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Original Article

Marginal Adaptation of Implant Ceramic Crowns Produced with Cerec® System

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Abstract

Aim: This study aimed to assess the marginal adaptation of two different ceramic materials produced with CEREC system. **Materials and Methods:** A master die was digitized with an intraoral scanner (CEREC Omnicam) and produced 20 lithium silicate crowns – 10 VITA Suprinity® (VS) and 10 Celtra Duo® (CD). Marginal disadaptation was measured using the replica method and optical microscopy. **Results:** The Student's *t*-test showed a significant difference ($P < 0.05$) between VS (63.65 µm) and CD (97.05 µm). Results also showed statistical difference within the CD group ($P < 0.005$); on the other hand, there was no significant difference within the VS group. **Conclusion:** Based on the methodology used here, we are able to conclude that the VS group shows less marginal disadaptation and that, in addition to a larger marginal discrepancy, the CD crowns failed to maintain homogeneity since samples varied largely within the group.

Keywords: Ceramics, computer-aided design/computer-aided manufacturing, dental marginal adaptation, replica techniques

Introduction

Marginal adaptation has always been one of the major concerns regarding dental prosthesis.[1] The presence of a marginal space between the dental pieces promotes cementing agent dissolution,[1,2] leading to biofilm accumulation, which in turn, results in cavities[3] and periodontal disease. The optimal placement of pieces, avoiding spacings, contributes to clinical success and treatment longevity. The crown is well adapted when the gap is not visually noticeable or when the clinical probe fails to detect it. Acceptable gaps range between 100 and 120 µm.[4-6]

Disadaptation or marginal discrepancy is defined as the distance between the crown edge and the finish line.[3,5,7]

With the advent of computer-aided design/computer-aided manufacturing (CAD/CAM) system and other new technology, better outcomes were obtained regarding the accuracy and piece adaptation since their preparations are not dependent on the laboratory's technical capacity.[6,8-11]

Digital moldings have shown several benefits in comparison to conventional dental material such as better patient acceptance, lack of distortions,[7] tridimensional preview of preparation, and better use of clinical time.[9,10,12] Digital techniques are often used for measuring the accuracy of fixed dental restorations because they are relatively accurate and their use does not cause the destruction of the sample. However, it necessary to considered that the angle at which the object is observed affects the accuracy of the measurement.[7]

Premanufactured crystal reinforced porcelain blocks are carefully and precisely machined by CAD/CAM systems. These crystals significantly increase piece resistance and have become increasingly common in clinical practice. However, whether these restorations can be compared to the laboratory-produced conventional restorations is yet to be shown.[13,14]

Studies on the marginal adaptation of CAD/CAM machined pieces and the new materials used for digital dentistry are essential to provide information on the crowns clinical longevity.

The aim of this study was to assess the marginal adaptation of CAD/CAM-designed crowns in two different

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zirconia-reinforced lithium silicate (VITA Suprinity® and CELTRA DUO®).

Materials and Methods

This study was approved by the Ethics Committee of the School of Dentistry and Center for Dental Research São Leopoldo Mandic under the process number 2015/0484.

The initial master model used an anatomical abutment Straumann® IPS e-max® (Straumann®, Basel, Switzerland), with 5.5 mm of height and platform of 4.8 mm tilted by 6° and axial wall and chamfer finish. The same abutment was attached to a Bone Level RC implant analog with 4.1 mm of diameter (Straumann®, Basel, Switzerland).

The die was digitized with the intraoral scanner Omnicam (SironaCompany, Bensheim, Germany). The virtual crown was designed using software CAD CEREC 4.4.4 (SironaCompany, Bensheim, Germany) and spacings of 90 µm [Figure 1].[4,15]

The physical crowns were machined by the milling cutter MCXL (SironaCompany, Bensheim, Germany). To this end, we used two types of precrystallized zirconia-reinforced lithium silicate blocks VITA Suprinity® (Vita Zahnfabrik, Sackingen, Germany) and CELTRA DUO® (Dentsply-Sirona, Bensheim, Germany). Ten test specimens of each material were built, totaling 20 specimens. To assure machining standardization, each group used a pair of drills, and filters and cooling fluid as per recommended by the manufacturer. We then proceeded to test the crowns on the abutment [Figure 2].

Crown adaptation was measured using the replica method.[2]

The ensemble abutment analog was fixated in a Bioart B2 liner (Bioart Equipamentos Odontológicos Ltda, São Carlos; Brazil) and inserted into a bipartite acrylic box containing, in one half, heavy addition silicone Take 1 Advanced (Kerr Dental, Munich, Germany) for the confirmation of the positioning mold. Vestibular, lingual, mesial, and distal faces were marked, and silicone was insulated with lubricant K-Y Gel (Johnson and Johnson, New Jersey, USA).

