*Original Article*

# The Effect of Fluid Composite as Gingival Layer on Microleakage of Class II Composite Restorations

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## ABSTRACT

***Introduction:*** Fluid composites have been suggested as gingival layer beneath class II composite restorations to improve marginal integrity and reduce microleakage. This in-vitro study evaluated the influence of fluid composites as gingival layer on microleakage of class II packable, microhybrid, and fiber-reinforced composite restorations with the margins below the cementoenamel junction (CEJ).

***Methods and Materials:*** 45 sound premolars extracted for orthodontic reasons were selected. Class II cavities were prepared on the mesial and distal aspects with the gingival margin placed 1 mm below the CEJ, making 90 slot cavities. Teeth were randomly assigned into 3 groups (n=15). In each group, one side of each tooth was restored incrementally with respective packable, microhybrid, and fiber-reinforced composites; whereas, on the other side, fluid composite was placed as a 1 mm thickness gingival increment before restoration with the same composites. The teeth were stored for one week in distilled water at 37°C, thermo-cycled (5-55°C, x 1500), and immersed in 0.5% basic fuchsine for 24 hours. Dye penetration was evaluated using a stereomicroscope at 10x magnification. The data were analyzed statistically by Kruskal-Wallis analysis of variance and Mann-Whitney U-test.

***Results:*** The fluid composite reduced microleakage at gingival margins of Class II restorations ($P<0.05$). The packable composite -with or without fluid composite- showed lower microleakage, whereas microhybrid and fiber-reinforced composites without fluid composite, showed higher microleakage.

***Discussion:*** The fluid composite significantly decreased the microleakage at gingival margins of Class II composite restorations.



***Key Words:*** Microleakage, Posterior Composite, Packable Composite, Fiber-reinforced Composite, Fluid Composite, Microhybrid Composite.

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## Introduction

With the increasing demand for aesthetic procedures and concerns regarding mercury toxicity, the popularity of posterior composite restoration has increased. Direct class II composite restorations can be an acceptable standard, if the gingival margins are located at sound enamel. In addition, difficulty in obtaining intimate cavity adaptation and marginal complete sealing in posterior composite restorations may result in postoperative


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problems [1, 2, 3]. A study revealed that 43% of the in vivo class II hybrid composite restorations were overfilled and 25% were underfilled [4].

Intimate cavity adaptation can be obtained by condensing amalgam [3]. Unfortunately, unlike amalgam, traditional (hybrid) posterior composites have never been ideal amalgam alternatives because they: 1) require more handling time; 2) exhibit significant polymerization shrinkage; 3) present more microleakages with age; 4) provide questionable durability; 5) cannot be condensed or packed into the preparations, which makes establishing and adequate proximal contact difficult; and 6) tend to be "sticky" resulting in a tendency to pull away from the cavity wall when the placement instruments are withdrawn [1, 5-7].

Microleakage may provoke sensitivity due to an interfacial hydrodynamic phenomenon and can lead to colonization of microorganisms and the high incidence of secondary caries and subsequent pulpal infection and may clinically cause restoration fail [1, 5, 8, 9].

Recently, a new type of composite resin, termed "condensable" or "packable", has been introduced to the market, which is claimed to have better physical properties, particularly in the restoration of posterior teeth. They are characterized by a high-filler load and a filler distribution that gives then a different consistency, compared with the hybrid composites [1,6,10,11]. Because of the high depth of cure and low polymerization shrinkage of packable composites, a bulk-fill technique may be possible [1,6,11]. Their coefficient of thermal expansion is close to the tooth, and their modulus of elasticity is close to amalgam [7]. However, these stiffer materials may not adequately adapt to internal areas and cavosurface margins, particularly at the cervical joint [6]. Even though the average annual wear of these new composite resins may be equal to amalgam, microleakage still seems to be a problem. Packable composites of thick consistency have presented greater problems related to voids and cavity wall adaptation [7, 10].

In order to improve cavity wall adaptation and reduce microleakage, fluid composites may be suggested as gingival layer beneath class II composite restorations. Due to their low modulus of elasticity, increased elasticity, wettability, non-stickiness, and fluid injectability, fluid composites may be useful in absorbing stresses and reducing microleakage caused by polymerization shrinkage [5-8,10-14]. It has been shown that fluid composites have less microleakage and internal restoration voids and improved cavity adaptation and marginal sealing [3, 8]. However, the contributions of this technique are unproven [11].

