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MARGINAL ADAPTATION OF CAD / CAM OCCULUSAL VENEERS FABRICATED FROM DIFFERENT MATERIALS WITH TWO DIFFERENT THICKNESSES (AN IN-VITRO STUDY)

Shaimaa S. Abbass [*], Rabab M. Ibraheem [**] *and* Hanaa S. Nassar [*]

ABSTRACT

Purpose: The purpose of this study was to compare the marginal adaptation of occlusal veneers constructed from lithium disilicate (IPS e-max), Zirconia reinforced lithium silicate (Celtra Duo) and Resin matrix ceramics (Shofu) materials with two restoration thicknesses.

Materials and Methods: 42 Human 2nd mandibular molars were fixed into epoxy resin transparent blocks. Teeth preparation for occlusal veneer was done with 0.5 mm chamfer finish line. Samples were randomized equally into 3 groups according to the material: group 1: (IPS e-max CAD), group 2: (Celtra Duo) and group 3: (Shofu Hc). Samples were further subdivided into 2 groups of thickness: subgroup (A) conventional 1.5mm and subrоup (B) thin 1mm. Designing was done by Cerec 3D software version 4.5 with omnicam intraoral scanner. CEREC MCXL 4-Axis machine was used for milling of occlusal veneers. Each surface of the occlusal veneer restoration was subjected to stereomicroscope for testing marginal adaptation.

Results: The mean marginal gap of tested samples showed the highest marginal gap for thin thickness of IPS E-max CAD group (12.74 ± 3.8µm), and the lowest marginal gap for conventional thickness of Celtra Duo group (7.69 ± 4.24 µm). Comparison between the two tested thicknesses showed non-significant difference as $P>0.05$. Comparison between the different materials showed significant difference as $P<0.05$.

Conclusion: Celtra Duo group showed the highest marginal adaptation and IPS E-max CAD showed the lowest marginal adaptation. Both conventional and thin occlusal veneer thickness of the three tested materials presented marginal adaptation mean values within the clinical accepted range.

KEYWORDS: CAD/CAM technology, Ceramic materials. Marginal adaptation, Occlusal veneers.

* Department of Fixed Prosthodontics, Faculty of Dentistry, Ahram Canadian University
** Department of Fixed Prosthodontics, Faculty of Dentistry, Cairo University

INTRODUCTION

Loss of tooth structure from occlusal surface is a multifactorial process that may be caused by caries and non-carious lesions and para functional habits[1]. It is very advised to use less invasive methods to protect these dental structures, so new CAD/CAM ceramic and composite blocks are released to the dental market[2].

Occlusal veneers are a indicated restorative approach indicated for teeth with generalized and localized wear. In patients with substantial occlusal wear[3]. Occlusal veneers are a conservative alternative to full coverage crowns and traditional onlays[4].

Different ceramic materials can be fabricated for Occlusal veneers such as, Lithium disilicate glass ceramics [5]. 10% zirconia is added to the glass for the survival of the restorations with optimized translucency and high durability [6].

Hybrid ceramics affirm great strength following adhesive bonding enabling production of the material in thin restorations and sustain heavy occlusal forces [7].

Marginal fit is a key factor in determining a dental restoration's long-term viability. Marginal fit is necessary to keep the cement from dissolving and to maintain a healthy periodontium. Any marginal gap leads to cement dissolution, plaque accumulation, periodontal diseases, and esthetic problems [8].

MATERIALS AND METHODS

Sample Size Calculation and Samples Grouping

A total of 42 samples, then were randomly divided into three groups (n=21) according to material of fabrication of occlusal veneer: group (1): lithium disilicate (IPS e-max CAD), group (2): zirconia reinforced lithium silicate (Celtra Duo) and group (3): resin hybrid ceramic (SHOFU HC). Each group was subdivided into two equal subgroups (n=7) according to thickness of restoration: subgroup (1): conventional 1.5mm and subgroup (2): thin 1mm.

Teeth Selection, Fixation

42 sound mandibular 2nd molars with Intact occlusal surface free from caries, fillings or cracks or fractures, with sufficient, comparable bucco-lingual beyond height of contour area with (0.5mm to1 mm) and mesio-distal coronal dimension at contact area level with (0.5mm to1 mm). For creating epoxy resin blocks, a mix of 30 gm base to 30 gm catalyst was used. A dental surveyor was used for ensuring centralization of tooth position into the block. Each tooth was inserted to a level 2mm below the CEJ.

Randomization of the samples

Randomization software (www.random.org) was used for generation of random sequence of all the study samples.

Biogeneric copy

To ensure standardization of preparation thickness of all samples, a Biocopy mode on Cerec 4.5 CAD/CAM software was used before the preparation .