The crown was cemented on the abutment using light silicone Take 1 Advanced (Kerr Dental, Munich, Germany) and repositioned on the heavy silicone mold with a 20N load on the liner for 5 min for silicone polymerization. The abutment was removed [Figure 3], and the corresponding spacing was filled with extra light Take 1 Advance Monophase (Kerr Dental, Munich, Germany). The second half of the box was filled with heavy silicone and repositioned to obtain the abutment replica in fluid silicone [Figure 4].

The replica was covered in medium addition silicone Take 1 Advanced mono/medium (Kerr Dental, Munich, Germany) and, following its polymerization, was covered in heavy silicone, forming a replica of the complex abutment-cement-crown. This replica was evenly sliced into four parts, and measurements of the silicone layer relative to the cement line were taken in four points (mesial, distal, vestibular, and lingual) using an optical microscope Mitutoyo TM500 (Mitutoyo, Tokio, Japan) with ×30 magnification [Figure 5].

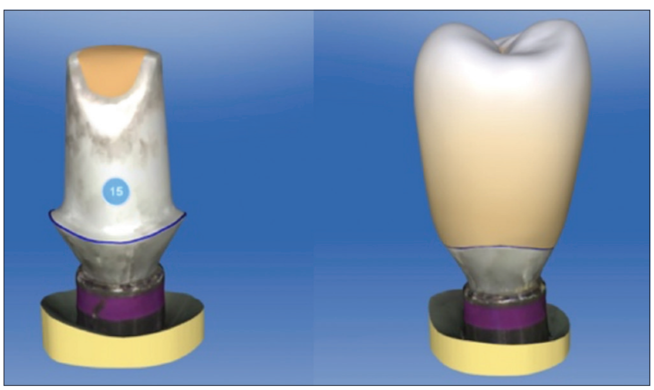

Figure 1: Digitized anatomical abutment and virtual crown design

Figure 2: Crowns test on the abutment

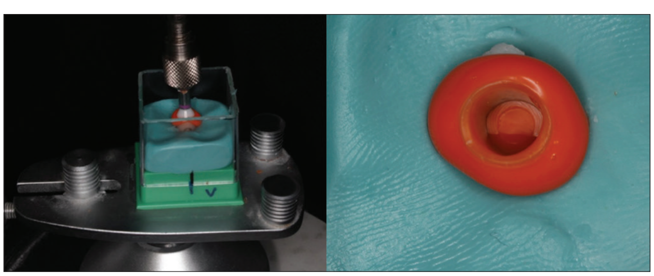

Figure 3: Positioning of the ensemble crown abutment

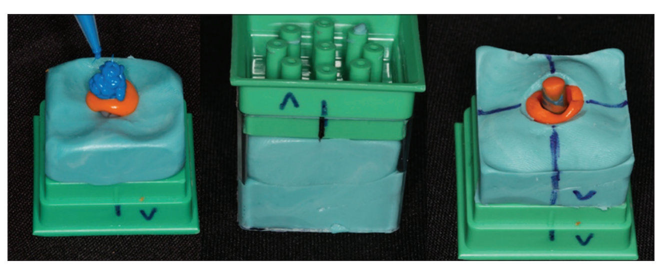

Figure 4: Confirmation of the abutment replica

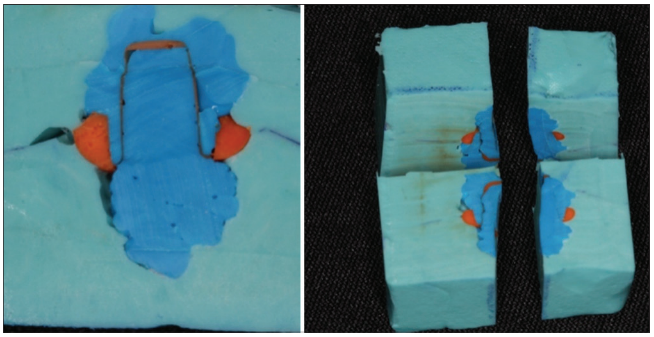

Figure 5: Finished replicas

Results

To assess the materials disadaptation (VITA Suprinity®, Germany; CELTRA DUO®, Dentsply-Sirona, Germany), we used Student's *t*-test for independent samples. For intragroup disadaptation, we used paired Student's *t*-test.

Statistical calculations were done using SPSS 20 (IBM®, SPSS Inc., Chicago, IL, USA), with a significance level of 5%.

