

Gingival Marginal Leakage of Different Tooth Colored Materials Combination as an Intermediate Layer in Class II Composite Restoration (A Comparative *In Vitro* Study)

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ABSTRACT

Background: The aim of this *in vitro* study was to evaluate and compare the microleakage between Vertise Flow™ composite material and other conventional (Filtek Z250, Riva light cure and SDR) composite materials when restoring CII mesial box only cavity at gingival margin through dye penetration test

Materials and methods: Forty maxillary first premolars were prepared with class II box design only cavities. Samples were divided into four groups of ten teeth according to material used: group I (FiltekZ250 only). Group II (SDR+FiltekZ250). Group III (Vertise Flow +FiltekZ250). Group IV (Riva light cure+ FiltekZ250). After 24 hrs. immersion in 2% in methylene blue, samples were sectioned and micro leakage was estimated.

Results: None of the materials showed zero score for dye penetration. Micro leakage percentage in group III had lowest value; followed by group IV then group I while in group II had highest value of micro leakage

Conclusion: All the materials show micro leakage at variable degrees and that the microleakage degree depend on materials type Vertise flow is a promising material to be used in clinic as it saves both time and effort and gives high degree of performance from the microleakage point of view.

Key words: Microleakage, self-adhesive composites, flowable composites. (J Bagh Coll Dentistry 2016; 28(4):43-48)

INTRODUCTION

Increasing the demand for highly esthetic tooth filling material, with less loss of tooth substance during cavity preparations, has increase the need to tooth colored restoration material for the posterior teeth in last few years.

For packable composites, they were claimed to be stress relieving. The handling properties were improved, but they had many problems including (marginal micro leakage due to their high polymerization shrinkage, low wear resistance, body of restoration fracture, voids, and insufficient proximal contact sensitivity after placement). The rate of success for these was relatively high in short periods of time when clinically evaluated, but start to drop after five years ⁽¹⁾.

The initial stresses of shrinkage of the composite resin, coefficient of thermal expansion difference between of materials and tooth, cervical area inaccessibility, in particular, are the main problems of bonding to the cervical substrate for class II cavities, and factors that are responsible for micro leakage problems ⁽²⁾. To achieve good marginal quality it is preferred to place the resin-based composite materials in layers not more than (2 mm) to prevent distortion of the cavity wall and securing adhesion to dentin ⁽³⁾.

In this study, we evaluate the microleakage between self-adhesive, self bonded composite material and other three conventional composite

type when restoring CII proximal cavities. Many techniques have been used to decrease the amount of microleakage, like (applying a thicker adhesive coat below the composite resin, using the incremental technique, resin matrix changing and production of composite resins having small polymerization shrinkage), may help reduce the polymerization shrinkage and the stress resulted ⁽⁴⁾.

MATERIALS AND METHODS

Forty sound maxillary first premolar teeth, non-carious, and non-restored with regular occlusal anatomy and similar crown size sound with absence of visible hypoplasia, defects, and cracks on visual examination using magnifying lens device ⁽⁵⁾. All the teeth were cleaned carefully for any calculus deposits with air scalarand teeth were polished with pumice ⁽⁶⁾.

All the teeth had been stored in distilled water at room temperature until use Prior to the experimental procedures, a restoration template was prepared acrylic teeth first molar and second premolar were inserted in self-cure acrylic resin, then a hole for the experimental tooth was drilled representing the space of upper first premolar.

These were put in one piece of self-cure acrylic resin and acrylic canine was inserted in a second piece of the cold cure acrylic resin alongside other teeth. A screw was used to position the teeth in contact with each other (Figure1) ⁽⁷⁾.

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Figure 1: Template for teeth fixation.

Forty sound maxillary first premolar teeth were divided into four main groups, (10 teeth) for each. Named according to the material they are filled with as follows: **GROUP I:** 10 teeth restored with **FILTK Z250** in 3 layers 2.0mm for each; **GROUP II:** 10 teeth restored with 4mm **SDR** composite and covered with 2.0mm Filtek Z250 composite; **GROUP III:** 10 teeth restored with 4.0mm **VERTISE™ FOLW** composite in three layers (0.5, 1.5, 2.0mm) and covered with 2.0mm Filtek Z250 composite; **GROUP IV:** 10 teeth restored with 4.0mm **Riva risen modified glass ionomer cement** 2.0mm for each layer and covered with 2.0mm Filtek Z250 composite.

