the main focus of the present study will be on the technological procedures and protocols.

MATERIALS AND METHODS

For the experimental part, four types of crowns were made, using different materials and technologies on a cast. All of them were done on the first upper molar, which was previously prepped using the chamfer finish line design. The first type of crown is a metallic infrastructure, obtained through the classical casting technique. Since our main aim is the marginal investigation, there was no use in adding the ceramic on top. The next 3 types of crowns were milled using the CAD-CAM technology: a metallic infrastructure initially milled in wax, a computerized milled zirconia and a computerized milled pressed ceramic infrastructure.

In order to minimize errors, all the crowns were made in the same dental laboratory, by the same dental technician and all steps were strictly recorded and documented.

Creating and duplicating the working casts with removable abutments

Firstly, the working cast will be duplicated, using the two component duplication silicone from Feguramed (Fig. 1). A class IV super hard gypsum from GC Fuji Rock was used for models' casting.

Figure 1. The cast's duplication

In order to create the working casts with removable abutments, the cast was poured, then, to insert the pins, the wells were drilled, using the Pindex system. Double pins with sheath were used, which were attached with superglue. To prevent the cast's gluing to the socle, the cast was isolated, using a gypsum-gypsum insulating agent. After that, a vertical preparation was performed and the abutments were sectioned, using the Model Cut device. Afterwards, the different materials and techniques were used to manufacture the crowns, as it follows.

Metal crown made using casting and waxing procedure:

The die spacer varnish, from Durolan company, was applied on the abutments. After it has dried, the abutment was isolated with a gypsum-wax insulating agent, which facilitates the wax template's removal from the cast.

After the abutment's isolation, it has been introduced into a wax immersion bath, in order to obtain the infrastructure's wax template. A 2 mm diameter sprue and a wax ball, which will serve as an alloy tank during the investing stage, were attached to the infrastructure (Fig. 2). Then, the entire structure was attached to the casting cone.

Figure 2. The sprue's attachment

The casting cone and the template were inserted into a conformer. Previously, on the template was applied a tension easer. Next, the investment material was chosen, the powder from Bellavest SH and the liquid from BegoSol HE, and prepared, according to the manufacturers' instructions. To obtain the best results, the vacuum-mixer was used for mixing the powder with the liquid.

After the investment material has strengthened, the pattern was introduced into a preheating oven, at 1000ºC, for wax removal (Fig. 3).

Figure 3. Preheating the oven

After the wax removal from the pattern, the next step is the metallic alloy's casting process. Co-Cr is the alloy used for metallic infrastructure's casting. The alloy was melted at 1450ºC, using the Power Cast automatic centrifuge from Heraeus-Kulzer.

The pattern, in which the metal was casted, is left for cooling. The next steps are the devesting, in order to clean the metal piece, and sandblasting (Fig. 4 & 5). By sandblasting, microretentions are created, to increase the contact surface with the polymer. Using a rotary instrument, the metallic substructure was cut from the sprue, followed by the processing and adaptation of the infrastructure to the cast.

Figure 4. Unpacking of the metal infrastructure

Figure 5. Infrastructure on the working cast

For the rest 3 restorations, the **digital protocol** was used, so, the casts were scanned with a laboratory scanner, to obtain the virtual casts (Fig. 6 & 7).


Figure 6. Mandibular virtual cast

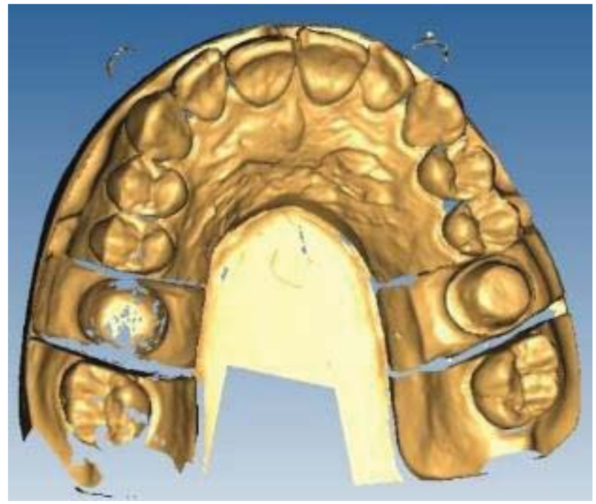
Figure 7. Maxilary virtual cast

The restorations' design were made using the Ceramill Mind program. After selecting the abutment teeth, the preparation's boundaries were set in order to obtain a both, functional and biological restoration, but also to have the best fit possible (Fig. 8 & 9).

