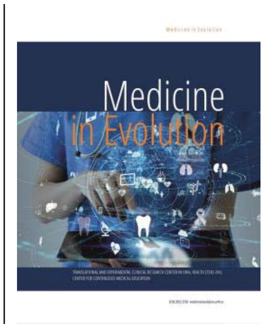
Comparative analysis of zirconia and lithium disilicate all-ceramic crowns manufactured using digital versus digital-conventional technique



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Abstract

Case presentation: This study aimed at presenting and evaluating two manufacturing technologies and two types of restorative materials (3rd generation zirconia oxide and lithium disilicate glass ceramic) for the rehabilitation of the upper anterior teeth. The outcomes were evaluated in terms of aesthetics, marginal adaptation, technologies and materials used, working protocol, time and costs.

Materials and method: A model with ideal preparations for the six upper anteriors was used in order to manufacture three zirconia oxide single units (Zirtooth Multi A2, Hass Corp) using the full digital protocol (1st hemiarch) and three lithium disilicate single units (Amber Press, LT, A2, *Hass Corp*) using the combined digital-analog protocol (2nd hemiarch). After fabrication, final layers of stains and glaze were applied for a better individualisation of the final restorations. The six restorations were evaluated on a printed model in order to asses the marginal fit, the final aesthetics, the optical characteristics and the elements of macro and microtexture.

Discussions/Conclusions: The two materials used together with the two different manufacturing techniques have produced very similar results, in accordance with the naturalness of teeth.

Keywords: zirconia, lithium disilicate, digital, analog

INTRODUCTION

In restorative dentistry, different types of dental materials had been constantly introduced for single or multiple fixed restorations with optical and mechanical properties that restore the morphology elements, the aesthetics and functionality of the natural dentition. In the last years, the all ceramic indirect restorations had become more and more popular due to improved biological, optical and mechanical properties such as biocompatibily with oral tissues, natural aspect and mechanical strength (1).

Zirconia (zirconium dioxide, ZrO2) is a ceramic restorative material used for the fabrication of crowns, bridges using CAD/CAM technology with ceramic stratification or simply with staining and glazing (2). Compared to other dental ceramics, zirconia exhibited good chemical and dimensional stability and high mechanical properties. This bioceramic material has monoclinic, cubic and tetragonal forms and is stabilised with oxides such as yttria (Y_2O_3), magnesia (MgO) and calcium oxide (CaO) (3).

Lithium disilicate glass ceramic is indicated for single tooth restorations such as veneers, partial and full crowns in anterior and posterior region and tooth replacement with 3-unit fixed dental prostheses, up to the second premolars. This material is considered an alternative to zirconia for the rehabilitation of the anterior teeth due to its improved optical properties and mechanical strength (4).

Aim and objectives

The aim of this study was to assess comparatively the technical procedures of two types of ceramic materials (full digital technique for zirconia monolithic and combined digital-analog technique for lithium disilicate) in case of six single units dental crowns for the upper anteriors in terms of aesthetic outcomes, marginal fit, workflows, working time and costs.

CASE PRESENTATION

Six monolithic ceramic restorations were fabricated for the rehabilitation of the six upper anterior teeth, of which three were 3rd generation zirconia crowns obtained through the full digital technique (1st hemiarch) and another three were lithium disilicate crowns manufactured through the combined digital and analog technique (2nd hemiarch).

In order to manufacture the six restorations, a maxillary model with ideal juxtagingival preparations from canine to canine was chosen and scanned using a laboratory scanner (3Shape E4, *3Shape*) (Fig. 1). After scanning, the 3D design of the future restorations was created using Exocad DentalCAD Plovdiv software (*Exocad GmbH*). The antagonist arch and the interocclusal relationships were not included so the functional outcomes had not been evaluated.

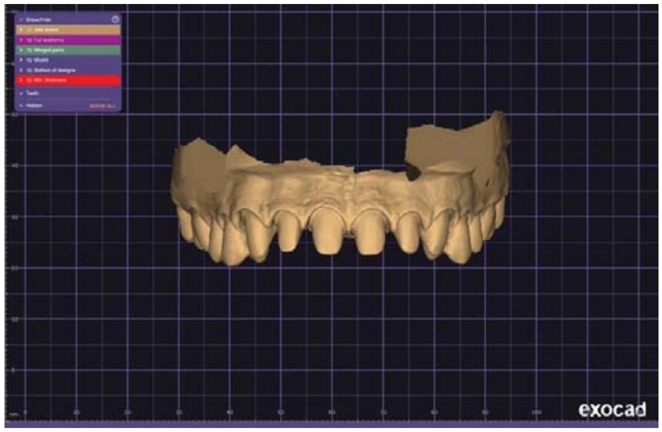

Figure 1. STL file of the working scanned model was imported in Exocad in order to design the future restorations

The 3D design begun with delimitation of the preparations and marginal fit of the future crowns and the selection of axis of insertion for each individual crown. The die space selected incisally and cervical for zirconia crowns was 0.02 mm in 1st hemiarch and 0 mm for lithium disilicate crowns in 2nd hemiarch.