Teeth Preparation

To ensure an equal amount of occlusal reduction for each sample, silicon index was made before teeth preparation. A guided preparation with a four-wheel stone for 1 mm occlusal reduction with a cylindrical coarse diamond stone following the occlusal surface the same processes were repeated to acquire the 1.5mm occlusal reduction **Figure (1).** A chamfer finish line 0.5 mm was done for all samples **Figure (2).**

Occlusal veneers construction

CAD/CAM occlusal veneers were fabricated using CEREC AC with Omnicam intra oral scanner (version 4.5, Sirona Dental Systems GmbH, Bensheim, Germany). The CEREC 3D software was

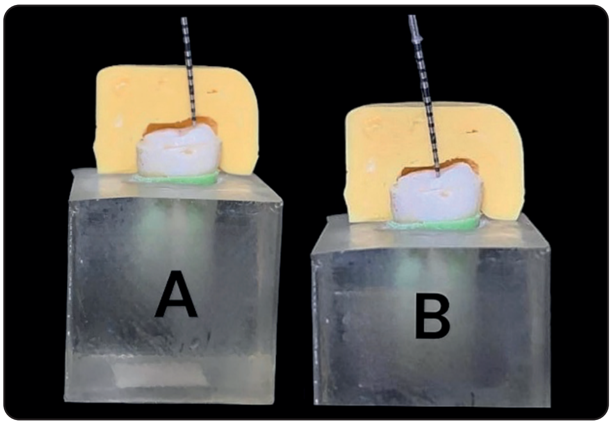

Fig. (1) (A) Occlusal preparation for 1mmocclusal veneer and (B) for 1.5 mm occlusal veneer.

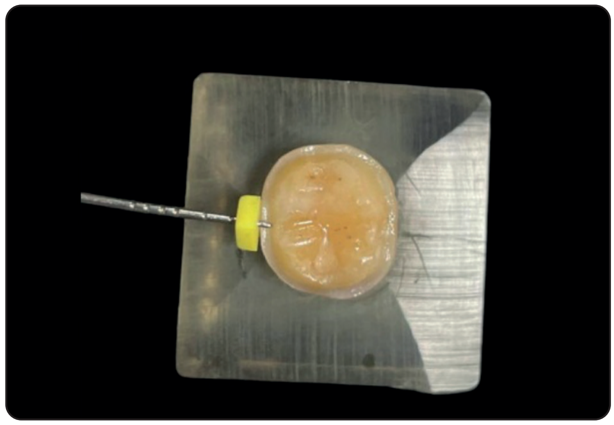

Fig. (2) Chamfer finish line 0.5 mm

used for designing the occlusal veneers restorations. 4-axis wet milling and grinding machine MCXL (Dentsply Sirona, Bensheim, Germany) was used **Table (1)**. For IPS e-max CAD and Celtra Duo groups, the milled specimens were crystallized and glazed in Programat P310 ceraamic furnace (Ivoclar Vivadent Inc., New York, USA). While the specimens of Shofu HC group were finished and polished using ZiLMaster Kit (SHOFU Dental GmbH, Ratingen), Germany.

Bonding procedure

All occlusal veneers were given a 3-minute ultrasonic cleaning, and the prepped teeth were given a 15-seconds ultrasonic cleaning followed by a 15-seconds thorough water rinse. After 20 seconds of etching each IPS e.max CAD and Celtra Duo with 9.5% hydrofluoric acid gel (Porcelain Etchant 9.5%, BISCO, USA), then completely cleaned and dried then silane coupling agent (Porcelain Primer Bis-silane, BISCO – USA) was used. Shofu primer (HC Primer, SHOFU Dental, Ratingen, Germany) was applied to Shofu HC restorations; it was left for 30 seconds before being let to air dry. Each prepared surface was etched for 30 seconds using a 37% phosphoric acid etchant gel (Etch-37TM. BISCO – USA), then washed and allowed to air dry. Then covered with two successive coats of bonding agent (All-Bond Universal, BISCO – USA), which were light cured for 20 seconds.

TABLE (1) Materials Used For Construction of Occlusal Veneers

Material	Brand name	Manufacturer	Chemical composition	Batch number
Lithium disilicate ceramics LT/A1/C14	IPS E.max CAD	Ivoclar vivadent, Schaan, Liechtenstein	Partially crystallized lithium disilicate glass-ceramic.	605328X40783
Zirconia reinforced lithium disilicate LT/A1/C14	CELTRA DUO	Dentsply Sirona	10% zirconia crystals by weight in the glass phase in atomically dissolved form	18002431942
Hybrid resin ceramics LT/A3.5/M	SHOFU HC	SHOFU	(61% by weight) zirconium silicate nanofiller and 39% polymeric resin matrix	16D20200221

Dual-cured adhesive resin cement (Duo link dual cure self-etch resin cement. BISCO, USA) using a light curing unit (ElipareTM, 3MESPE, USA); before full light curing, the margins were covered with glycerin gel, an oxygen-inhibited layer; and finally, they were subjected to a fixed weight of one kilogram **Figure (3)**.

