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EVALUATION OF MARGINAL GAP OF CAD/CAM CROWNS MILLED FROM TWO CERAMIC MATERIALS

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ABSTRACT

Aim: The purpose of this invitro study was to evaluate and compare the marginal gap of CAD CAM crowns milled from two ceramic materials.

Materials and methods: Sixteen natural sound upper first molars were prepared for full coverage crowns using computer numerical control (CNC) .CAD CAM all ceramic crowns were fabricated and seated to the corresponding molars. Samples were divided into two groups according to the ceramic material ; group (E): Emax CAD (Lithium disilicate glass ceramics) (n=8), group (V): Vita suprinity(Zirconia reinforced lithium silicate ceramic) (n=8). Vertical marginal gap of all samples was measured by digital microscope.

Results: Emax CAD group (Lithium disilicate glass ceramics)showed significantly higher marginal gap values (M=95.4, SD=8.27) in comparison with Vita suprinity group (Zirconia reinforced lithium silicate ceramic) (M=75.47, SD=8.9).

Conclusions: Marginal gap values were within the clinically acceptable range where full coverage Emax CAD crowns revealed higher gap values than Vita suprinity crowns.

KEYWORDS: Marginal gap, CAD CAM, Glass ceramics.

INTRODUCTION

Esthetics and function are nowadays the main concern among clinicians regarding full coverage,partial coverage crowns and fixed partial dentures .Due to the continuous search for a better quality restorations together with the current revolution in the field of CAD-CAM technology, many innovative metal free ceramic materials have been introduced in the market to be used for different restorative solutions aiming to combine the desired mechanical properties and the esthetic expectations of patients.

Metal ceramic restorations proved clinical durability but usually need extensive tooth

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preparation with compromised structural durability, moreover thick restoration margins are usually accompanied by probability of marginal misfit . However, nowdays biomimetics is a recent concept in restorative dentistry based on conservative tooth preparation followed by emulation of the natural esthetics and mechanics of teeth with suitable adhesive tooth like materials. In that sense biology and mechanics will be preserved together with optimizing white and pink esthetics. [1]

One popular ceramic is lithium disilicate glass ceramic which contains approximately 70% by volume needle-like crystals in a glassy matrix. This unique crystalline structure provides high edge strength, and fracture resistance allowing them to be ideally used for inlays,onlays,endocrowns ,posterior crowns and even for three-unit anterior bridges. [2, 3]

Zirconia reinforced lithium silicate ceramic is an innovative high-strength ceramic developed and supplied as CAD CAM machinable blocks where 10% zirconia is added to lithium silicate .It has been suggested to be an esthetic and durable solution for single restorations in esthetic stress bearing areas with high edge strength . [4-6]

The ultimate goal of a successful restoration is based on achieving biocompatibility and durability where marginal adaptation is considered a critical factor otherwise leakage followed by caries and tooth decay will be an inevitable negative consequence. [7]

Marginal gap threshold values represent an issue of controversy that needs ongoing investigations especially for the newly introduced materials and alternative atypical preparations. Clinically accepted values varies from 50 μm up to 200μm, however 120μm is considered an average acceptable value. [8-10]

Marginal fit and the ability to withstand aging affect the fracture resistance of the material which consequently controls the restoration serviceability. [11] Proponents of each material claim its marginal integrity and high edge strength . Therefore the purpose of this study is to evaluate and compare the marginal gap values of full coverage crowns milled of litium disilcate glass ceramics and Zirconia reinforced lithium silicate ceramic.

MATERIALS AND METHODS

In this in-vitro study, Sixteen natural sound upper first molars were selected of approximate similarity in size, shape, and crown morphology.The teeth were cleaned, debrided using manual scaler and examined with a magnifying lens to exclude the defected teeth and then stored in saline solution of 0.9% concentration at roomtemperature until required for experimentation. All teeth were embedded in autoplymerizing acrylic resin in readymade tubes with the cementoenamel junction 1.5mm mm above the resin margin using surveyor to ensure upright position of teeth in moulds.All molars were prepared using computer numerical control (CNC) for full coverage crowns with total occlusal convergence of 20 degrees ,occlusal surface following the occlusal anatomy, occluso-gingival height 5 mm (from central groove) and chamfer finish line of 1 mm thickness .Then finishing of preparations was done to remove sharp angles. All molars were then randomly divided into two groups according to the ceramic material ; group (E): Emax CAD (Lithium-disilicate glass ceramics) (n=8), group (V): Vita suprinity (Zirconia reinforced lithium silicate ceramic) (n=8).