For standardization, a modified dental surveyor was used in such a way so that the long axis of the bur was kept parallel to the long axis of the tooth during the preparation⁽⁸⁾. All cavo-surface line angles are not beveled⁽⁹⁾

On each tooth, a standardized Class II box only cavity was prepared in the proximal surface (3mm bucco-lingual width, 6mm height, and 2mm mesiodistal depth), margins are (1mm) above cemento-enamel junction⁽¹⁰⁾.

For Filtek™ Z 250 group, the cavities were etched with 37% phosphoric. Then 5th generation bonding agent (Adaper Single Bond 2) (3M, USA) was applied according to the manufacturer instructions then cured for 10 second with a light cure device (type LED, light intensity: 856mW/cm²), the cavity was filled with Filtek™ Z250 in three separated layers of 2mm and was cured for 20 second for each layer then finally finished.

For the SDR GROUP etching followed by 5th generation bonding agent Adaper Single Bond 2 was applied then cavity was filled with SDR in bulk increment (4mm) according to manufacturer instructions and cured then we completed by 2mm of Filtek Z250.

For Vertise flow group, Vertise Flow was dispensed in to the preparation with dispensing tip and by the fine brush a thin layer of (0.5 mm)

was brushed into cavity wall with moderate pressure for 15 sec and the excess material was removed then light cured for 20 second then a second layer of (1.5mm) was applied and light cured for 20 second and a third layer of the Vertise Flow of 2mm thickness was applied and also light cured for 20 sec to complete 4mm of Vertise Flow then layer of 2mm of Filtek Z250 was applied to finish the restoration.

For Riva light cure, Etchantagent (37% phosphoric acid) then washed thoroughly, excess water was removed but not completely and tooth was left glistening. After that the capsule was activated by pushing the plunger until it was flushed with the body then capsule was placed immediately into the amalgamator (ULTRAMAT 2) and titrated for 10 second, then immediately the capsule was removed and placed into the Riva applicator 2 then it carefully extruded in to the cavity for not more than 2mm for each layer and light cured for 20 second and finally a third layer of 2 mm Filtek Z250 to complete the filling of the cavity.

After specimens were stored in distilled water at 37°C for 7 days⁽⁶⁾ All specimens were thermocycled for 500 cycles, at 5° to 55°C, with a 30 second dwell time^(11,12) the thermocycling procedure was done by thermocycler machine which is especially fabricated for this study. Then specimens were subjected to the microleakage testing procedures. Apical foramina were sealed with resin modified glass ionomer cement. In order to prevent dye penetration into the dentinal tubules or the lateral canals⁽¹³⁾, the teeth were coated with two layers of nail varnish except for an area approximately 1 mm around the gingival margin of the restorations. This procedure was intended to prevent the penetration of dye into unwanted areas^(6,14).

The teeth were then immersed in 2% Methylene Blue for 24 hours at 37°C inside medical incubator. After removal from the dye solution, the teeth rinsed with running tap water.

The root was embedded in chemically cured acrylic resin with the long axis of tooth by dental surveyor up to (2 mm) apical to the cemento-enamel junction (**CEJ**) to facilitate handling during sectioning procedures and by using special sectioning bur and dental engine. Specimens were sectioned in mesio-distal direction at the center of the restorations. The fragment that exhibited greater dye leakage was evaluated and the other was discarded⁽¹⁵⁾.

The extent of dye penetration was scored according to a five-points scale⁽¹⁶⁾ the cervical marginal micro leakage was recorded based on the following criteria: **0:** No dye penetration, **1:** Dye

penetration less than half the length of the gingival floor, **2:** Dye penetration greater than half, up to the whole length of the gingival floor, **3:** Dye penetration the whole length of the gingival floor plus up to half of the axial wall, **4:** Dye penetration the whole length of the gingival floor plus greater than half the axial wall and existence of lateral microleakage at dentin tubules (17).

The data was analyzed using Kruskal-Wallis test ($p \leq 0.05$) at 95% confidence level to detect the significant differences among the groups. Further analysis with Mann-Whitney U-test was conducted for pair-wise comparisons among groups ($p \leq 0.05$) at 95% confidence level.

RESULTS

The microleakage percentage in Vertise Flow group has lowest value (30% score zero, 20%

score 1, 40% score 2, 40% score 3 and 0% score 4), while in SDRgroup has highest value (100% for score 4). The statistical analysis of data by Kruskal-Wallis H non-parametric test revealed highly significant difference ($p < 0.001$) among the groups Since the P-value is less than 0.05, there is a statistically significant difference amongst the medians at the 95.0% confidence level to determine which mean are significantly different from which others, All groups show significance at ($p < 0.05$) except SDR - FILTEK Z250 did not show any significance.