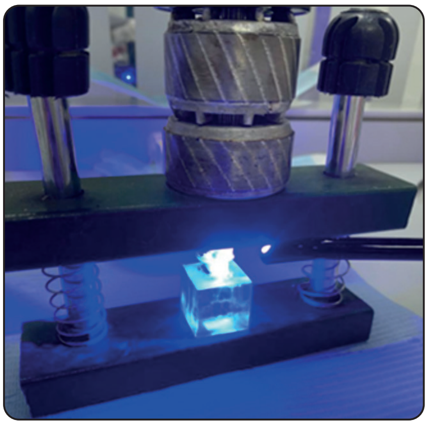

Fig. (3) Custom made loading device.

Marginal Adaptation Test

Measurements were made for every tooth along the circumference of the tooth/restoration margin at evenly spaced preset points on the buccal, mineral, lingual, and distal surfaces of each sample. Four marks were made on each surface, two millimeters apart. The vertical margin gap distance of all veneers was measured using an image analysis system (Image J-1b, NIH, USA) combined with a stereomicroscope (Leica, SZ-PT: Japan) at magnification 100 X **Figure (4).** All results were collected and statistically analyzed and recorded graphically using analyzing data software (Microsoft excel version 2016).

Fig. (5) Stereomicroscopic image of representative sample showing the marginal gap at magnification 100X.

RESULTS

Comparison between different surfaces and different thicknesses of each material:

Mean and standard deviation of marginal adaptation at all surfaces of each material **Table (2-4)** was performed by using One Way ANOVA test and Comparison between different thickness was performed by using Independent T test regarding buccal, lingual, mesial, and distal surfaces.

Comparison between all 3 groups of materials according to thickness:

A. ***Thin (1.00 mm) material thickness:*** Mean and standard deviation of marginal adaptation at different surfaces of thin (1.00 mm) material in all groups were presented in **Table (5)** using One Way ANOVA test then followed by Tukey`s Post Hoc test for multiple comparisons.

B. ***Conventional (1.5 mm) material thickness:***

Mean and standard deviation of marginal adaptation at different surfaces of conventional (1.5mm) material in all groups were presented in **Table (6)** using One Way ANOVA test then followed by Tukey`s Post Hoc test for multiple comparisons.

TABLE (2) Mean and standard deviation of marginal adaptation at all surfaces of group 1 (L) regarding either thin (1.00 mm) and conventional (1.5 mm) thickness of material

Group (1) (LD) IPS E.max	Thin 1.00 mm		Conventional 1.5 mm		Independent t test				P value
					MD	SED	95% CI		
	M	SD	M	SD			L	U	
Buccal	14.15	2.11	12.44	2.47	-1.71	1.21	-4.33	0.91	0.18
Lingual	13.59	1.02	12.36	1.23	-1.22	0.53	-2.51	0.06	0.061
Mesial	14.63	3.12	12.68	1.14	-1.9	1.26	-4.68	0.78	0.14
Distal	14.29	1.5	13.08	1.11	-1.21	0.705	-2.47	0.32	0.1
P value	0.15		0.17						

TABLE (3) Mean and standard deviation of marginal adaptation at all surfaces of group 2(Z) regarding either thin (1.00 mm) and conventional (1.5 mm) thickness of material

Group (2) ZLS (Celtra Duo)	Thin 1.00 mm		Conventional 1.5 mm		Independent t test				P value
					MD	SED	95% CI		
	M	SD	M	SD			L	U	
Buccal	10.09	4.18	6.69	0.84	-3.4	1.75	-7.67	0.88	0.06
Lingual	10.19	2.04	7.94	1.91	2.25	1.056	-4.55	0.05	0.06
Mesial	8.68	1.71	7.53	0.82	-1.15	0.71	-2.71	0.41	0.13
Distal	9.21	1.51	7.31	1.98	-1.9	0.94	-3.95	0.15	0.06
P value	0.11		0.51						

TABLE (4) Mean and standard deviation of marginal adaptation at all surfaces of group 3 (R) regarding thin (1.00 mm) and conventional (1.5 mm) thickness of material

