The Effect of Ceramic Material and Thermocycling on the Marginal Adaptation of Onlay Restorations

***Afnan Thamer Hassan*[a], *Dr. Marwa Mohamed Wahsh*[b], *Dr. Soha Osama Nabih*[c]**
[a] *Master's degree student, Department of Fixed Prosthodontics, Faculty of Dentistry, Ain Shams University*
[b] *Professor, Department of Fixed Prosthodontics, Faculty of Dentistry, Ain Shams University*
[c] *Lecturer, Department of Fixed Prosthodontics, Faculty of Dentistry, Ain Shams University*

Abstract:
Objectives:: The current study aimed to assess marginal adaptation of polymer infiltrated ceramic (Vita Enamic) and Zirconia reinforced lithium silicate ceramic (Vita Suprinity) onlays with palatal anatomical occlusal preparations.
Materials and Methods: In this study 20 Caries free human maxillary premolars were used with a standard onlay cavity preparation with anatomical occlusal preparation on the palatal cusp. Preparations were scanned, designed and sent for milling the ceramic onlays using CORiTECH 250i milling machine. Half of onlays were milled from Vita Enamic blocks and the other half from Vita Suprinity blocks. Resin cementation weas done for all the onlays. The onlays were subjected to 5000 cycles of thermocycling. Marginal gaps (µm) were measured using digital microscope before and after thermocycling.two-way ANOVA was used to study the effect of tested variable and its interaction on marginal gap (µm).
Results: Zirconia reinforced lithium silicate ceramic (Vita Suprinity) had higher marginal gap than Polymer infiltrated ceramic (Vita Enamic) before and after thermocycling (40.52µm) (30.29µm) and (71.86µm) (62.10µm) respectively. Also, thermocycling had increased the marginal gaps for all onlays sample.
Conclusion: Polymer infiltrated ceramic (Vita Enamic) onlays had better marginal adaptation compared to Zirconia reinforced lithium silicate ceramic (Vita Suprinity) onlays before and after thermocycling using anatomical occlusal preparations.
Keywords*:* Anatomical preparation – Hybrid ceramics - Marginal adaptation- Onlays-

Introduction

Over the past decade, the patient's demands for highly esthetic restorations have become of prime importance. The clinical choice to select a material for restoration of posterior tooth, is influenced by multiple factors. If patient demands an "esthetic'' restoration, options are limited to composite or ceramic [(1)]
Direct resin composite restoration is accepted by patients not only for anterior teeth but also for posterior teeth. However, clinical cases involving a large coronal defects, recovery of the proximal contacts, anatomical form, wear resistance, and gingivo-marginal adaptation present challenges for direct resin composite. [(2)]
Indirect ceramic restorations have developed because of their translucency and high strength. [(3)]Another advantage includes minimal tooth reduction compared with metal ceramics, minimal thermal conductivity and mimic natural dentition. Also, they have desirable properties including; their physical and mechanical properties, excellent biocompatibility to periodontal tissues, reduced plaque accumulation and high compressive strength. [(4)]
One of the developments in dental ceramics was hybrid ceramics. It consists of organic matrix and the inorganic filler particles such as: zirconia or polymer. These fillers play a role in changing the ceramic properties. Adding zirconia will increase the flexural strength of the ceramic by making high percentage of glassy matrices. On the other hand, by adding polymer it will have higher structural reliability as a result of the so-called crack-stop function mechanism, which occurs when a crack that is propagating through the polymer network halts due to the presence of the ceramic phase. Therefore, these materials have better mechanical properties, esthetics properties and greater occlusal load compensation capacity [(5)]

Onlay is a partial coverage restoration covering at least one cusp. The use of tooth colored partial coverage restoration such as onlays have increased because these restorative designs provide a conservative and an esthetic option that requires minimal tooth preparation. [(6)] The preparation design of onlays is different according to the clinical situation. Anatomical design provides maximum hard tissue preservation and minimum dentin exposure because it follows the anatomy of the cusp.[(7)]

