Journal of Genetic and Environmental Resources Conservation, 2016, 4(1):10-20.
www.jgerc.com

Evaluation of the marginal and internal fitness of full contour CAD/CAM crowns made from zirconia, lithium disilicate, zirconia-reinforced lithium silicate and hybrid dental ceramic by silicone replica technique (A comparative *In vitro* study)

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Abstract

Accurate marginal and internal fitness of all ceramic crowns are very important considerations for the clinical success from the biological and mechanical points of view. The objective of this *in vitro* study was to evaluate and compare the marginal and internal fitness of full contour CAD/CAM crowns made from four different materials (zirconia, lithium disilicate, zirconia-reinforced lithium silicate and hybrid dental ceramic) using silicone replica technique. Dentoform tooth of the maxillary left first molar was prepared according toa standard protocol of all ceramic crown .The prepared tooth was then duplicated to have a metal die. Thirty-two impressions for the metal die with two-stage putty-wash impression technique were taken and poured with die stone to obtain thirty-two stone dies. The stone dies were then divided into four groups of eight dies each according to the material used for the fabrication of full contour CAD/CAM crowns as follow: Group I: crowns fabricated from zirconia; Group II: crowns fabricated from lithium disilicate; Group III: crowns fabricated from zirconia-reinforced lithium; Group IV: crowns fabricated from hybrid dental ceramic. All crowns were fabricated by using Sirona CEREC in- Lab CAD/CAM System. Themarginal and internal gaps were measured by silicone replica technique, in which low viscosity addition silicone impression material was used for the cementation of each crown on the master metal die. To support this thin silicone film, a heavy body silicone impression material was poured in the inner surface of the crown to form one piece with the film of the light body impression material to obtain a silicone replica. This silicone replica was then sectioned bucco-palatally and mesio-distally, and the thickness of the light body was measured using a digital microscope at twenty one different pr-determined points. The results of this study, showed that for all tested groups different levels of adaptation were observed and the least gaps recorded at the axial area, while the largest gaps recorded at the occlusal area. The least marginal, internal and total gaps were recorded for Group IV with statistically highly significant differences when compared with all other groups, followed by Group I, while the highest marginal internal and total gaps recorded by Groups II and III with statistically non-significant difference between them. The results of this study also showed that there was a statistically highly significant difference between marginal and internal gap of each group with a positive correlation between marginal and internal gap for all tested groups. As a conclusion, the marginal, internal, and total gap of hybrid dental ceramic crowns and zirconia crowns were within the clinically acceptable range.

Keywords: zirconia-reinforced lithium silicate, hybrid dental ceramic, silicone replica, internal fitness.

Introduction

The interest and demand for metal-free biocompatible restorations from both clinicians and patients has encouraged researchers to seek alternatives. To meet this need, all-ceramic restorations with the advantages of soft tissue biocompatibility, color stability, improved wear resistance, and excellent light transmitting properties have been developed (Gallucci *et al.*, 2007). Many ceramic system, which may differ in composition or fabrication technique, are available. Two of the clinically well-spread materials are the lithium disilicate and zirconia-based systems. They can be fabricated from prefabricated blocks, which are milled with a computer-aided design/computer-aided manufacturing (CAD/CAM) system (Raigrodsk, 2004). Zirconia blocks can be milled either at the green stage, the partially sintered stage or the completely sintered stage. In the milling of partially-sintered zirconia blanks, enlarged frameworks are designed and fabricated to compensate for about 20-25% material shrinkage after final sinter firing (Filser *et al*., 2001).On the other hand, lithium disilicate blocks are initially partially-sintered and relatively soft, so they are easier to mill. After milling process, this material needs crystallization firing, which is usually associated with a 0.2% shrinkage accounted for by the designing software (Shen and Kosmac, 2014).Vita Enamic is a novel polymer-infiltrated ceramic dental material. After CAD/CAM milling of this hybrid-ceramic block, a firing process is not required since the material has reached its final strength (Bilkhair, 2013). One of the most recently introduced CAD/CAM materials is Vita Suprinity, which is zirconia-reinforced lithium silicate glass ceramic material. This new CAD/CAM material exhibits its final esthetic and physical properties only after final crystallization in a specialized dental furnace (Vita Zahnfabrik, 2014).Poor marginal fitness or too large an opening will negatively affect the restoration's strength, reduce its longevity and lead to higher risk of recurrent caries and periodontal disease (Felton *et al.,*1991).On the other hand, the internal fitness has an important role in the retention of the restoration and plays a positive role in the longevity of full-coverage restorations, but, unfortunately, the internal fitness has not been studied to the same extent as the marginal fitness (Svanborg *et al*., 2014).