Group (3) (R) (Shofu Hc)	Thin 1.00 mm		Conventional 1.5 mm		Independent t test				P value
					MD	SED	95% CI		
	M	SD	M	SD			L	U	
Buccal	13.28	1.17	11.88	1.27	-1.4	0.65	-2.88	0.022	0.06
Lingual	13.47	2.15	11.53	1.28	-1.95	0.94	-4.01	0.12	0.06
Mesial	14.92	0.51	12.45	2.19	-0.47	0.84	-2.32	1.3	0.59
Distal	14.3	1.69	12.23	2.4	-2.07	1.19	-4.48	0.34	0.08
P value	0.91		0.11						

TABLE (5) Mean and standard deviation of marginal adaptation at different surfaces of thin (1.00 mm) material in all groups and comparison between them

Thin 1.00 mm	Group (1) (L)		Group (2) (ZLs)		Group (3) (R)		P value
	M	SD	M	SD	M	SD	
Buccal	14.15 b	1.11	10.08 a	4.18	13.28ab	1.17	0.0200*
Lingual	13.58 b	1.02	10.19 a	2.04	13.47 b	2.15	0.0003*
Mesial	14.62 b	3.12	8.68 a	1.71	12.92 ab	0.51	0.0001*
Distal	14.28 b	1.5	9.21 a	1.51	14.29 b	1.69	0.0001*

Significantly different as $P<0.05$.

TABLE (6) Mean and standard deviation of marginal adaptation at different surfaces of conventional (1.5 mm) material in all groups and comparison between them:

Conventional thickness 1.5mm	Group (1) (L)		Group (2) (ZLS)		Group (3) (R)		P value
	M	SD	M	SD	M	SD	
Buccal	12.44 b	1.47	6.69 a	0.84	11.88 b	1.27	0.0001*
Lingual	12.36 b	1.23	7.94 a	1.91	11.53 b	1.28	0.0001*
Mesial	12.68 b	1.14	7.53 a	0.82	12.44 b	2.19	0.0001*
Distal	13.08 b	1.11	7.31 a	1.98	12.23 b	2.4	0.0001*

DISCUSSION

Patients with generalized wear require more sophisticated care. Awareness of esthetics and tissue conservation must be taken into consideration, in addition to the difficulties in maintaining vertical dimension, occlusal stability, and the shape and morphology of the dentition [(10)]. Because of advancements in biomimetic restorative materials, computer-aided design/computer-aided manufacturing (CAD/CAM), and new adhesive protocols with properties similar to natural teeth, minimally invasive treatment options have been developed [(11).]

Natural teeth were used to simulate natural clinical conditions and provide good quality substrate for optimum bonding protocol[(12)]. To ensure standardization in this study, some procedures were adopted; at first fabrication of silicon index material and biogeneric copy that can be superimposed on scans of teeth after preparation to check amount of occlusal reduction and copy the occlusal morphology to the final restoration [(13)]

The thickness of 1 mm occlusal veneers was selected for this study because, according to **Albelasy et al. (2020)** **[(14)]** systematic review, who stated the majority of published literature stated that partial coverage ceramic restorations showed favorable results in terms of fracture strength and structural durability at a thickness of 0.7–1.0 mm. However, as 1.5 to 2.0 mm is the typical suggestion for ceramic restoration thickness.

Chamfer finish line was done as they offer more rounded internal gaps than shoulder finish lines. Additionally, the possibility of lipped margins, sharp line angles, beveled finish lines is eliminated by using chamfer finish line. Furthermore, it allows to mill the thin margins without chipping [15].

Comparison of the thickness of each materials showed insignificant difference as P>0.05. The highest mean value of marginal gap was for IPS Emax thin group at the four surfaces of tested occlusal veneer; and the lowest mean value of marginal gap was for Celtra Duo conventional group at the four surfaces of occlusal veneer ; Therefore, the mean marginal gap of all the tested samples with clinical accepted ranges and below the repeated values in other literatures [16] that stated that the accepted range of marginal adaptation of all ceramic restorations are within 120 µm. It could be assumed that all the tested specimens have accepted marginal adaptation that prevents further marginal leakage, cement dissolution and secondary caries.

Based on the results of this study, the null hypothesis was partially rejected as the marginal adaptation of occlusal veneer was dependent on the material type. Because there was a statistically significant difference between different materials used for construction of occlusal veneers. On the other hand, there was no statistically significant difference between the two tested occlusal veneer thicknesses conventional 1.5 and thin 1mm.