The aim of this in vitro study was to evaluate the effect of fluid composites (Tetric Flow, Ivoclar Vivadent Ets, Schaan, Liechtenstein and/or Stick Flow, Dental Pty, NSW, Australia) as a layer on the gingival marginal microleakage in class II cavities of three packable (Premise, Kerr Corp, Orange, CA), microhybrid (Tetric Ceram, Ivocclar Vivadent Ets, Schaan, Liechtenstein), and fiber-reinforced (Nulite F,Dental Pty, NSW, Australia) composites.

## Methods and Materials

Forty five sound maxillary first premolar teeth, recently extracted for orthodontic reason, were selected. After cleaning with pumice slurry, the teeth were stored in saline at room temperature for less than three months. The teeth were stored in an aqueous buffered solution of formal (5%) for 2 hours for infection control. Mesio-occlusal and disto-occlusal class II cavity preparations were made in each tooth using a # 836R cylinder diamond bur (Diatech Dental AG, Heerbrugg, Switzerland) with a head diameter of 1 mm and a head length of 6 mm in high-speed hand piece with water cooling. A new bur was used for every five preparations.

The box-only cavity preparations were separated with sound tooth structure. The buccolingual width was 3 mm and the gingival margins of all cavities were placed 1 mm apical to the cementoenamel junction (CEJ). Buccal and lingual wall of the preparations were approximately parallel and connected to the gingival floor with rounded line angles. The boxes were prepared axially depth of 2 mm and the margins were not beveled (90° cavosurface angle), but smoothed with a # 23 hatchet (Duflex, SS White, Rio de Janerio, RJ, Brasil).

In order to simulate clinical posterior teeth alignment, the teeth were mounted in stone jigs with one canine on mesial and one second premolar on distal sides. The prepared teeth were randomly assigned into three groups (n=15). A matrix retainer (Tofflemire,KerrHawe SA, Bioggio, Switzerland) and a metal band (Tofflemire, KerrHawe SA, Bioggio, Switzerland) were placed on the tooth and tightly held by two wooden wedges (Hawe-Neos Dental, Bioglio, Switzerland). A sharp explorer was used to confirm the fitness between the metal matrix and cervical margin. The cavities prepared by a single operator and restored according to manufacturer's instructions.

All preparations in each group were rinsed with tap water, etched with phosphoric acid etching gel (Total Etch, Ivoclar Vivadent Ets, Schaan, Liechtenstein) for 15 seconds, rinsed with water for 20 seconds, and gently air dried to leave the surfaces wet.

In group 1, the bonding agent (Excite, Ivoclar Vivadent Ets, Schaan, Liechtenstein) was applied to the preparations with brush for 10 seconds, dried with a gentle stream of air, and light cured for 20 seconds with a visible light unit (Optilux 401, Kerr/Demetron, Danbury, CT,). One side of each tooth was restored incrementally with packable composite (Premise, Kerr Corp, Orange, CA) and fluid composite (Tetric Flow, Ivoclar Vivadent Ets, Schaan, Liechtenstein) was carefully placed on the respective side as a gingival layer with thickness of 1 mm; this depth was judged by a periodontal probe (Hu-Friedy Mfg.Co.,Inc, Chicago). The remainder of this part was then restored with packable composite.

In group 2, the same procedures were followed as in the first group. The bonding agent (Stick Resin, Dental Pty, NSW, Australia) was applied to the preparations with brush, dried with a gentle stream of air, and light cured for 20 seconds. One side of each tooth was restored incrementally with fiber-reinforced composite (Nulite F, Dental Pty, NSW, Australia); whereas, on the other side, gingival layer was placed with fluid composite (Stick Flow, Dental Pty, NSW, Australia) and restored with fiber-reinforced composite.

In group 3, the Excite bonding agent was applied to the prepared cavities, as previously described. The cavities were restored either with microhybrid composite (Tetric Ceram, Ivocclar Vivadent Ets, Schaan, Liechtenstein) or fluid composite (Tetric Flow, Ivoclar Vivadent Ets, Schaan, Liechtenstein) same as in other groups.

Horizontal incremental technique with four increments from the cervical to the occlusal surfaces where used for restoring the cavities. Light curing was done from occlusal aspect for 20 seconds for each increment. Following the restoration procedure, the metallic matrix was removed, light cured for 20 seconds from the buccal and lingual surfaces and the occlusal surface was finished and polished.