Marginal adaptation is known as the distance between the finish line and the restoration margin. It is considered one of the most important criteria affecting the long term prognosis of ceramic restoration. If a significant gap is present luting material will be exposed to the oral environment and result to dissolution and microleakage. This will lead to recurrent caries, marginal discoloration and eventually restoration failure. [(4)] Marginal adaptation is influenced by several factors such as: ceramic type, thermal ageing, impression material and technique, die spacer, fabrication technique either milling or pressing. [(8)]
Therefore, this study was designed to investigate the effect of the two ceramic materials: polymer infiltrated ceramic (Vita Enamic) and zirconia reinforced lithium silicate

Table (1): The material used in this study:

Product	**Chemical composition**	**Manufacturer**
Polymer infiltrated glass-ceramic.	1-The inorganic phase is a feldspathic ceramic (86 wt. % or 75 vol. %). 2-The organic phase is UDMA (urethane dimethacrylate) and TEGDMA (triethylene glycol dimethacrylate)(14 wt. % or 25 vol. %).	Vita Enamic (VITA Zahnfabrik, bad sack Germany)
Zirconia reinforced lithium disilicate.	1-Glass ceramic: lithium silicate ceramic. 2-10% zirconia (ZrO2).	Vita Suprinity (VITA Zahnfabrik, bad sack Germany)
Ceramic etch.	9.5% hydrofluoric acid gel	Bisco Inc, Schaumburg,I1, USA
Porcelain primer (Silane copling agent)	HEMA, Ethanol, purified water, silane coupling agent ,methacrylate ester monomer HEMA(2-hhydroxyethyl methacrylate	Bisco Inc, Schaumburg,I1, USA
Self-adhesive dual cure Resin cement	Base paste: Bis-GAMA, TEGDMA, urethane dimethacrylate, glass fillers. Catalyst: Bis-GAMA, Tegdma, glass fillers.	Aureocem NE Germany
Enamel etch	Phosphoric acid (37%)	SPIDENT USA

ceramic (Vita Suprinity) on the marginal adaptation of the onlay restorations using anatomical occlusal preparation design before and after thermocycling.

2-MATERIALS AND METHODS:

The materials used in the current study are summarized in table 1.

Tooth selection and preparation:

20 Caries free human maxillary premolars were used for a standard onlay cavity preparation with mesial and distal boxes. Preparation was carried out with an onlay diamond burs set (Ser –Onlay set III Extended, 1Sevuk, Istanbul) using dental milling machine (AF 30 milling machine NOUVAG). The prepared cavity was 2mm in-depth at the central groove and 2mm palatal cusp reduction with an anatomical design. The cavity was prepared with isthmus width 2mm, 6° occlusal tapers of axial walls and 90° cavo-surface margin. The gingival seat of the proximal boxes was prepared 1.5mm below to pulpal floor. To ensure proper cusp reduction a silicon index and periodontal probe were used. Then, finishing of axial walls was done then finishing of the pulpal floor and roundation of the occluso-axial line angles were done using finishing stones.

Preparation scanning, designing and milling:

Preparations were scanned by desktop extra oral scanner E2 Lab scanner (3 shape, Copenhagen, Denmark) then, Exocad in-lab system software (GmbH, Darmstadt, Germany was used to design the onlays. After 3D –model calculation, wall smoothness, detection of any undercuts and sharp or point angles were checked. Automatic margin line detection was used to trace the margin of all preparations. The cement space values were set at 15µm for all samples. Then, the height of palatal cusp was designed at 2mm, the cavity depth was detected at 2mm. CORiTECH 250i milling machine was used to mill 10 VITA ENAMIC and 10 VITA SUPRINITY onlays.

Finishing and polishing of the onlays restorations:

Inspection was also done for every onlay on the corresponding tooth for proper seating. For Vita Enamic onlays, Enamic polishing set was used with a micro motor. And forVITA Suprinity finishing was doneusing fine –grit diamond stone under water coolant, then the restorations were cleaned using the ultrasonic cleaner for 5 minutes. Crystallization cycle was adjusted on (Programat P510, Ivoclar, Vivadent) according to manufacturer's recommendations after application of VITA firing paste.

Adhesive procedures:

The inner surface of the Enamic onlays were etched according to the manufacturer's instructions using 9.5% of hydrofluoric acid for 30 seconds, while the Suprinity onlays were acid etched for 15 seconds. Then silane was applied, air dried and left for 60 seconds.

All prepared teeth were selectively etched with 37% of phosphoric acid for 20 seconds on enamel margin.