Mann-Whitney U test shows that: The SDR group is in significant difference with Vertise flow and Riva light cure, but did not show any significance with Filtek Z250 group, Vertise flow is significant difference with all groups, RIVA light cure is in significant difference with Filtek Z250.

Table 1: The scores percentages for experimental groups

Score	Filtek Z250 group	SDR group	Vertise Flow group	RIVA light cure group
0	0 (0%)	0 (0%)	3 (30%)	0 (0%)
1	0 (0%)	0 (0%)	2 (20%)	0 (0%)
2	0 (0%)	0 (0%)	4 (40%)	2 (20%)
3	3 (30%)	0 (0%)	1 (10%)	6 (60%)
4	7 (70%)	10 (100%)	0 (0%)	2 (20%)
Total	10	10	10	10
Mean	3.70	4.00	1.30	3.00
SD	0.483	0.000	1.059	0.667

Table 2: Statistical analysis of data by Kruskal-Wallis

Test	Statistical value	P-value
Kruskal -Wallis	29.3046	0.000

Table 3: Descriptive statistics of microleakage for groups

Groups	Sample No.	Mean	Median Q1	Median Q2	Median Q3	Minimum	Maximum
Filtek Z250	10	3.7	3.0	4.0	4.0	3.0	4.0
RIVA	10	3.0	2.75	3.0	3.25	2.0	4.0
SDR	10	4.0	4.0	4.0	4.0	4.0	4.0
Vertise Flow	10	1.3	0.0	1.5	2.0	0.0	3.0

Table 4: Mann-Whitney U test

Contrast	Mann-Whitney	p value	Sig.
SDR - Vertise Flow	0.000	0.0000	S
SDR - Filtek Z 250	35.000	0.0671	N.S
SDR - RIVA	10.000	0.0005	S
Vertise Flow - Filtek Z 250	1.500	0.0002	S
Vertise Flow - RIVA	9.000	0.0013	S
Filtek Z 250 - RIVA	22.000	0.0193	S

DISCUSSION

The statistical analysis showed that the Kruskal-Wallis test had a significant relation between the scores of penetration and the restorativematerials by their sequences of the dye

penetration. Scores from lowest to highest were: Vertise Flow, riva light cure RMGIC, Filtek Z250 and SDR.The highest degrees of microleakage were observed in flowable sure full SDR composite. The possible explanation for these

results is that SDR material is a flowable material with 68% wt filler loading and low filler content leading to a low modulus of elasticity, thus reducing curing stresses. Yet, the lightly filled resin undergoes greater polymerization shrinkage⁽¹⁸⁾. The reduced filler load may also impair the resistance to deformation of the restorations during function. Due to their inferior mechanical properties, this is agree with Baroudi⁽¹⁹⁾ who said that flowable composite resins are generally not recommended as stand-alone restorative materials especially in cavities with high-stress occlusal function.

The higher matrix content may also contribute to increased water solubility, possibly affecting the restorations long-term performance. The reduced filler load may also impair the resistance to deformation of the restorations during function. Due to their inferior mechanical properties, flowable composite resins are generally not recommended as stand-alone restorative materials especially in cavities with high-stress occlusal function⁽¹⁸⁾.

Narayana⁽²⁰⁾ states that hybrid composite have a better adaptability than the packable composite this may be to that Z250 particle size distribution is (0.01 to 3.5 μm) with an average particle size is (0.6 μm) and that the loading is (60% by volume) of inorganic filler. This lowering in leakage results could be due to the smaller particle size of hybrid. Another explanation is that SDR is bulk fully filled in one layer of 4mm as manufacturer instruction, while Vertise Flow in this study filled in three layers (0.5, 1.5, 2mm) and both Filtek Z250 and RIVA light cure incrementally filled in (2, 2mm). This makes use of the main advantage of incremental technique, that is the volume reduction of each increment will be compensated by the next increment, thus the polymerization shrinkage of the last layer only, may damage the bond⁽¹⁸⁾, but on the other hand few authors like⁽²¹⁾ advocate the bulk increment as a safe restorative technique claiming that it fills the total volume of the preparation and creates less residual shrinkage stress than the incremental technique minimizing marginal leakage.