Student's *t*-test for independent samples showed that the average marginal disadaptation within the VITA Suprinity® group, 63.65 (±7.81) µm, was significantly lower than that obtained for Celtra DUO®, 97.05 (±13.65 µm) ($P < 0.05$), as shown in Figure 6.

Student's *t*-test for paired samples showed higher correlation coefficients of disadaptation measurements for the Celtra DUO® group ($P < 0.05$), with marginal discrepancy values varying between 76 µm and 140 µm within the same group [Table 1].

However, paired Student's *t*-test results for VITA Suprinity® showed nonsignificant correlation coefficients ($P > 0.05$), with marginal discrepancy values varying from 51 µm to 79 µm within the same group [Table 2].

Discussion

Digital dentistry is becoming a reality, and chairside systems will soon occupy the dental office. With this technological advancement in consideration, this study aims to assess the vertical marginal discrepancy of porcelain crowns. According to Jacobs and Windeler,[4] this is a critical factor to the success of the clinical treatment. The author sought to identify the amount of marginal disadaptation that would lead to failure in prosthetic treatment and showed that spacings above 120 µm increase the likelihood of failure due to plaque accumulation and the resulting decalcification of the tooth structure.

Here, we used an anatomical abutment Straumann® IPS e-max® as master model, chosen based on studies that show that chamfer finished preparations result in smaller marginal disadaptation for ceramic crowns.[3,16,17] On the other hand, other studies failed to find significant differences in marginal disadaptation between chamfer finish, shoulder, and round shoulder preparations.[6]

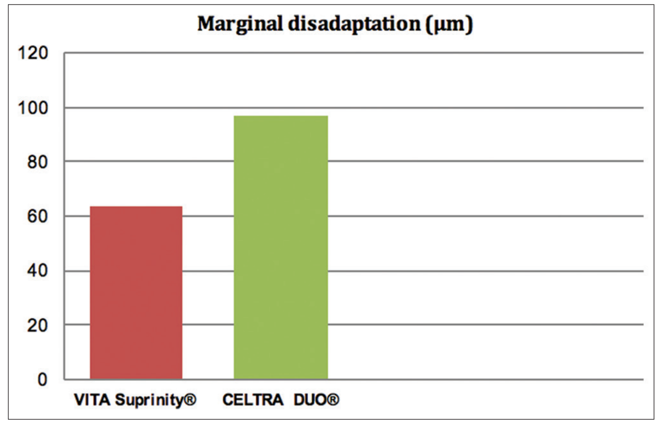

Figure 6: Comparative diagram of marginal disadaptation (µm) of test specimens VITA Suprinity® and CELTRA DUO®

Table 1: Marginal disadaptation results (mm) for Celtra DUO® test specimens (paired Student's *t*-test=*P*<0.05)

Specimens	Celtra DUO®				
	Buccal	Lingual	Mesial	Distal	Mean
C1	0.0800	0.0760	0.0840	0.0920	0.0830
C2	0.0970	0.1030	0.0980	0.0930	0.0978
C3	0.0830	0.0790	0.0900	0.0830	0.0838
C4	0.1210	0.1080	0.1010	0.1200	0.1125
C5	0.1030	0.1000	0.0980	0.1060	0.1018
C6	0.0880	0.0860	0.0850	0.0930	0.0880
C7	0.0930	0.0970	0.0930	0.0990	0.0955
C8	0.0990	0.1070	0.1030	0.0980	0.1018
C9	0.0760	0.0880	0.0810	0.0970	0.0855
C10	0.1090	0.1150	0.1200	0.1400	0.1210
Mean	0.09705 (mm)				

Table 2: Marginal discrepancy results (mm) for VITA Suprinity® test specimens (paired Student's *t*-test=*P*>0.05)

Specimens	VITA suprinity®				
	Buccal	Lingual	Mesial	Distal	Mean
C1	0.0790	0.0630	0.0740	0.0710	0.0718
C2	0.0660	0.0640	0.0690	0.0610	0.0650
C3	0.0700	0.0780	0.0730	0.0690	0.0725
C4	0.0790	0.0750	0.0710	0.0680	0.0732
C5	0.0530	0.0580	0.0620	0.0610	0.0585
C6	0.0510	0.0560	0.0580	0.0610	0.0565
C7	0.0670	0.0710	0.0620	0.0680	0.0670
C8	0.0550	0.0520	0.0610	0.0520	0.0550
C9	0.0570	0.0590	0.0550	0.0610	0.0580
C10	0.0590	0.0610	0.0630	0.0530	0.0590
Mean	0.06365 (mm)				