The next step was to generate the teeth library which were applied individually on each die. Each crown was individualised using specific elements of morfology (Fig. 2.a.b).

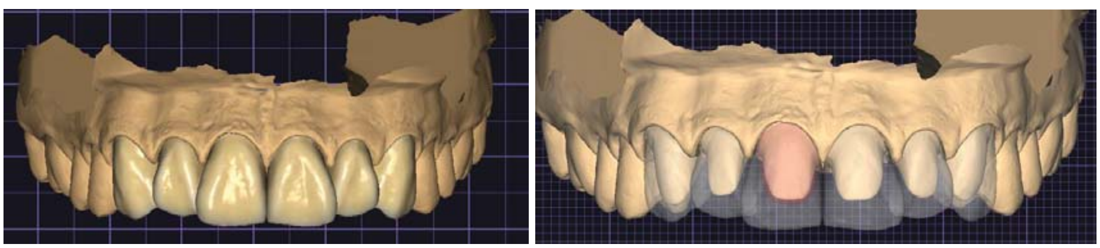

Figure 2. a. Teeth library with specific morfology elements; b. final aspect of design on the dies

Afterwards an alveolar printed model was fabricated by virtually sectioning the scanned model at the level of each preparation (Fig. 3). The future printed model was used as a control model and for a comparative analysis of the two types of restorations (marginal fit, proximal contacts and aesthetic outcomes).

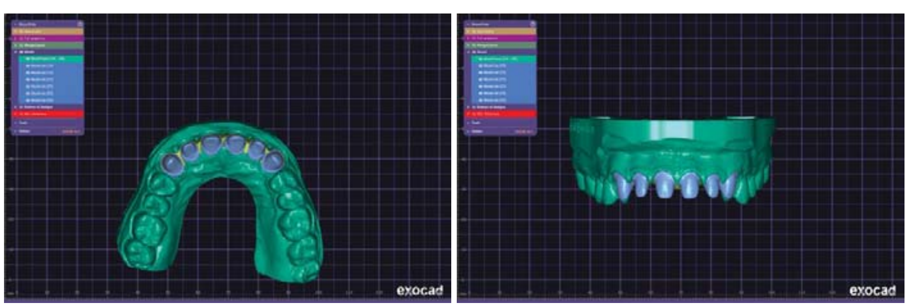

Figure 3. Virtual alveolar model with mobile dies a. occlusal view; b. frontal view

The alveolar model was printed using 3D printing machine (Asiga MAX 4K, *Asiga*) and dental resin for dental models (DentaModel, *Asiga*). After printing (Fig. 4.a), the model was washed for 5 minutes using isopropilic alcohol. Afterwards, it was rinsed and dried in order to be light cured (Sibari SR620, *Sirio*) to increase its resistance (Fig. 4.b).

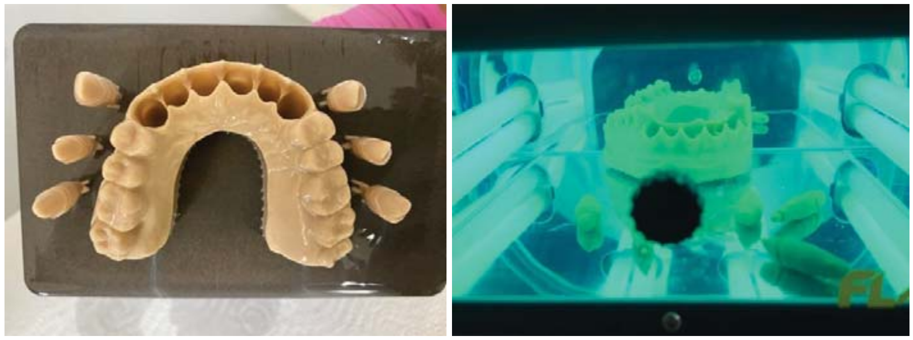

Figure 4. a. The printed alveolar model on the 3D printing machine platform; b. the alveolar model in photopolymerization environment

The manufacturing of the three Zirconia crowns

The.STL files from Exocad were sent to Dental CAM (*VHF*) software in order to mill the final restorations using a 5 axis milling machine (VHF S2, *VHF*). The characteristics of zirconia disk were set (thickness and scalling coeficient) (Zirtooth Multi NEO, multilayer, A2, *Hass Corp*). The three crowns were positioned in order to obtain the maximum number of milled elements from a single zirconia disk. The final restorations were milled using a specific dry milling strategy (Fig. 5).