Many techniques have been used to measure the internal and marginal fitness of restorations such as direct measurement, sectioning method, profilometry, micro-CT technique and silicone replica technique. Each one has advantages and disadvantages. The silicone replica technique offers the advantages of being a non-destructive and a reliable method to determine the adaptation of crowns to the tooth structure (Reich *et al.,* 2011).

Materials and method

A dentoform maxillary left first molar tooth was prepared according to the standard protocol of full ceramic crown preparation, with planar occlusal reduction and axial reduction of about 1.5 mm and a heavy chamfer finishing line of uniform thickness of 1.2 mm, with a convergence angle6°. The dentoform tooth was then duplicated to metal die using the standard protocol of lost wax technique.

Impression procedure: The impression was taken using two-stage putty-wash impression technique using addition silicone putty consistency (Express™ XT Penta™ Putty, 3M ESPE, Germany) and light body consistency(Express™, 3M ESPE, Germany). Impression separation wafer (GC, USA) was used to provide a uniform thickness of the light body impression material. The loaded special tray with putty silicone was then seated on metal die using dental surveyor under a defined load of 200g.After the setting of the impression material, the special tray was removed from the master die and the seperation wafer was removed. The light body silicone material was then carefully injected in the tray over the putty body in the area of prepared tooth and the special tray was reseated carefully over the metal die using modified dental surveyor as in the first stage of impression taking. The set impression material tray was then removed from the master die after 5 minutes. After two hour, the impression was poured with type IV die stone (high strength, low expansion) (Elite® rock, Zhermack).The same procedures for impression and pouring were repeated thirty-two times to obtain thirty-two stone dies.

Sample grouping: The thirty-two stone dies were divided into four groups of eight dies each, according tothe material used for the fabrication of full contour CAD/CAM crowns as follow: Group I: Fullcontour crowns fabricated from zirconia (InCoris TZI C). Group II: Fullcontour crowns fabricated from lithium dislicate (IPSe-max CAD), Germany). Group III: Full contour crowns fabricated from zirconia-reinforced lithium silicate (VITA Suprinity). Group IV: Full contour crowns fabricated from hybrid ceramic (VITA Enamic).

Crowns Fabrication: Cerec InLab CAD/CAM System (Sirona, Germany) with version 4.02 software was used for the fabrication of all crowns. The fabrication was done following the standard protocol of CAD/CAM crown fabrication by sirona, “SCAN” phase with in Eos Blue scanner, “MODEL” phase, “DESIGN” phase were crown parameter in this study were set(80 μm cement spacerand100 μm marginal thickness) was according to manufacture instructions of Cerec In Lab, Sirona CAD/CAM System. Crown fabrication was done using wet milling process with MC XL milling machine, the milling process was fully automated without any interference with the two diamond cutting instrument acting together simultaneously in the shaping process, with copious water cooling sprayed. After milling, crowns made from zirconia (Group I)were sintered in(In fire HTC Speed, Sirona, Germany) at 1531° C for four hours, while crowns made from lithium disilicate (Group II) and zirconia-reinforcedlithium silicate (Group III) were subjected to crystallization firing in a short 30 minutes firing cycle in a ceramic firing furnace (Ivoclar Vivadent, Liechtenstein, Germany) at 840°C.On the other hand, crowns made from hybrid ceramic (Group IV) required only polishing process with a special kit of (VITA ENAMIC Polishing set technical) (VITA

Zahnfabric, Germany) used for the purpose of smoothening, finishing, and polishing.