The master model was digitized using an Omnicam intraoral scanner. Studies show that the digital method is advantageous in comparison with the conventional modeling since it is standardized and streamlines the clinical workflow.[9] It is also faster and avoids repetitions.[12,18] On the other hand, some studies have shown more precise results for conventional molding, suggesting that they outperform the digital alternative regarding fidelity and precision.[19] However, some works have shown precision in internal and marginal adaptation, without significant difference between digital and conventional molding.[20,21]

We used the software CAD CEREC 4.4.4 to design the virtual crown, using 90 µm of cement spacing, as per the study of Prudente *et al*.[8] which used 80 µm of spacing according to the manufacturer's recommendations. It has been shown that a larger cement spacing affects marginal adaptation of ceramic crowns.[1,22] Particularly, Mously *et al.*[23] have shown smaller vertical disadaptations with spacings of 100 µm. Regarding the resin cement thickness, Molin *et al.*[2] observed that a variation in thickness in the range of 50–100 µm optimizes performance and resistance of the adhesion interface or line. It is worth mentioning that our spacing parameter was chosen based on Kim *et al.*[24] as well, which observed a 10 µm increase in average marginal disadaptation after crown crystallization. Here, the crowns were analyzed in the precrystallization stage.

The lithium silicate crowns were machined on a MCXL milling cutter (Sirona Company, Germany), a 4-axis equipment used in office environment, as per the studies by Hamza and Sherif[25] who assessed several milling cutters and concluded that the marginal disadaptation found were clinically acceptable.

For the vertical discrepancy assessment, we used the replica method, supported by several authors[3,5,15,26,27] and particularly by Trifkovic *et al.*[7] who concluded that this method improves the possibility of verifying disadaptation and offers more precise results relative to other techniques.

Here, we used precrystallized zirconia-reinforced lithium silicate from two commercial brands (VITA Suprinity®, Germany; CELTRA DUO, Dentsply-Sirona, Germany). Suprinity® has been shown to have low probability of clinical failure due to its superior mechanical properties when compared to IPS e.max CAD.[14] When compared to each other, both Suprinity® and CELTRA DUO® present great performance with a very low failure rate.[28] They also present similar flexural strength CELTRA DUO® with 626.84 MPa and Suprinity® with 611.24 MPa[8] and microstructure.[29]

In this study, the VITA Suprinity® group showed marginal disadaptation values of 63.65 µm, significantly smaller than those found in the CELTRA DUO® group – with 97.05 µm ($P < 0.05$), both values clinically acceptable. These results are similar to those showing smaller marginal disadaptation values in comparison to the conventional method, suggesting that overall CAD/CAM technology is advantageous.[9,26,30] Notwithstanding, some authors have shown that conventional copings and CAD/CAM adaptation are very similar,[5,31] while others observed significantly larger internal discrepancies in CAD-/CAM-produced crowns.[23,27]

Here, we show a significant difference in marginal disadaptation between microstructurally similar materials. In CELTRA DUO® group, the results were higher than those showed in Suprinity® group. In addition to that, the marginal disadaptation within the CELTRA DUO® group showed high correlation coefficients, with a range of marginal discrepancy of 76 µm–140 µm. This lack of homogeneity can be explained by the material's machinability, i.e., its ability to be machined without harming its mechanical properties or burring and factors that affect marginal adaptation. Chavali *et al.*[32] corroborated this finding when they compared the milling cutter rate of penetration between the hybrid materials LAVA Ultimate (3M) and Enamic (VITA), and the ceramic materials E-max and CELTRA DUO®, obtaining smaller machinability rates for CELTRA DUO®, with 0.80 mm/min. Elsaka and Elnaghy[14] also observed larger hardness values in zirconia-reinforced lithium silicate, another factor that explains its smaller machinability.

Conclusion

Based on the methods used and the results obtained, it can be concluded that there are significant differences in the values of marginal misfit between the two materials. VITA Suprinity® lithium silicate crowns showed better performance with lower marginal discrepancy values (63.65 ± 7.81 µm). The CELTRA DUO® lithium silicate crowns, in addition to presenting higher marginal discrepancy values (97.05 ± 13.65 µm), also showed an inconsistency in the results since the values of misfit varied greatly within the group (from 76 µm to 140 µm). The VITA Suprinity® group presented more homogeneous results within its group with little variation of marginal discrepancy values (from 51 µm to 79 µm).

In this study, the null hypothesis was not accepted because there was a significant difference ($P < 0.05$) in the results of the marginal misadaptation of the VITA Suprinity® and CELTRA DUO® ceramic crowns.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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