Figure 5. The milled zirconia elements

Afterwards, the sintering process was performed using the sintering furnace (Z7, *Supertherm Electro*) thus obtaining the necessary mechanical strength and shade A2 for the final zirconia restorations. The sintering process was made in three steps: first, increasing the furnace temperature up to 1000°C with a rate of heating of 9°C/min and a waiting time of 10 minutes, second, increasing the furnace temperature up to 1500°C with a rate of heating of 3.5°C/min and a waiting time of 2 hours, third, decreasing the furnace temperature with a rate of cooling of 8°C/min). In the end, the final restorations were applied on the control model, finishing and polishing were performed and the interdental contact points were evaluated using a 8μ articulating paper (Bausch Arti-Check, *Bausch*) (Fig. 6).


Figure 6. Three zirconia crowns after sintering process on the control model

The manufacturing of three Lithium Disilicate crowns

The process started with the milling process of three wax crowns (WAX Disc 98/16 mm, *Sagemax*) according to initial design. After, the investing and pressing of ceramic ingot were performed using the combined analog and digital protocol. The same 5 axis milling machine was used to mill the wax crowns (Fig. 7).


Figure 7. The milled wax crowns

After the milling process the investing was performed using packaging mass (JP Vest, *Just Pressables*). The following steps were performed: attachment of the 2.5 mm diameter wax rod on each crown in a vestibular position, attachment of the 2.5 mm diameter wax rod on silicone pattern, pourring of the packaging mass (JpVest, Just Pressables) into the into the packaging cylinder (Fig. 8.a.b.c).


Figure 8. The attachment of rod wax on each milled wax crown; b. The attachment of rod wax on silicone pattern; c. the packaging cylinder

They are subsequently placed inside the STC 18.26 calcination furnace (Supertherm Electro) at a temperature of 850^0 C for 45 min, then transferred into the press furnace (Dekema Press Dent Austromat 3001, *Dekema Dental-Keramiköfen GmbH*), having applied the lithium disilicate ingot (Amber Press, LT, A2, *Hass Corp*).

Disassembling lithium disilicate crowns was performed using Effegi Brega Atlantis (*Effegi Brega*), the sandblaster (ESB 2, *Eurocem)* and 50-110m aluminium oxide particules at 2-4 barrs pressure (Fig. 9.a.b).

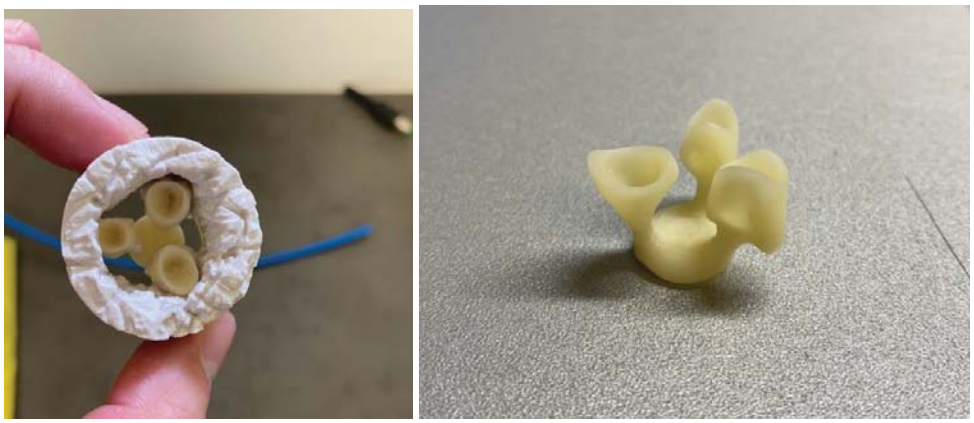

Figure 9. a: Disassembling lithium disilicate crowns; b. The final aspect of lithium disilicate crowns after sandblasting

The connecting rods are severed under water cooling with diamond drills and then polished, and the crowns are positioned onto the model, by checking the contact points with 8 µm Bauch articulating paper (Bausch Arti-Check, *Bausch*).

Both types of crowns were applied onto the printed model and the contacts between the two central incisors were adjusted (Fig. 10).

Figure 10. Final aspect after sandblasting and sintering of six upper anterior crowns on the model a. frontal view; b. incisal view

Staining and Glazing

Each final restoration was individualised using a first layer of staining (HeraCeram Stains, *Heraceram*) in different shades („ocean", „ivory", „white") to customise the colour and to obtain superior aesthetics (Fig. 11).