Silicone replica technique: For silicone replica technique, a specially designed split-mold was used in this study. Low viscosity addition silicone impression material (Express™, regular set, light body, 3M ESPE, Germany) was used for the cementation of each crown on the master die. The light body was injected into the inner surface of crown then the crown was seated on the metal die with a constant load of 5 Kg (50 N) using a modified dental surveyor (Trifkovic *et al*., 2012).To support this thin silicone film, a heavy body silicone impression material (Express™ XT Penta™ H, 3M ESPE, Germany) with a contrasting color was poured in the inner surface of the crown to form one piece with the film of the light body.

The silicone replica was then sectioned bucco-palatally and mesio-distally using cutting knife in a specially designed sectioning base. Measurement of the marginal and the internal gaps was done by measuring the thickness of the light body silicone material at pr-determined points, under a digital microscope at the magnification of (180 X).For each specimen, a total of twenty-one different measurements were done at pre-determined points for the bucco-palatal and mesio-distal sections collectively, as shown in (Figure 1).These measuring points represented four different areas of measurement: margin, chamfer, axial, and occlusal areas.

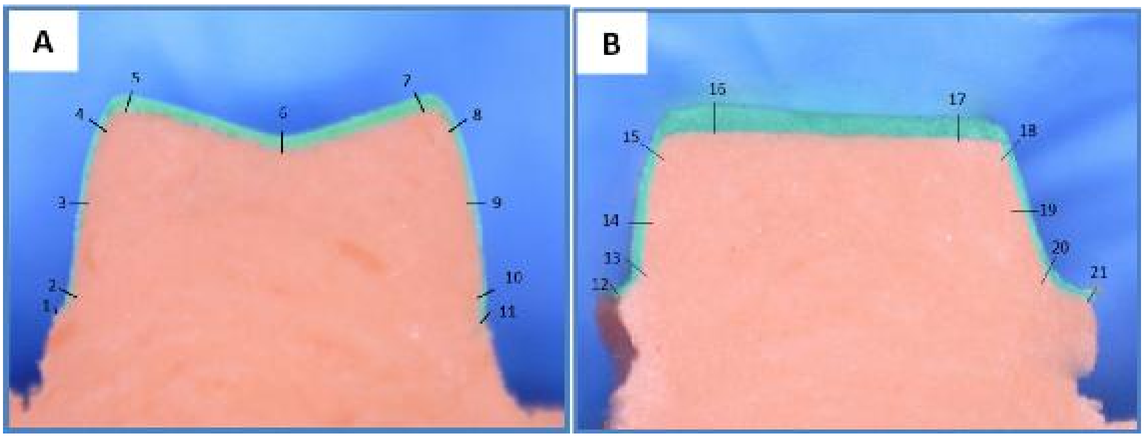

Figure (1): Microscopical images at low magnification (20X) showing the measuring points: (A) Bucco- palatal section. (B) Mesio-distal section.

For each specimen, the internal and the total gaps were then calculated. Internal gaps was measured by calculating the mean values of the occlusal, axial, and chamfer area gaps, while total gapswas measured by calculating the mean values of the internal gap and the marginal gap.

Image analysis software (Image J) (version: 1.47) was used for the measurement of the gap at the different areas. All measurements were performed by one operator, as recommended by Holmes *et al.* (1989).

Results and Discussion

The descriptive statistics showed that for all groups, the highest mean value of the gap recorded in the occlusal area. While the least gap was in the axial area, with Group IV showing less gap at all tested areas (margin, chamfer, axial, occlusal, internal, and total) when compared with the other three tested groups (Table 1).