These differences in layers between different types of materials used in this study had its effect on polymerization shrinkage from the depth of cure point of view since it is important to achieve sufficient irradiance at the bottom surface of each incremental layers used in building up the restoration. The concept of the point of sufficiency in this respect is called "depth of cure" (DOC)⁽²²⁾ The intensity of light (strictly, the irradiance), at a given depth and for a given irradiation period, is a critical factor in

determining the extent of reaction of monomer into polymer, typically referred to as "degree of conversion. A certain degree of conversion (DC) in resin-based materials must be achieved for the material to develop adequate physical and mechanical properties⁽²²⁾.

Many factors influence the degree and adequacy of the polymerization process, such as the type and relative amount of monomers, filler and initiator/catalyst as well as the shade and translucency of the material, its temperature during polymerization, the wavelength and intensity of the incident light, and the irradiation time⁽²³⁾. Absorption and scatter within the material are the major factors causing light attenuation, rather than reflection from the restoration surface, as this is dependent on the formulation of the material, particularly the filler size, type and content⁽²⁴⁾.

The actual time of 20 second as recommended by manufacturer to cure (4 mm) thickness of SDR, is thought to be insufficient for optimum polymerization, mainly on the bottom surface. The increasing of the distance from bottom up to the cusp tip makes a serious problem in curing causes the resin composite on the bottom surface and disperses the light of the light curing unit. As a result, when the light passes through the bulk of the composite, the light intensity is reduced and the energy of the light emitted from a light-curing unit decreased drastically when transmitted through resin composite, leading to a gradual decrease in degree of conversion of the resin composite material at increasing distance from the irradiated surface⁽²⁴⁾.

These finding come with agreement with Aguiar⁽²⁵⁾ and with clinical report of Christensen⁽²⁶⁾ who compared different types of bulk fill resins he concluded that the most bulk fill resins have many challenges which still exist for most material that include the light cure does not reach the bottom of deep box form. Camargo⁽²⁷⁾ states that increments must be kept to a maximum thickness of (2.0 mm) to achieve a good curing depth. While Lotfi⁽¹²⁾ compared gingival microleakage in class II restorations by using different flowable composites as liner found that the lowest amount of microleakage was in SureFil SDR flow group.

Another explanation is that composite composition affects the depth of cure, which is dependent on the formulation of the material, particularly the filler size, type and content this may explained by that smaller filler particles scatter the light more than large filler particles because those particle sizes are similar to the wavelengths emitted from composite curing

lights. Light attempting to penetrate small particle composites, therefore, has a more difficult task to penetrate the deeper regions of the material and greater irradiances or exposure times are required to cure the composite adequately.

Another important factor, is the proportion of the filler relative to resin matrix: the higher the proportion of fillers, the more difficult to penetrate the composite by curing light source, the total summation of curing time that is received for each group will be as follows (80, 60, 60, 40) for Vertise flow, RIVA light cure, Filtek z250, and SDR respectively.

So, the Vertise flow group had received the highest total time for curing, this may explain the results of our study, as increasing time of curing will increase cross-linking of polymerization and thus enhance its properties. This comes in agreement with Thiab⁽²²⁾ who compared the effect of curing time on depth of cure, he found that groups that were cured for 60 seconds gave significantly higher DOC values than groups that were cured for 40 seconds, while 20 seconds curing time gave the least DOC values. The possible explanation is that absorption of light with an appropriate wavelength initiates a free radical polymerization process of the methacrylate groups in visible light cured composite resins resulting in the formation of a cross-linked polymeric matrix⁽²⁸⁾ and more time of curing will enhance this cross-linking process.

Another explanation for the good results of the Vertise Flow is that the bonding mechanism of Vertise Flow is primarily based on the chemical bond between the phosphate functional group of GPD monomer and calcium ions of the tooth. A micromechanical bond resulting from an interpenetrating network between Vertise Flow polymerized monomers and dentin collagen fibers, also contributes to adhesion (**Vertise Flow Product Manual, 2009**).

In vivo study conducted by Vitthii⁽²¹⁾ to study the properties of Vertise Flow with recall intervals, he noticed that at the 6-month recall, no post-operative sensitivity was reported of the forty performed restorations. Therefore, he confirmed the claimed ability of Vertise Flow to achieve effective sealing between the tooth and restoration. The results of this 6-month study demonstrated a successful clinical outcome of the self-adhering flowable composite resin Vertise Flow when used to restore small Class I cavities. For Riva Light Cure utilizes SDI's proprietary ionglass™ filler which is a radiopaque, high ion releasing, reactive glass used in SDI's range of dental cements. Riva Light Cure

releases fluoride to assist with remineralization of the natural dentition.

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