Figure 11. Final restorations after staining

The second layer was made up of transparent glazing and was applied to obtain a natural shiny finish (HeraCeram Glaze, *Heraceram*) (Fig. 12).

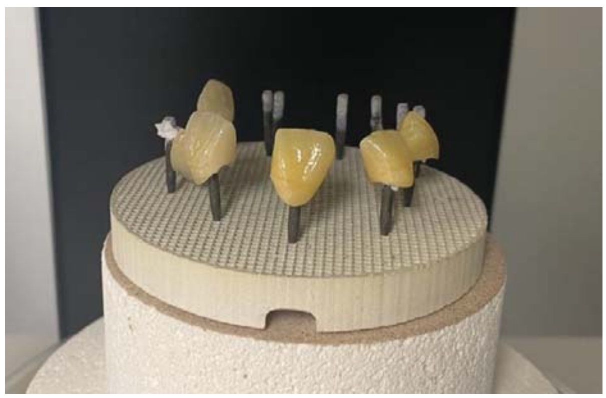

Figure 12. Final restorations after glazing

Polishing was performed with grinders, brushes and Zirkopol polishing paste (Zirkopol, *Feguramed*) (Fig. 13, Fig. 14).

Figure 13. Finishing using grinders

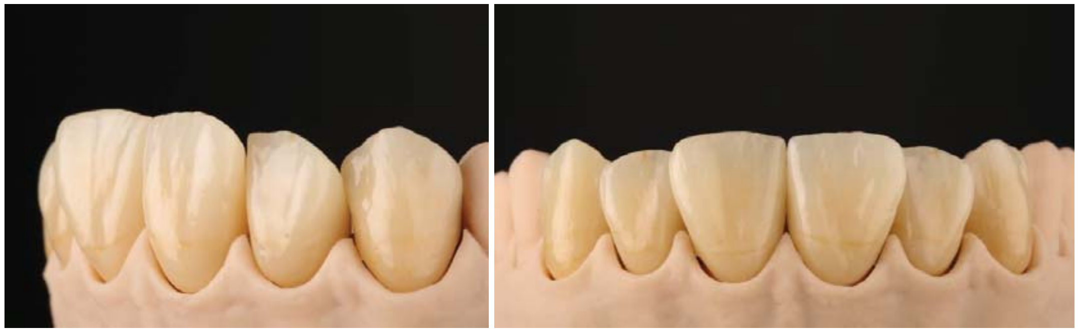

Figure 14. Final aspect: a. frontal view; b. lateral view

DISCUSSIONS

Due to the importance of the appearance and aesthetics of the teeth, especially in the case of the upper maxillary "the social six", this being the main reason why the patients voluntarily end up in a dental clinic, the evolution of dental materials is essential, from both mechanical and aesthetic perspectives.

The two materials used together with the two different manufacturing techniques have produced very similar results, in accordance with the naturalness of teeth, characteristics which have been described in Ziyad et al (5).

The tendency towards an aesthetic that is as natural as possible, in the shortest amount of time, using the same technical steps and with minimal human intervention is supported by the progress in the field. This, the 3rd generation zirconium oxide, in the multi-layer variant used in this case has proven itself to be satisfactory from an aesthetic standpoint even before the glazing procedure when it was compared with the LT lithium disilicate variant, used in this same case. Studies have shown that the translucency and transparency of multi-layer zirconium oxide, even if similar to the lithium disilicate glass ceramic, still produces inferior results (6).

Related to the macro texture and the shade of zirconium oxide, this had good optical properties and natural texture even before glazing. The lithium disilicate ceramic, after unpacking, has a faded aspect and only after glazing it presented the characteristics of transparency and translucency. The glazing has shown that for different materials, obtained through different procedures, in the end these have resulted in nearly the same shade and colour, both being close to natural teeth.

CONCLUSIONS

Prosthetic restorations made from third-generation multi-layer zirconium oxide with staining have presented optical characteristics and elements of micro- and macro-textures similar to disilicate lithium restorations in the upper anteriors.

Regarding the related costs for the necessary equipment and the materials needed, in addition to manufacturing time, the zirconia restorations required less working and processing time compared to the restorations made of disilicate lithium materials.

The marginal fit on the alveolar printed model of both types of restorations was excellent in an ideal work scenario (the visibility of preparation limits on the scanned model were properly evidenced and the delimitation of thresholds in the design stage was strictly enforced).

Lithium disilicate in the HT variant (high translucency) can be considered, at this current time, the best choice for the restoration of the upper anteriors due to its versatility and optical similarities with natural dentition, respectively the aesthetic standards imposed in every clinical case.

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