A. Comparison of the gap at the different areas of each group: Using one-way ANOVA test revealed a statistically highly significant difference among areas ($p< 0.01$) (Table 2).

Further comparisons among areas were done using (LSD) test which showed that there were statistically highly significant differences in gaps between all areas of all groups ($p< 0.01$), except in Group I where there was a statistically non-significant differences between the gap at the marginal and axial areas ($p > 0.05$), and in Group II where there was significant difference between the gap at the marginal and chamfer areas ($p<0.05$) (Table 3).

B. Comparison of the gap at the same area of the different groups: Comparison of the gap at each area among the different groups using one-way ANOVA test revealed a statistically highly significant difference among groups ($p< 0.01$) (Table 4). Further comparisons among areas were done using LSD test showed that there were statistically highly significant differences in gaps at all areas between groups ($p< 0.01$)except between Group II and Group III where there was no statistically significant difference in gaps at all areas ($p>0.05$) (Table 5).

Table (1): Descriptive statistics of the gap at the different areas of the four different groups measured in micrometer.

Groups	Areas	N	Mean	±SD	Min	Max
Group I	Marginal	8	113.375	6.588	103.00	125.00
	Chamfer	8	161.000	8.864	148.00	172.00
	Axial	8	110.500	8.766	98.00	121.00
	Occlusal	8	210.500	6.948	200.00	219.00
	Internal	8	160.250	4.166	156.00	168.00
	Total	8	136.500	4.208	133.00	191.00
Group II	Marginal	8	171.250	3.370	166.00	175.00
	Chamfer	8	193.1250	5.866	180.00	199.00
	Axial	8	135.000	7.483	125.00	147.00
	Occlusal	8	270.625	23.237	223.00	299.00
	Internal	8	199.375	10.391	176.00	209.00
	Total	8	184.875	6.104	172.00	191.00
Group III	Marginal	8	170.500	10.392	153.00	181.00
	Chamfer	8	198.750	9.392	187.00	209.00
	Axial	8	128.625	7.707	116.00	143.00
	Occlusal	8	278.875	15.403	258.00	302.00
	Internal	8	201.750	10.375	187.00	218.00
	Total	8	185.875	10.105	170.00	199.00
Group IV	Marginal	8	60.125	11.801	46.00	76.00
	Chamfer	8	120.625	5.730	114.00	129.00
	Axial	8	84.875	6.010	79.00	95.00
	Occlusal	8	169.250	6.860	160.00	181.00
	Internal	8	124.625	5.423	118.00	133.00
	Total	8	92.125	8.322	82.00	104.00

Table (2): One way ANOVA test for comparison of the gap among the different areas of each group.

Group	df	F	Significance
Group I	3	288.223	0.000(HS)
Group II	3	163.914	0.000(HS)
Group III	3	260.824	0.000(HS)
Group IV	3	281.418	0.000(HS)

Table (3): LSD test for comparison of the gap among the different areas of each group

Groups	Areas		Mean Difference	Significance	Standard Error
Group I	Marginal	Chamfer	-46.625*	0.00(HS)	3.930
		Axial	-2.875*	0.47(NS)	3.930
		Occlusal	-97.125*	0.00(HS)	3.930
	Chamfer	Axial	50.500*	0.00(HS)	3.930
		Occlusal	-49.500*	0.00(HS)	3.930
	Axial	Occlusal	-100.000*	0.00(HS)	3.930
Group II	Marginal	Chamfer	-21.875-*	0.02(S)	6.333
		Axial	36.250*	0.00(HS)	6.333
		Occlusal	-99.375-*	0.00(HS)	6.333
	Chamfer	Axial	58.125*	0.00(HS)	6.333
		Occlusal	-77.500-*	0.00(HS)	6.333
	Axial	Occlusal	-135.625-*	0.00(HS)	6.333
Group III	Marginal	Chamfer	-28.250-*	0.00(HS)	5.550
		Axial	41.875*	0.00(HS)	5.550
		Occlusal	-108.375-*	0.00(HS)	5.550
	Chamfer	Axial	70.125*	0.00(HS)	5.550
		Occlusal	-80.125*	0.00(HS)	5.550
	Axial	Occlusal	-150.250-*	0.00(HS)	5.550
Group IV	Marginal	Chamfer	-60.500-*	0.00(HS)	3.994
		Axial	-24.750-*	0.00(HS)	3.994
		Occlusal	-109.125-*	0.00(HS)	3.994
	Chamfer	Axial	35.750*	0.00(HS)	3.994
		Occlusal	-48.625-*	0.00(HS)	3.994
	Axial	Occlusal	-84.375-*	0.00(HS)	3.994
*The mean difference is significant at the 0.05 level					