Bonding protocol:

The Self-adhesive Duo-Link resin cement Aureocem NE was used for cementation of the onlays. A load device was used to apply a standardized load of 1 Kg directly towered the central groove. Onlays were exposed to a brief light curing for only 2 seconds using 3M ESPE curing light and excess resin cement was removed. Then, light curing was done for 20 seconds for each side.

Thermocycling:

The teeth were subjected to thermocycling for 5000 cycles between 5 ±2° C and 55 ± 2° C with a dwell time of 30 seconds in each bath and 20sec interval between baths at ambient air.

Marginal gap measurement:

Each specimen was photographed using a USB Digital microscope with a built-in camera (U500X Digital Microscope, Guangdong, and China) connected with a compatible personal computer using a fixed magnification of 45X. A digital image analysis system (Image J 1.43U, National Institute of Health, and USA) was used to measure and qualitatively evaluate the gap width. Within the Image J software, all limits, sizes, frames and measured parameters were expressed in pixels with a scale generated by the Image J software. 4 Shots for etch sample were taken (Mesial, buccal, distal, and palatal). Then, a total 8 equidistant points of measurement along the circumference were recorded for each onlay restoration.

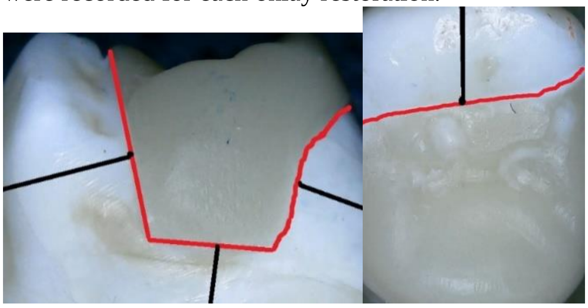

Figure (1): Digital microscope picture shows occlusal and mesial views marginal gap measurements.

Statistical analysis:
Numerical 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 parametric distribution so; it was represented by mean and standard deviation (SD) values. Two-way ANOVA was used to study the effect of different tested variables and their interaction on marginal gap (µm). Comparison of main and simple effects were done utilizing Bonferroni correction. The significance level was set at p ≤0.05 within all tests. Statistical analysis was performed with IBM (IBM Corporation, NY, and USA) SPSS (SPSS, Inc., an IBM Company) Statistics Version 26 for Windows.

3-RESULTS
Descriptive statistics for marginal gap (µm) values were summarized in table (2).
The results of the current study showed that Polymer infiltrated glass-ceramic (Vita Enamic) had better marginal adaptation before and after thermocycling than Zirconia reinforced lithium silicate ceramic (Vita Suprinity) before (30.29µm) (40.52µm) and after (62.10µm) (71.86) respectively. Thermocycling had a negative effect on the marginal gap for both materials Polymer infiltrated glass-ceramic (Vita Enamic) and Zirconia reinforced lithium silicate ceramic (Vita Suprinity) (30.29µm, 40.52µm) and (62.10µm, 71.86µm).

4-DISCUSSION:
In this study, Vita Enamic was selected since it is characterized by a double network structure including the excellent features of composite as well as ceramic. Vita Enamic allows the reinforcement of the dominant ceramic