The high value of marginal gap in E.max CAD in both thicknesses were statistically significant compared to all the other tested groups. The inferior marginal fit may be attributed to the dimensional changes that occur during crystallization firing of e.max CAD. As IPS e.max CAD was milled in a partially crystallized form then after crystallization firing transformed into fully crystalized form. Therefore IPS e.max CAD is expected to have linear shrinkage **Bosch et al. (2014)** [18].

The highest marginal adaptation was for Celtra Duo in both thicknesses may be due densification of the ceramic material which consists of approximately 58% silica crystals and additional 10% Zirconium Dioxide, The 10% zirconia is completely diluted in amorphous glass is added to the composition of Celtra Duo to create a fine-grained structure of (0.5 – 1 μm) in length and the crystallites embedded in the glass phase of IPS e.max CAD are 2000-4000nm in size, which might be the cause of the less linear shrinkage after firing could be a factor for better marginal adaptation than lithium disilicate **Dirxen et al. (2016)** [19].

The results of Shofu can also be explained by the fact that Shofu hybrid nano ceramic material doesn't need any heat treatment after milling and doesn't suffer from linear shrinkage which may and has modulus of elasticity 12.77 GPa Which allows the material to cut smooth edges with intimate contact with the preparation and better marginal fit enabling the material for milling in very thin sections without chipping **Lauvahutanon et al (2016)** [20].

The findings can also be explained by the variable machinability of the different ceramic materials, the machinability of the IPS E.max can influence the integrity of a minimally designed restoration. The machinability of a material can be measured with the calculation of its brittleness index (BI) and marginal chipping factor (CF) **Tsitrou et al. (2021)**[21] .

The results of our study agreed with **Abuhagar et al. (2022)**[22] who measured the marginal adaptation of occlusal veneers fabricated from IPS E.max CAD, Celtra Duo and vita enamic ceramic restorations with thickness 1.5mm and 1mm. Also, these results agreed **with Emam & Aleem (2020)**[23] who compared the marginal adaptation of occlusal veneers made from IPS e.max CAD, Vita Suprinity and hybrid nano ceramic materials and they recorded that Vita Suprinity showed the highest marginal adaptation than other tested materials.

Also, these findings agreed with. **Taha& Wahsh (2020)**[24] who measured the marginal adaptation of IPS E.max and Celtra Duo and vita enamic for monolithic crowns with feather edge finish line and concluded that marginal adaptation of vita enamic and Celtra Duo is higher than IPS E.max due to the fully crystalizied state of Celrta Duo and vita enamic than IPS E.max that need crystalization firing after milling.

On the other hand, these results disagreed with **Preis et al. (2015)** [25] and **Taha et al. (2018)** [26] who measured the marginal adaptation of IPS E.max and Celtra Duo endocrowns and found no significant difference in both materials due to the similarity in composition of both materials and slight difference in the microstructure that were not affect the marginal adaptation.

Contrast to our results, **Sasse et al. (2022)**[27] who investigated the marginal adaptation of occlusal veneers made from lithium disilicate, vita suprinity and vita enamic with different thicknesses (0.6- and 1.0-mm). it was found that marginal adaptation of vita enamic at 0.6mm and 1.0-mm thick occlusal veneers were better marginal adaptation than lithium disilicate and vita suprinity materials. This can be attributed to the tested materials undergoing thermocycling and mechanical loading.

Considering the limitations of this study there were no thermocycling or dynamic loading and no immersion in artificial saliva or different PH fluids before measurement of marginal adaptation which resemble intraoral conditions. Also, using one adhesive cement and one adhesive protocol. Further studies are needed to study the impact of different bonding protocols and cements on the marginal adaptation and to evaluate the marginal adaptation after cyclic loading. Clinical studies are required to test the effect of different occlusal veneer thickness on the clinical behavior of the tooth-restoration complex.

CONCLUSION

1. Occlusal veneers constructed of different restorative materials (lithium disilicate, Zirconia reinforced lithium silicate, resin nano ceramic material) showed insignificant difference in marginal adaptation at different tooth surfaces.
2. Irrespective to the occlusal veneer thicknesses, the different restorative materials (lithium disilicate, Zirconia reinforced lithium silicate, resin nano ceramic material) showed significant effect on marginal adaptation.
3. Variations in occlusal veneer thicknesses (conventional 1.5mm or thin 1mm) for the different restorative material used, showed insignificant effect on marginal adaptation.
4. Zirconia reinforced lithium silicate showed the highest marginal adaptation and Lithium disilicate occlusal veneer showed the lowest marginal adaptation.
5. Marginal adaptation of all occlusal veneer materials and thicknesses used are within the clinical acceptance.

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Ethics: This study protocol was accepted by the ethical committee of faculty of dentistry -Cairo university on :13/5/2022, approval number 1315.

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