Table (4):One-way ANOVA test for comparison of the gap at the same area among the different groups.

Area	df	F	Significance
Marginal	3	300.011	0.000(HS)
Chamfer	3	176.368	0.000(HS)
Axial	3	70.669	0.000(HS)
Occlusal	3	98.874	0.000(HS)

Table (5): LSD test for comparison of the gap at the same area among the different groups

Areas	Groups		Mean Difference	Significance	StandardError
Marginal	Group I	Group II	-57.875-*	0.00(HS)	4.344
		Group III	-57.125-*	0.00(HS)	4.344
		Group IV	53.250*	0.00(HS)	4.344
	Group II	Group III	0.750	0.864(NS)	4.344
		Group IV	111.125*	0.00(HS)	4.344
	Group III	Group IV	110.375*	0.00(HS)	4.344
Chamfer	Group I	Group II	-32.125-*	0.00(HS)	3.824
		Group III	-37.750-*	0.00(HS)	3.824
		Group IV	40.375*	0.00(HS)	3.824
	Group II	Group III	-5.625-	0.153(NS)	3.824
		Group IV	72.500*	0.00(HS)	3.824
	Group III	Group IV	78.125*	0.00(HS)	3.824
Axial	Group I	Group II	-24.500*	0.00(HS)	3.778
		Group III	-18.125-*	0.00(HS)	3.778
		Group IV	25.625-*	0.00(HS)	3.778
	Group II	Group III	6.375	0.103(NS)	3.778
		Group IV	50.125*	0.00(HS)	3.778
	Group III	Group IV	43.750*	0.00(HS)	3.778
Occlusal	Group I	Group II	-60.125-*	0.00(HS)	7.384
		Group III	-68.375-*	0.00(HS)	7.384
		Group IV	41.250*	0.00(HS)	7.384
	Group II	Group III	-8.250-	0.273(NS)	7.384
		Group IV	101.375*	0.00(HS)	7.384
	Group III	Group IV	109.625*	0.00(HS)	7.384
* The mean difference is significant at the 0.05 level					

C. Comparison of the internal and total gaps among the different groups: Comparisons of the internal and total gaps among the different groups using one-way ANOVA test revealed a statistically highly significant difference among groups ($p< 0.01$) (Table 6).

Table (6): One-way ANOVA test for comparison of the internal and total gaps among the different groups.

Gap	df	F	Significance
Internal	3	165.605	0.000 (HS)
Total	3	284.364	0.000(HS)

Further comparisons among groups using LSD showed a statistically highly significant differences in the internal and total gaps between each two groups ($p<0.01$), except between Group II Group III where there was no statistically significant difference ($p>0.05$).

Table (7): LSD test for comparison of the internal and total gaps among groups.