All preparations were then scanned with the omnicam in several directions to create a 3D virtual model .Sixteen full coverage crowns were designed on the scanned models, using CEREC in-Lab 3D software (Sirona Dental systems) with the biogeneric copy design option where all parameters were standardly set including insertion axis, margin placement, occlusal and wall thickness and cement gap as shown in **figure 1 & 2**

Fig. (1) CAD CAM Crown parameters

Fig. (2) Full Coverage Design

Lithium disilicate glass ceramic blocks with appropriate size were selected, the machining icon was marked and the selected glass ceramic block was placed in the milling chamber of the MC XL unit with the appropriate grinding instruments mounted for milling of the crowns . Low speed and light pressure were used in finishing and adjusting IPS e.max CAD crowns (precrystallized / blue) state, then checked on their corresponding molars. The crowns were then secured on crystallization tray/firing tray with crystallization/firing pins by object fix putty material,IPS e.max CAD Crystal /Glaze Paste (Fig.) was applied evenly on the outersurfaces and placed into the programat P3010 furnace where the program started to run automatically. Crowns were removed from the furnace and allowed to cool to room temperature, then cleaned in ultrasonic water bath to remove any residues and checked again for any minor adjustments. Similar fabrication steps were done for Vita suprinity (Zirconia reinforced lithium silicate ceramic) crowns following manufacturer instructions.

All crowns were seated on the corresponding molars. Vertical marginal gap of all crowns was evaluated using digital microscope. Shots of the margins were taken for each crown using hand held digital microscope with a built in camera fitted on a precision microscopic stand connected to IBM compatible personal computer using a fixed magnification of 40X) Then morphometric measurements were done on an IBM compatible personal computer equipped with the Image-tool software (Image J 1.49d, National Institute of Health, USA) which was used for image analysis. Within the Image J software, all limits, sizes, frames and measured parameters are expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real world units. Calibration was made by comparing an object of known size (a ruler in this study) with a scale generated by the Image J software .The vertical gap distance was measured for each shot 5 equidistant landmarks along the cervical circumference for buccal , palatal, mesial and distal surfaces of each crown as shown in **figure 3 & 4.** Then the data obtained were collected, tabulated and then

Fig. (3) Digital microscope on precision stand

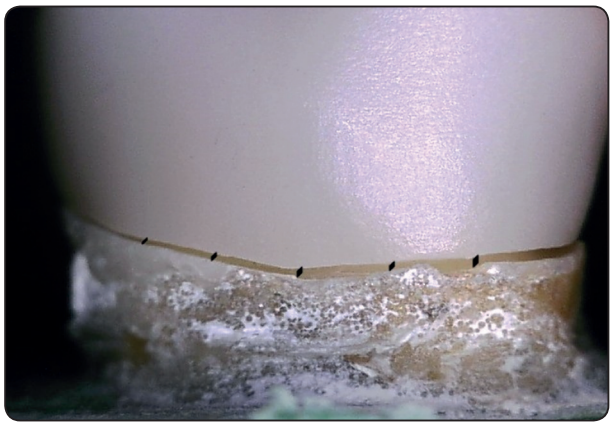

Fig. (4) Lines of measurements at equidistant points

subjected to statistical analysis.

RESULTS :

Data were explored for normality by checking the data distribution, calculating the mean and median values and using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data showed normal distribution. Data were presented by mean and standard deviation (SD) values. T test was used for comparison between groups with continuous data.Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

P- value: level of significance:

- P>0. 05: Non significant (NS).
- P≤0. 05: Significant (S).
- P≤0. 01: Highly significant (HS).

The null hypothesis for the present study was that the two different types of CAD CAM ceramic crowns will not differ in their marginal gap after milling

TABLE (1): Mean, standard deviation (SD) of marginal gap values

Group	N	Mean	Std. Deviation	Std. Error Mean	P value
Gr (E) EmaxCAD	8	95.4118	8.27499	2.92565	<0.001
Gr (V) Vita suprinity	8	75.4706	8.92419	3.15518	

All mean values are within the normal clinical limits. t-test showed statistically significant difference between groups, where Gr (E) EmaxCAD showed significantly higher marginal gap valuesin comparison with Gr (V) Vita suprinity

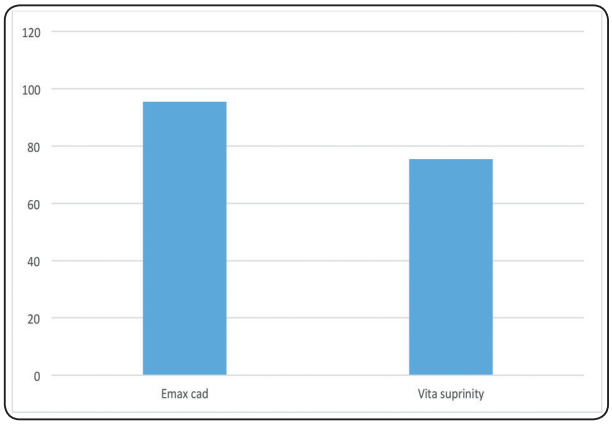

Fig. (5) Emax cad showed higher value compared to vita suprinity

DISCUSSION

Nowadays the success of recently introduced tooth colored materials and systems may be attributed to several factors, including technological advances and biomimitic properties which increase the move towards the avoidance of the use of metals in the mouth and their replacement with esthetic materials whenever possible.