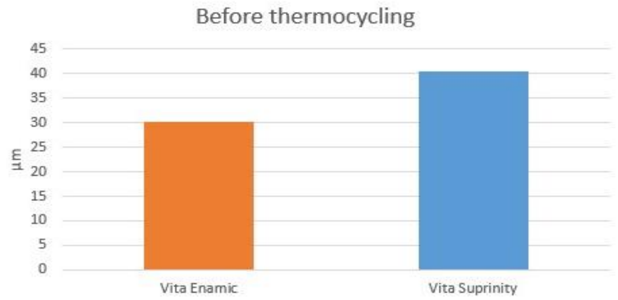

Figure (2): Box plot showing marginal gap values (µm) before thermocycling

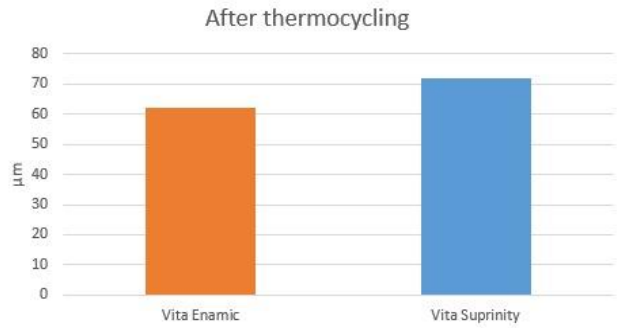

Figure (3): Box plot showing marginal gap values (µm) after thermocycling

mesh with a polymer network with the two networks fully combined [3]. In addition, it has excellent edge stability, massive loading capacity because of its ability to absorb the masticatory forces. Also, Vita Enamic has great accuracy and combined crack-stop job. [9]
Also in this study, Vita Suprinity is used since it is characterized by a specific regular and fine-grain microstructure that provides a great material quality and hence a constantly great loading capacity and long-term reliability. Additionally, it has an outstanding processing characteristics including high strength and hardness duo to present of 10% zirconia in there structure Also, it offers a notably natural aesthetic result via its fluorescence, translucency, and opalescence features[4]

The use of partial coverage restoration such as onlays have increased due to the reason of providing a conservative and an esthetic option that requires minimal tooth preparation.[6] Especially in case of cuspal fracture while enough remaining tooth structure is still present to work with [10]
The marginal adaptation of CAD/CAM restorations depend on how accurately the scanner can capture the data and how precisely the milling machine can grind the blocks. [4]

The geometry of the preparation could affect data capture, despite that the anatomical design provide maximum hard tissue preservation and minimum dentin exposure, but the elevation of the cusp will make the data scanning and seating of the final restoration harder. [11]
Also, the Machinability of blocks can affect the adaptation

Table (2): Descriptive statistics of marginal gap (µm).

Thermocycling	Material	Mean	SD	Median	Range
Before	**Vita Enamic**	30.29	5.05	31.16	13.34
	Vita Suprinity	40.52	7.45	39.30	21.40
After	**Vita Enamic**	62.10	6.72	64.89	19.19
	Vita Suprinity	71.86	11.17	71.56	29.46

as it define the ease in which a given material is cut, which can be derived from the hardness and fracture toughness, chipping factor, and microstructure of the material. It was found that the penetration rate of a cutting bur was higher in polymer containing ceramics than zirconia containing ceramics.[8,12] This is why the ENAMIC restorations is statistically having lower marginal gaps (46.19.70µm) when compared to SUPRINITY samples (56.19µm).

For all groups, after thermocycling the marginal gap has increased. Furthermore this is due to thermal changes that occurs between 5-55°C; water absorption phenomena of composite resin cement and microleakage .Also as a result of the moist oral environment, degradation and wear of luting cement occurs.[13] Another explanation for the increase in the marginal gap could be related to the relationship between marginal gap distance, cement thickness and differences in coefficient of the thermal expansion .This is mainly due to the presence of many interfaces; enamel, dentine, resin cement and restorative material. In a study by Stappert et al, (2008). [14] it was concluded that the evidence of wide cement space widths during thermal changes expedited degradation of marginal cement material and impaired the integrity of a ceramic restoration by increasing elution of fillers. Krejci et al, (1993). [15] Also experienced a decrease in marginal adaptation due to an increase in chemical abrasion, thermal cycling and loading fatigue on ceramic onlay. Finally, thermocycling may have caused hydrolysis of the silane causing degradation of the chemical bond between the resin cement and the ceramic .[16]
All the tested samples showed mean values within the recommended clinical range (35.40 µm to 66.98µm). As in the study by McLean who has conducted a five-year study on over one thousand restorations. McLean has determined that 120 µm was the maximum acceptable marginal adaptation value . [17]

5-Conclusions:

By studying the effect of different variables and their interaction on marginal gap the following were concluded:
1-Marginal adaptation was material dependent.
2- Polymer infiltrated ceramic (Vita Enamic) had better marginal adaptation than Zirconia reinforced lithium silicate ceramic (Vita Suprinity).
3- Both Polymer infiltrated ceramic (Vita Enamic) and Zirconia reinforced lithium silicate ceramic (Vita Suprinity) provided marginal adaptation within clinical accepted range.
4- Thermocycling has adverse effect on marginal adaptation.

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