Gaps	Groups		Mean Difference	Sig.	Standard Error
Internal gap	Group I	Group II	-39.125-*	0.00(HS)	4.065
		Group III	-41.500-*	0.00(HS)	4.065
		Group IV	35.625*	0.00(HS)	4.065
	Group II	Group III	-2.475-	0.544(NS)	4.065
		Group IV	74.750*	0.00(HS)	4.065
	Group III	Group IV	77.248*	0.00(HS)	4.065
Total gap	Group I	Group II	-57.875-*	0.00(HS)	4.344
		Group III	-57.125-*	0.00(HS)	4.344
		Group IV	53.250*	0.00(HS)	4.344
	Group II	Group III	-0.750-	0.864(NS)	4.344
		Group IV	110.375*	0.00(HS)	4.344
	Group III	Group IV	110.375*	0.00(HS)	4.344
* The mean difference is significant at the 0.05 level					

D. Comparison of the marginal gap versus internal gap of each group: Comparison of the marginal gap versus the internal gap using independent t-test showed that a statistically highly significant difference between marginal and internal gap of each group (p<0.01) (Table 8).

Table (8): t-test for comparison of the marginal gap versus the internal gap of each group.

Group	Fitness	Mean	SD	t-test	*P*- value	Significant
Group I	Marginal gap	113.375	6.588	17.008	0.000	HS
	Internal gap	160.250	4.166			
Group II	Marginal gap	171.250	3.370	7.282	0.000	HS
	Internal gap	199.375	10.391			
Group III	Marginal gap	170.500	10.392	6.019	0.000	HS
	Internal gap	201.750	10.375			
Group IV	Marginal gap	60.125	11.801	14.047	0.000	HS
	Internal gap	124.6250	5.423			

E. Correlation between the marginal and internal gaps: Correlation test between the marginal and internal gaps of the four different groups using Pearson correlation test showed that there was positive correlation between marginal and internal gap in the four tested groups (Table 9).

Table (9):Correlation between marginal and internal gap for each group.

Groups	Gaps	r	P-value	Sig.
Group I	Marginal gap	0.235	0.574	NS
	Internal gap			
Group II	Marginal gap	0.433	0.283	NS
	Internal gap			
Group III	Marginal gap	0.939	0.001	HS
	Internal gap			
Group IV	Marginal gap	0.144	0.734	NS
	Internal gap			

In the present study, different levels of adaptation were evaluated (margin, chamfer, axial, occlusal) to obtain a complete picture about crown seating. Although it is important to produce restorations with a uniform cement space so as not to compromise the retention and resistance forms, especially for all-ceramic restorations that have a brittle behavior(May *et al*., 1998), the results of this study showed that the CAD/CAM technique used was unable to create a homogenous gap width along the tooth preparation, even though a uniform 80μm cement space setting was used. These differences in the adaptation level may be related to the quality of acquisition and processing of the digital data, the relief of undercut areas and the diameter, shape and limited ability of the milling instruments to produce fine details (Pfeiffer, 1999; Luthardt *et al*., 2002).

In this study, the results showed that the marginal, chamfer and occlusal gaps were greater than the axial gap in all tested groups with statistically highly significant difference. This may be attributed to the limited escape and the hydraulic pressure of the luting material (the light body in this case) which forces the material occlusally and cervically. Additionally it could be attributed to the axial convergence of the prepared tooth which might help the flow of the cement material and allowing its continuous escape till reaching the minimum thickness (Holmes *et al.*, 1996; Boening *et al*., 2000). This result is in agreement with Naguib and Saad Eldeen (2002), Abdelaziz *et al*. (2006) and Beuer *et al*. (2009). On the other hand, this result is disagreement with study done by Borba *et al.* (2013) who stated that marginal gap is less than other measurement areas. This disagreement may be due to the difference in scanning ability of CAD/CAM system or the difference in the method used in measuring marginal and internal fitness as they used micro-CT technique or the difference in the type of indirect restoration as they measured the fitness of zirconia frameworks.

At the same time, the results of this study showed greater gap at the occlusal area when compared with other areas and this could be attributed to the following:

1.The limitation in the scanner resolution, which may produce slightly rounded edges, a phenomenon called "point clouds", that is obtained in the scanning area were the scanning process transformed into smooth continuous surface and this can lead tointernal inaccuracies as reported by Pfeiffer (1999) and Luthardt *et al.*(2002).