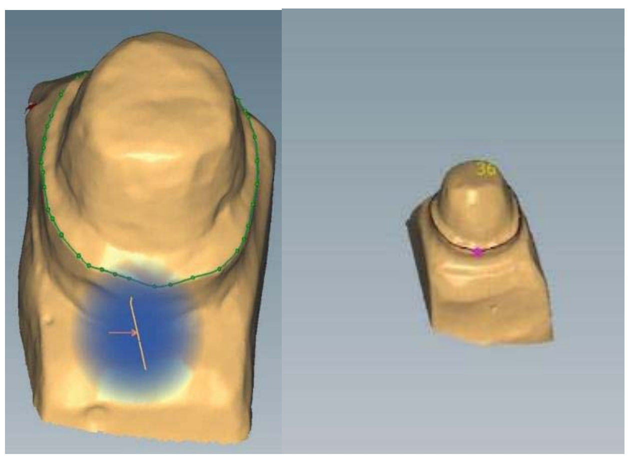
Figure 8,9. Setting the preparation's margins

The first digital restoration created was a full pressed **ceramic** crown, initially milled in wax. After obtaining the wax template using the CAD-CAM, the next step was the investing. A 0,4 mm diameter sprue has been attached to the pressed ceramic infrastructure's template. The materials used were investing mass from IPS Press Vest (Ivoclar Vivadent, Lichtenstein), liquid for investing mass from Ivoclar Vivadent and distilled water. The powder-liquid dosage was performed according to the manufacturer's instructions. Initially, the powder and the liquid were mixed with a spatula, to obtain homogenization and after, the mixture was introduced into a vacuum-mixer to achieve the optimal consistency. Then, the paste was carefully casted, until the ring was filled, without deforming the template.

After being kept in the same position for 40 minutes, the assembly was placed into a preheating oven, at 700ºC, for about 40 minutes (Fig. 10).

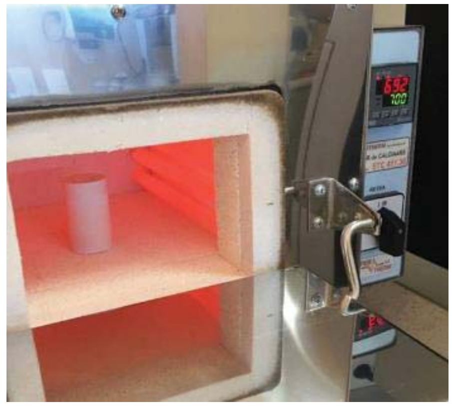

Figure 10. The preheating oven

When the preheating was complete, the assembly was pulled out from the oven. The ceramic ingot was inserted into the ring, and above the ingot, the pressing cylinder was placed. Next, the final assembly was positioned into the ceramic pressing oven Programat EP3010 from Ivoclar Vivadent, at 710ºC, for 15 minutes.

The next steps are the devesting and sandblasting, before checking the fit on the cast (Fig. 11 & 12). At the end, the pressed ceramic infrastructure can be individualized for better aesthetic outcome.

Figure 11. The sandblasted crown

Figure 12. The crown's check up on the cast

The second digital restoration was also a **metal** crown. After realizing the digital design, a wax pattern was milled using the CAD-CAM. For milling procedure of the metal infrastructure, a unit with 5 axes Ceramill Motion 2 from Amann Girrbach was used. After obtaining the pattern, the rest of the technological steps were done as previously described to finish the metallic infrastructure (Fig. 13).

