**ABSTRACT**

**Aim:** to quantify the effect of presence of enamel wall and thermocycling on marginal microleakage of class V cavities restored with preheated bulk-fill or preheated nano-filled composite. **Methods:** Class V cavities were prepared on the buccal surface of forty-eight extracted maxillary first premolars. The teeth were divided into two groups according to the type of preheated composite used (either bulk-fill or Nano-filled) and further subdivided according to thermocycling or no thermocycling. The teeth were immersed in 0.5% methylene blue dye solution for 24 hours at room temperature and then sectioned buccolingually to examine the extent of microleakage by dye penetration. Microleakage was assessed by a stereomicroscope at 40x magnification and measured in micrometers depending on the extent of dye penetration for both occlusal and gingival walls separately. Statistical analysis was done by Kruskal-Wallis test for comparison between groups and Mann-Whitney test for comparing occlusal and gingival dye penetration in each group. **Results:** preheated Nano-filled composite subjected to thermocycling showed more significantly microleakage than other groups (P < 0.05). Microleakage was significantly more (P < 0.05) in gingival (cervical) walls of teeth compared to occlusal walls in all groups except preheated Nano-filled composite directed to thermocycling which showed no significant difference between gingival and occlusal walls (P > 0.05). **Conclusions:** thermocycling of preheated Nano-filled composite produced more microleakage than thermocycling of preheated bulk-filled composite. More microleakage was recorded in cervical areas than occlusal areas of class V cavities.

**INTRODUCTION**

Composite resin as a direct or indirect restorative material have been widely used by dentists owing to its good physiochemical properties and outstanding aesthetics \[^1\]. Through time there have been a lot of advancements in composite resins materials, properties, and techniques of placement but still, polymerization shrinkage is one of the challenges that could affect the longevity of the restoration leading to failure \[^2\]. Polymerization shrinkage results in stresses along the restoration/
tooth interface that leads to gap formation and microleakage with subsequent fluids and bacterial penetration that could lead to post-operative hypersensitivity, secondary caries and/or fracture of the restoration [3]. Also, composite resin suffers from some drawbacks regarding application due to its stickiness and higher viscosity that may decrease its adaptation to the cavity walls. So, to overcome these limitations some new materials or techniques are proposed to improve its properties such as pre-heating of composite resin before polymerization [4].

Pre-heating of composite resin reduce its viscosity due to thermal energy pushing monomers and oligomers apart and letting them slide more easily, which result in more adaptation to the cavity wall, better handling characteristics and lesser microleakage [5,6]. Recent systematic reviews found out that pre-heating of composite results in less viscosity, more conversion degree, better microhardness, lesser microleakage and better marginal adaptation [7-9]. Pre-heated composite resin could be used as a direct restorative material or for luting indirect restorative materials [10,11]. Introduction of bulk-fill composites made it easier to restore the cavity in a larger single increment of 4 or 5 mm without fearing of shrinkage or time-consuming application compared to conventional incremental composite [12].

Fluctuations of the temperature and pH in the oral environment poses huge stresses on the dental restoration that may lead to gap formation and microleakage at the tooth/restoration interface owing to the mismatch in coefficients of thermal expansion between the two. Thermocycling and ageing of restoration by subjecting them to different thermal cycles and mechanical loads is used to study the effect of oral environment on the microleakage of the restoration [13]. Effect of thermocycling on microleakage of preheated composites is not extensively studied in class V restorations with few studies showing controversial results [4,8,9]. So, the aim of this study is to examine the effect of thermocycling on microleakage of pre-heated bulk-fill and conventional composite in class V cavities.

MATERIALS AND METHODS

Forty-eight extracted intact and caries free maxillary 1st premolar teeth were used in this study. Standardized class V cavities were prepared on the buccal surface of the teeth using a plain fissure carbide bur, mounted on a high-speed hand-piece with water coolant. The cavity dimensions were 3 mm width x height 2.5 mm x 1.5 mm depth and marked on the tooth surface using a marker before preparation. To standardize the depth, a Teflon stopper was added to the shank of the bur at the desired length.

After cavity preparation, enamel and dentin were etched with 37% phosphoric acid for 30 seconds for enamel and 15 seconds for dentin, rinsed with water for 15 seconds, then excess water was removed by using a mini-sponge. The adhesive (All-Bond Universal, BISCO Dental Products, Schaumburg, Illinois 60193 U.S.A.) was applied according to the manufacturer’s instructions to all cavity walls, using a disposable applicator, then light cured with an LED curing unit for 10 seconds (intensity 1200 mW/cm²).

