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

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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 was 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. Three-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-
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.

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

<table>
<thead>
<tr>
<th>Product</th>
<th>Chemical composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymer infiltrated glass-ceramic</td>
<td>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 32 vol. %).</td>
</tr>
<tr>
<td>Zirconia reinforced lithium disilicate</td>
<td>1-Glass ceramic: lithium silicate 2-10% zirconia (ZrO2).</td>
</tr>
<tr>
<td>Ceramic etch.</td>
<td>9.5% hydrofluoric acid gel</td>
</tr>
<tr>
<td>Porcelain primer (Silane coupling agent)</td>
<td>HEMA, Ethanol, purified coupling agent, methacrylate ester, silane coupling agent, HEMA (2-hydroxyethyl methacrylate) (57.5 wt. % or 75 vol. %).</td>
</tr>
<tr>
<td>Self-adhesive dual cure Resin cement</td>
<td>Base paste: Bis-GAMA, TEGDMA, unfillers. Catalyst: Bis-GAMA, Tegdma, glass fillers.</td>
</tr>
<tr>
<td>Enamel etch.</td>
<td>Phosphoric acid (37%)</td>
</tr>
</tbody>
</table>

Adhesive procedures:

The inner surface of the Enamic onlays were \( \text{enamed} \) before cementation. The enamel surface was etched for 30 seconds, while the Suprinity onlays were etched for 15 seconds. Then silane coupling agent was applied to the enamel surface. 10 VITA ENAMIC onlays were exposed to a brief light curing for 20 seconds on enamel margin. 10 VITA SUPRINITY onlays were exposed to a brief light curing for 20 seconds on marginal gap measurement.

Preparation, scanning, design 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 modeling 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 for VITA Suprinity finishing was done using 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 PS10, Ivoclar, Vivaident) according to manufacturer’s recommendations after application of VITA firing paste.

Each specimen was photographed using a USB Digital microscope with a built-in camera (U500X Digital Microscope, Guangdong, and China) connected to 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 each 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.

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°occclusal tapers of axial walls and 90°cavo-surface margin. The gingival seal of the proximal boxes were recorded for each onlay restoration.

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Digital microscope picture shows occlusal and mesial views marginal gap measurement.
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).

<table>
<thead>
<tr>
<th>Thermocycling</th>
<th>Material</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>Vita Enamic</td>
<td>30.2</td>
<td>5.05</td>
<td>31.16</td>
<td>13.34</td>
</tr>
<tr>
<td></td>
<td>Vita Suprinity</td>
<td>40.5</td>
<td>7.45</td>
<td>39.30</td>
<td>21.40</td>
</tr>
<tr>
<td>After</td>
<td>Vita Enamic</td>
<td>62.1</td>
<td>6.72</td>
<td>64.89</td>
<td>19.19</td>
</tr>
<tr>
<td></td>
<td>Vita Suprinity</td>
<td>71.8</td>
<td>11.1</td>
<td>71.56</td>
<td>29.46</td>
</tr>
</tbody>
</table>

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) (71.86µm) 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 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 (4). 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 (5).

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 (5). 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. (6)

Also, the Machinability of blocks can affect the adaptation 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...
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. 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) 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). 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.

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.

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.

References