Lithium disilicate glass ceramic has been used for long time as clinically successful adhesive restoration based on long term clinical and laboratory studies which support its use as a standard for comparison with other newly introduced CAD/CAM ceramics.[2,3] Zirconia reinforced lithium silicate ceramic is a new category of ceramics where the

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lithium silicate is reinforced by 10% zirconia aided by nanotechnology,moreover the manufacturers claim that milling ability is easier with optimized marginal stability and edge strength.[4-6] Nevertheless, few studies are available in literature to verify manufacturers claims regarding the mechanical properties and edge stability of the materials they develop. In addition, mechanical properties of the newly developed materials must be evaluated before being suggested for clinical use ,thus the current study was conducted to evaluate marginal gap of those CAD/CAM ceramics .

Since digital dentistry is leading now and CAD-CAM technology offers a diversity of restorative options, therefore the clinical goal is to achieve reliable CAD-CAM fabrication of high quality crowns where marginal integrity is considered the forerunner for successfully durable restorations.[12]

Despite digitally designing the cement space for the CAD-CAM restorations and digitally controlling designing and milling parameters , it is still questionable whether the machine could transfer such parameters to the final milled restoration with the required optimal marginal integrity.

Natural molars have been selected in this study for clinical condition simulation, where standardization was achieved by selecting teeth of approximate similarity ,size and morphology .

A variety of studies have used different testing methods to evaluate the marginal gap of crowns which has resulted in variability of the marginal gap values. In our study imaging the marginal gap area under microscope and use of image analyzing software for measurement was used. Being a nondestructive methods,as the digital microscope allows precise measurements with the advantage of enabling evaluation while preserving samples to be later analyzed for fracture resistance with no effect on the results .[13]

Regarding the results of our study ,the marginal gap of all samples were within the average acceptable limits which goes in accordance with asystematic review by Boitelle et al who reported that CAD-CAM technology provides dental prostheses with MD values less than 80 μm.[12]

The null hypothesis for the present study was rejected where Emax CAD group (Lithium disilicate glass ceramics)showed significantly higher marginal gap values (M=95.4, SD=8.27) in comparison with Vita suprinity group (Zirconia reinforced lithium silicate ceramic) (M=75.47, SD=8.9).

The microstructure of the materials might explain such results, where Zirconia reinforced lithium silicate ceramic incorporates zirconium dioxide in a highly dispersed form providing a homogeneous, finer crystalline structure with an average crystal size of 0.5 μm compared to the needle-shaped crystals with an average size of 1.5 μm found in the lithium disilicate ceramic, moreover, high glass content is achieved with a net high flexural strength.[14,15]

Interestingly, our results are consistent with Elsaka et al who concluded that Vita suprinity glass-ceramic revealed higher fracture toughness and flexural strength compared with Emax glass-ceramic. They attributed this findings to the incorporation of zirconia fillers to the composition of suprinity . The glass matrix is reinforced, without getting clouded by the dissolved zirconia particles, which gives it higher fracture toughness ,moreover they stated that that Vita suprinity showed higher Weibull modulus with less flaws and defects and higher degree of uniformity and structural reliability which is again conforming to our results regarding marginal gap emphasizing the direct relationship between marginal quality and other structural properties .[4]

It is also worth mentioning that the manufacturers of Vita suprinity have demonstrated the difference in the edge stability between the lithium disilicate and the zirconia reinforced lithium silicate by milling a wedge-shaped 30° test specimen of each material

using MC XL milling machine. They found, after milling, that the thickness of a stable edge for the ZLS ceramic measured as low as 163 μm as compared to the lithium disilicate at 275 μm, thus they claimed that this allows the zirconia reinforce lithium silicate to achieve margins with a thickness of approximately 0.16 mm.

On the contrary, Elsaka et al proved that Vita suprinity have higher brittleness index than Emax and it has been reported that the lower the brittleness index of a material, the higher the machinability which is in favor to Emax. [4] The findings of the later study is matching with another study which showed that Vita suprinity implant supported crowns had higher marginal misfit than Emax crowns. [16] Therefore, more investigations are needed to evaluate the material properties in addition to clinical performance follow up studies to be able to provide reliable recommendations.

CONCLUSIONS

Within the limitations of this study:

Marginal gap values were within the clinically acceptable range for both groups while full coverage Emax CAD crowns revealed higher marginal gap values than Vita suprinity crowns

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