Preheating of composite was performed by composite heater for all samples at 50 °C (Fig.1). Then the 40 specimens were randomly divided into four groups of 10 each according to the type of composite and thermocycling:

- **Group A1**: Nano filled composite with no thermocycling
- **Group A2**: Nano filled composite with thermocycling
- **Group B1**: bulk-fill packable composite with no thermocycling
- **Group B2**: bulk-fill packable composite with thermocycling
• Group B2: bulk-fill packable composite with thermocycling

The resin composite in all groups were applied according to the manufacturer instructions and cured for 20 seconds each. Types of composite used are shown in Table 1

Table (1) Types of composites used in the study.

<table>
<thead>
<tr>
<th>Composite</th>
<th>Specification</th>
<th>Manufacturer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Estelite α</td>
<td>Supra Nano spherical filled composite (Silica-zirconia, 0.2 micron)</td>
<td>Tokuyama Dental Corporation, Japan</td>
</tr>
<tr>
<td>2. X-tra fill</td>
<td>Micro hybrid bulk-fill packable composite</td>
<td>Voco GmbH, Germany</td>
</tr>
</tbody>
</table>

The samples of groups A2 and B2 were thermocycled for 3000 cycles (5±2°C -55±2°C, one-minute dwell time) (SD Mechatronic Thermocycler, Feldkirchen, Westerham, Germany, Fig.1). Teeth were coated with two layers of a nail varnish 1mm away from the margins of restorations to eliminate micro leakage from areas other than the restoration margins to avoid false positive results. The teeth were immersed in 0.5% methylene blue dye solution for 24 hours at room temperature.

To measure the extent of micro leakage; teeth were sectioned longitudinally through the restorations in a buccolingual direction using a diamond disc. The sectioned teeth were evaluated for micro leakage with a stereomicroscope at (40x) magnification (Fig. 2) and measured in micrometers depending on the extent of dye penetration for both occlusal and gingival walls separately [14].

RESULTS

Forty-eight extracted first maxillary premolars were divided into 4 groups according to the type of composite used and according to thermocycling or no, where each group had 12 teeth that were sectioned bucco-lingually and evaluated for microleakage occlusally and gingivally. The mean values of dye penetration as measured in micrometers are presented in Table 2.

Fig. (1) Resin composites, composite heater and thermocycler used in study.
Comparing occlusal and gingival dye penetration mean values for each group using 2 tailed Mann-Whitney test, gingival walls showed significantly more dye penetration than occlusal walls in all groups (P value < 0.05) except for thermocycled preheated Nano-filled composite (Table 4).
<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Rank</th>
<th>Sum of ranks</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 occlusal</td>
<td>12</td>
<td>8.17</td>
<td>98.00</td>
<td>0.002*</td>
</tr>
<tr>
<td>A1 gingival</td>
<td>12</td>
<td>16.83</td>
<td>202.00</td>
<td></td>
</tr>
<tr>
<td>A2 occlusal</td>
<td>12</td>
<td>15.17</td>
<td>182.00</td>
<td>0.64</td>
</tr>
<tr>
<td>A2 gingival</td>
<td>12</td>
<td>9.83</td>
<td>118.00</td>
<td></td>
</tr>
<tr>
<td>B1 occlusal</td>
<td>12</td>
<td>6.50</td>
<td>78.00</td>
<td>&lt; 0.0001*</td>
</tr>
<tr>
<td>B1 gingival</td>
<td>12</td>
<td>18.50</td>
<td>222.00</td>
<td></td>
</tr>
<tr>
<td>B2 occlusal</td>
<td>12</td>
<td>7.17</td>
<td>86.00</td>
<td>&lt; 0.0001*</td>
</tr>
<tr>
<td>B2 gingival</td>
<td>12</td>
<td>17.83</td>
<td>214.00</td>
<td></td>
</tr>
</tbody>
</table>

A: Nano-filled composite, B: Bulk-fill composite, 1: no thermocycling, 2: thermocycling, *: significant

**DISCUSSION**

The aim of the study was to compare microleakage (using dye penetration measurements) between preheated nano-filled composite and preheated bulk-filled composite, where both were subjected to thermocycling or no. Previous studies [15–40] in the literature found out that pre-heating of different composite resin restorations resulted in better physiochemical properties such as: better marginal adaptation, less viscosity, better microhardness, more monomer conversion and lesser microleakage. Improvement in the composite physiochemical properties means improved handling and better adaptation of the material to the cavity walls especially in cavities with high ratio of bonded surfaces to free surfaces (high C-factor) as in class V cavities [41]. Increased stresses due to polymerization shrinkage leads to gap formation in the tooth/restoration interface that leads to microleakage and subsequent failure of the restoration [42].