2. The planar occlusal reduction used in this study rather than the flat occlusal reduction design used in other studies. This preparation design may produce more occlusal gaps due to the inaccuracies created during the scanning process based on the principle of "not at the same plane surface" as reported by Ardekani *et al*. (2012).This finding is in agreement with previous studies done by Colpani *et al*. (2013) and Borba *et al*. (2013).

Crowns of all groups showed better marginal fitness than internal fitness which could be attributed to the "point clouds" phenomena previously mentioned. Additionally, the grinding process and the preparation design may also affect the internal adaptation. The narrowest possible diameter of the preparation is determined by the smallest diameter of the bur used for machining the internal surface. Thus, in structures smaller than the narrowest bur diameter, more internal substance may be removed than necessary. This may also result in larger than mandatory internal gaps for a good fit(Tinschert *et al.,* 2004).

This results is in agreement with findings of Reich *et al*. (2005)and Yildiz *et al*. (2013).

Correlation test between marginal and internal gaps for all tested groups showed a positive relation between marginal and internal gap(i.e when the marginal gap increased, the internal gap increased also). This may be attributed to the fact that in each tested group all areas of the crown (marginal or internal) were exposed to the same fabrication procedure from milling processto finishing; this may permit constant changes in the dimensions of the final restoration. From a clinical point of view, this may give an indication that any crown restoration with poor marginal adaptation will also have poor internal adaptation. This result is in agreement with the results of the study done by Ali and Sabea (2013).

When the comparisons among groups were done, the results showed statistically highly significant differences, in the marginal and the internal fitness among all groups, which could be attributed to the differences in the chemical composition of the material used for crown fabrication and the differences in the post milling treatment needed.

The best marginal and internal fitness were shown by crowns made from hybrid ceramic (Group III), which were statistically highly significant when compared with all other groups. This could be attributed to the fact that this material obtains its final esthetic color and physical properties directly after milling and no firing process was required according to their manufacturer's instructions. Crowns of this group were not exposed to the high temperature of sintering or glazing as for other groups which may help to ensure a high degree of dimensional accuracy of the final restoration when compared with other groups. This finding is in agreement with Bilkhair (2013)

On the other hand, crowns made from zirconia (Group I) showed better marginal and internal fitness than crowns made from lithium dislicate (Group II) and zirconia reinforced lithium silicate (Group III). Although crowns made from zirconia were exposed to sintering process, this might not have a great effect on the internal and marginal fitness, which may be attributed to the high strength of zirconia. This is in agreement with Komine *et al*. (2007). In addition, the zirconia blocks used in this study are classified as zirconium oxide ceramic with a higher degree of pre-sintering and characterized by a reduction of shrinkage factor with less sinter distortion (Beuer *et al*., 2008).Also the precision of the zirconia-based restorations depends on the homogeneity of the pre-sintered YTZP block and the software's ability to estimate the material contraction on prosthesis design, so in this study the compatibility of Cerec in Lab CAD/CAM Sirona software with Sirona sintering furnace was able to successfully calculate and compensate the sintering shrinkage occurred for Sironazirconia-based CAD/CAM blocks (Ardekani *et al*., 2012). This finding is in agreement with Ardekani *et al*. (2012), but in contrast, disagreement with Kunii *et al*. (2007).

When comparing the fitness of crowns made from lithium disilicate (Group II) and the zirconia-reinforced lithiumsilicate (Group III) statistically no significant difference were found. This could be attributed to the relative similarity in the chemical composition of both materials and similarity in post-milling crystallization firing which was done in the same furnace at the same temperature for the same time (840ºCfor 25 minutes), so they were exposed to same fabrication method from milling to firing process. However, the inferior fitness of crowns made from lithium disilicate (Group II) and the zirconia-reinforced lithium silicate (Group III) as compared with crowns made from zirconia (Group I) could be attributed to that the crystallization firing process may have an effect on dimensional accuracy of glass ceramic. This is in agreement with Farid *et al*. (2012) who stated that glass ceramic was not strong as zirconi aso increasing the temperature during firing would affect the fitness of the crowns. In addition the firing step of glass ceramic is usually associated with a 0.2% shrinkage (Shen and Kosmac, 2014).This might not be well-accounted by the software used in this study.