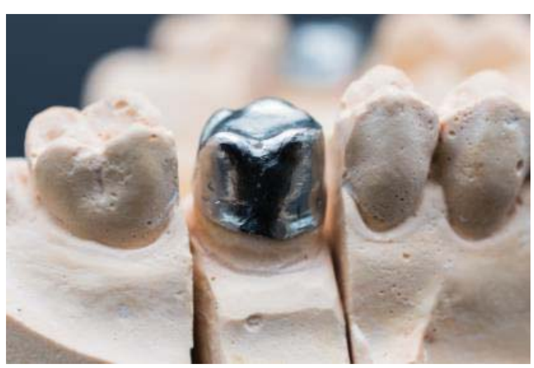

Figure 13. The final infrastructure

The third and last digital restoration was a **zirconia** infrastructure. The milling was also done with the 5 axes milling machine Ceramill Motion 2 from Amann Girrbach. Being a substractive system, the process was realised with a zirconium oxide disk. After finishing the milling, the zirconia restoration was inserted into the sintering oven, at 1500ºC, for 7 hours. Afterwards, the check up was done on the cast (Fig. 14). At the end, the zirconia infrastructure will be individualized for better aesthetic outcome. Through the same method a full zirconia crown can be manufactured, where no layering is done.

Figure 14. The final zirconia infrastructure

RESULTS

All 4 restorations were completed and multiple HD pictures were taken from all angles to observe the marginal fitting and to spot any defects on/in the materials.

The restoration with most observable flaws was the conventional metal infrastructure done through the waxing and casting procedure.

The main defects, observed in a close-up image on the buccal side of the infrastructure, were two gaps at the cervical finish line and multiple porosities (Fig. 15).

Figure 15. The defects on the metal infrastructure

All the rest of the crowns made for this study, regardless of the material, had insignificant observable differences between them, regarding marginal fitting and surface status. Moreover, all of the 3 restorations done with CAD-CAM technology needed shorter lab time to complete, compared with the one done through conventional means.


Figure 16. CAD-CAM metal


Figure 17. CAD-CAM ceramic

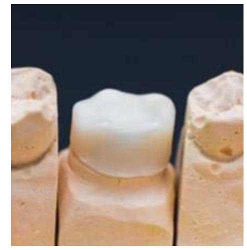
Figure 18. CAD-CAM zirconia

DISCUSSIONS

Taking in consideration the limited number of samples of the present study, but also the time efficiency during lab work, it is clear that digitalization has a positive impact on the workflow of dental technicians and, thus, on the overall outcome of the clinician. Having the possibility to obtain both the design and the milled wax pattern or straight away the final restoration in just few minutes, the dental laboratory saves a lot of time. This doesn't only make it more profitable, but also reduces the chances of human errors.

While using the very time consuming conventional procedures, many factors may interfere and affect the final restoration, such as: properties of the materials that are used, the skill and knowledge of the dental technician and, of course, the little errors that might appear from the multitude of steps that sometimes go unnoticed until the clinical phase.

It is also important to mention the fact that even though the metal crown done using the digital protocol went through the same conventional technological procedures once the wax pattern was digitally conceived, the chances of error are still smaller. That's due to the proprieties and qualities of the CAD CAM milled wax pattern, compared to the handmade version; the thickness, the morphological features and the cervical margins are all under strict control of the dental technician with the help of the digital design.

CONCLUSIONS

Within the limits of the present study, we can conclude that the digital workflow has numerous advantages compared to the conventional one, from time saving to profitability and, of course, the quality of the final restorations.

The marginal fit can be controlled much better and easier by establishing the restoration's margins, digitally, prior to the design. In other words, the dental technician can see with great magnification exactly where the preparation stops and, also, if there are any retentive areas that could pose problems. This will ensure that the final restoration, done through digital means, will have the proper and correct fit on the abutment.

The limitation of the manufacturing steps also reduces the chance of human error. While the conventional protocol takes a lot of time and skills, the CAD-CAM machine does most of the work by itself. The thickness of the material, the marginal fit, or the occlusal anatomy can all suffer variations from on dental technician to another, or even from crown to crown made by the same dental technician, while using the digital protocol, most of these problems go away. Of course, there's a learning curve to begin with, but the efficiency and benefits are worth the effort.

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