Thermocycling is an oral environment simulation testing for the thermal fluctuations that occur during chewing which could affect the bond durability and microleakage of the restoration due to difference in the thermal coefficient of both the tooth and the restorative material [13]. Thermocycling is one of the most significant factors that increase microleakage around composite resin restoration as it impacts the marginal adaptation and increases gap formation along the interface [42].

The results of the study showed that preheated Nano-filled composite exhibited the highest microleakage values when directed to thermocycling, this value was significantly more than all other groups, which agrees with a study by Arora et al. 2018 [43] which found that Nano-filled composite had the highest microleakage values compared to bulk-fill composite after thermocycling. The results of the study also showed that gingival walls had more dye penetration than occlusal walls in all groups except the thermocycled preheated nano-filled composite group where both walls had similar results (Fig. 3). This result is also in agreement with Karaarslan et al. 2012 [44] which found out that dentin surfaces had higher microleakage than enamel surfaces. Enamel walls provide better sealing and bonding to composite resin than dentin walls, which showed more microleakage than enamel and as shown by a study by Wagner et al 2008 [45].

Studies assessing the effect of pre-heating bulk-fill and conventional composite resin on microleakage after thermocycling the specimens had controversial results [42–53]. Cayo-Rojas et al. 2021 evaluated the degree of marginal microleakage of class II restorations with pre-heated bulk-fill or conventional Nano-hybrid composites and found no significant difference in microleakage after thermocycling [53]. Another study by Mostafa et al. 2020 compared pre-heated bulk fill composite to unheated flowable bulk-fil and conventional composite in class V cavities and found out that
pre-heated bulk-fill composite presented better marginal adaptation than conventional composite but more microleakage than flowable bulk-fill composite after thermocycling [52].

Fig. (3) Apparent die penetration at cervical margins in comparison to no die penetration at occlusal margins (B2 group)

Another study by Elbahrawy & Attia 2018 found out no significant difference regarding microleakage of pre-heated high viscosity bulk-fill and conventional nano-hybrid composites with different preheating temperatures (24 C, 37 C and 68 C) in class II cavities after thermocycling [51].

CONCLUSIONS

Thermocycling of preheated Nano-filled composite produced more microleakage than thermocycling of preheated bulk-filled composite. More microleakage was recorded in cervical areas than occlusal areas of class V cavities, so all efforts should be done to preserve enamel margins at cervical areas of cavities.

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Microleakage at Occlusal Margins Versus Cervical Margins of Thermocycled Preheated Class V Resin Composite Restorations


1. Microleakage at Occlusal Margins Versus Cervical Margins of Thermocycled Preheated Class V Resin Composite Restorations

The aim of this research was to study the effect of the presence of the enamel wall and thermal cycling on the fine leakage of Class V restorations.

1. Materials and Methods

Eighty-four incisors were prepared for Class V cavities on the labial surface of forty-two extracted upper teeth. The teeth were divided into two groups based on the type of resin composite preheated (either loaded with a nano-hybrid filling or filled with a nanohybrid material) and then divided into two subgroups according to thermal cycling or no thermal cycling. The teeth were immersed in a solution of 2% methylene blue for 0.5 hour according to thermal cycling or no thermal cycling. The teeth were then cut vertically through the restorative material to examine the fine leakage through the color penetration. The microscopic examination was performed using a microscope and the leakage was measured in micrometers according to the penetration of the color into the enamel and cementum separately. The statistical analysis was performed by the Kruskal-Wallis test for comparison between the groups and the Mann-Whitney test to compare the color penetration into the enamel and cementum in each group.

Results: The nano-hybrid material preheated and subjected to thermal cycling showed a significantly higher fine leakage than the other groups. The microscopic leakage was more pronounced in the cervical margins than the occlusal margins in all groups except for the nano-hybrid material preheated and subjected to thermal cycling, which showed no significant difference between the cementum and enamel.

Conclusion: Thermocycling of the nano-hybrid material preheated resulted in a significantly higher fine leakage compared to the other groups. The microscopic leakage was more pronounced in the cervical margins than the occlusal margins in all groups except for the nano-hybrid material preheated and subjected to thermal cycling.