There is a controversy in dental literature regarding the clinically acceptable marginal gap, but many literatures reported that a marginal gap below 120 μm is considered as clinically acceptable (Boening *et al*., 1992; Beuer *et al*., 2009,Borba *et al*., 2013; Al-Zubaidi and Al-Shamma, 2015). Accordingly, only Group IV and Group I, which showed marginal gap of (60.125μm, 113.375 μm respectively) are considered within the clinically acceptable limit.

Unfortunately, the internal fitness has not been studied to the same extent as the marginal fitness (Svanborg *et al*., 2014), so the clinically acceptable range of the internal and total gap differs from one article to another, yet there is no standard protocol to assess the adaptation of dental restorations. This lack of standardization may lead to misinterpretation and limits the comparisons between results from different studies. Therefore, it is important to understand the limitations of the existing techniques and the type of data they can provide (i.e. internal gap, total gap, axial gap, occlusal gap, etc.) (Colpani *et al*., 2013). Another important factor that might hinder comparisons is cement space, previously pre-determined by the software of CAD/ CAM system and this factor differs from one study to other and range from (0-200 μm)(Ardekani *et al.,* 2012;Ali and Sabea 2013).

Concerning the axial gap, one study considered 122 μmas the clinically acceptable limit of the *axial gap*, below which the fracture strength of all ceramic crowns is compromised (Tuntiprawon and Wilson, 1995). Another study suggested that axialgap is in the range of 93-127 μm is considered clinically acceptable(Karlsson, 1993).Accordingly, only Group IV and Group I, which showed axial gaps of (84.875 μm and 110.500 μm, respectively) are below this threshold.

Concerning the occlusal gap it has been suggested that the occlusal gap of crown restorations should be in the range of 161-177μm (Karlsson, 1993). Accordingly, only Group IV which showed an occlusal gap of (169.250μm)is within this range.

Concerning the internal gap it has been suggested that internal gap of all ceramic restorations it should be in the values of 49 -136 μm (May *et al*., 1998; Bindl and Mormann, 2005). Accordingly, only Group IV which showed an internal gap of (124.625 μm), falls in this range.

Concerning the total gap it has been suggested that acceptable fit discrepancy (total gap) have to be ranged from 50-150 μm (Yeo *et al*., 2003;Quintas*et al*., 2004;Baig*et al*., 2010). This indicates that in this study, only Group IV and (Group I) showed a clinically acceptable total gap.

Conclusion

1. Full contour CAD/CAM crowns made from hybrid dental ceramic (Group IV) showed better marginal

and internal fitness than other groups, followed by zirconia crowns (Group I), while crowns made from lithium disilicat (Group II) and zirconia-reinforced lithium silicat (Group III) showed the least marginal and internal fitness with no statistically significant difference between them. 2. For all tested groups, different levels of adaptation were observed and the occlusal area showed the greatest gap as compared to other tested areas (axial, chamfer, margin), while the axial area showed the least gap.3.For all tested groups, the marginal gap was less than internal gap, with a positive correlation between the marginal and the internal gap. This may give an indication clinically that any crown restoration with poor marginal adaptation will also have poor internal adaptation. 4.The marginal gap, internal gap, and total gap of hybrid dental ceramic crowns (Group IV)and zirconia crowns(Group I)were within a clinically acceptable range.

It seems that the difference in the chemical composition of the CAD/CAM materials used in this study and the difference in their need for post-milling firing procedures may reflect the difference in the marginal, internal and total fitness of the fabricated all ceramic crowns.

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