The specimens were removed from the stone mounting jigs, washed under running tap water for 2 minutes, stored in distilled water at 37°C for one week, and then thermocycled for 1500 cycles between 5-55°C with dwell time of 30 seconds. Prior to the microleakage test, the apices of the samples were sealed with utility wax. The tooth was painted with two coats of fingernail varnish except for restoration and 1 mm beyond the margins and allowed to be air dried, then immersed in a 0.5% basic fuchsine dye for 24 hours.

After removal from the dye, the samples were cleaned under running tap water for 2 minutes, and sectioned mesiodistally through the center of the restorations with diamond disk (Diamant, Horico, Berlin, Germany) to obtain two sections from each tooth. The sections were randomly arranged and assigned code numbers to permit blind evaluation. Dye penetration at the gingival margins was examined using a stereomicroscope (Olympus Optical Co, Tokyo, Japan) under 10x magnifications by two independent pre-calibrated examiners and consensus was forced when disagreements occurred. The examiners were blind to the material and technique. The following scoring criteria were used to evaluate the microleakage: score 0= no dye penetration, score 1= dye penetration up to 1/3 along the gingival floor, score 2= dye penetration up to 2/3 along the gingival floor without reaching the axial wall, score 3= dye penetration reaching the axial wall, and score 4= dye penetration past the axial wall (3,6,9,10,13). The data were statistically analyzed by Kruskal-Wallis analysis of variance and Mann-Whitney U-test with a significance level of 0.05.

## Results

None of the groups showed complete prevention of dye penetration. Table 1 shows the number of teeth in each microleakage rating category. The packable composite (Premise, Kerr Corp) had significantly lower microleakage ratings than the microhybrid (Tetric Ceram, Ivocclar Vivadent) and fiber-reinforced (Nulite F, Dental Pty) composites, both with and without fluid composite ($p<0.05$).

Comparing each material individually with or without fluid layer, there was significantly difference between microleakages of the microhybrid and the fiber-reinforced composites ($P<0.05$).

Although there was no significant difference between the packable composite with and without fluid composite, but fluid composite showed better results than packable composite alone ($P<0.05$). There was no significant difference between the microleakage scores of microhybrid and fiber-reinforced composites.

## Discussion

Microleakage is one of the most significant disadvantages associated with composite restorative materials and depends on several factors including adaptation of resin material to tooth surface, the bonding material used, the technique of bonding, polymerization shrinkage, and the thermal stability of the material. Most of studies show that dentinal microleakage remains a significant problem [2-9, 13, 14].

This in vitro study examined microleakages of packable, microhybrid, and fiber-reinforced composites with and without the fluid resin layer. The results of this study showed that the packable composite (Premise, Kerr Corp) with and without fluid composite layer (Tetric Flow, Ivoclar Vivadent) had significantly lower microleakage than microhybrid (Tetric Cream, Ivocclar Vivaden) and fiber-reinforced (Nulite F, Dental Pty) composites ($P<0.05$). The results showed that the tested microhybrid and fiber-reinforced composites had significant less microleakages when restored with the fluid resin layer ($P<0.05$); although it could not completely eliminate it. These results are in agreement with many studies in regard to marginal microleakage reduction [3, 5, 7, 9, 11, 12, 14]. Peris [12] showed that application of fluid composite under the microhybrid and compactable composites reduced the marginal microleakage at the cervical wall, although it did not eliminate it. The compactable composite with fluid layer showed slight improvement in the marginal microleakage.

The wear rate of fluid composites was higher than packable ones; therefore, fluid composites should be used only at contact-free areas [6, 11]. In this study, the application of approximately 1 mm thickness of fluid layer at the gingival floor was considered acceptable clinically since this is a contact-free area.

The main advantages of packable composite over hybrid ones are the elimination of stickiness of the material and the ability to produce good proximal contacts by condensing incrementally [1, 2, 7, 9, 10]. Also, despite being more favorable, concerns related to their ability to being sufficiently wet and adapting to cavity walls, especially at the cervical margins below the CEJ, have been raised [11,14].

**Table 1.** **The gingival microleakage scores of class II composite restorations with and without fluid layer (n=15).**

| Groups | Composite Resin | Fluid Composite | Microleakage scores | | | | | Mean | SD |
|---|---|---|---|---|---|---|---|---|---|
| Premise | Packable Composite | YES | 7 | 5 | 2 | 1 | 0 | 0.8 | 0.9 |
| Nulite F | Fiber-reinforced Composite | YES | 3 | 5 | 3 | 3 | 1 | 1.6 | 1.2 |
| Tetric Ceram | Microhybrid Composite | YES | 3 | 2 | 4 | 5 | 1 | 1.9 | 1.3 |

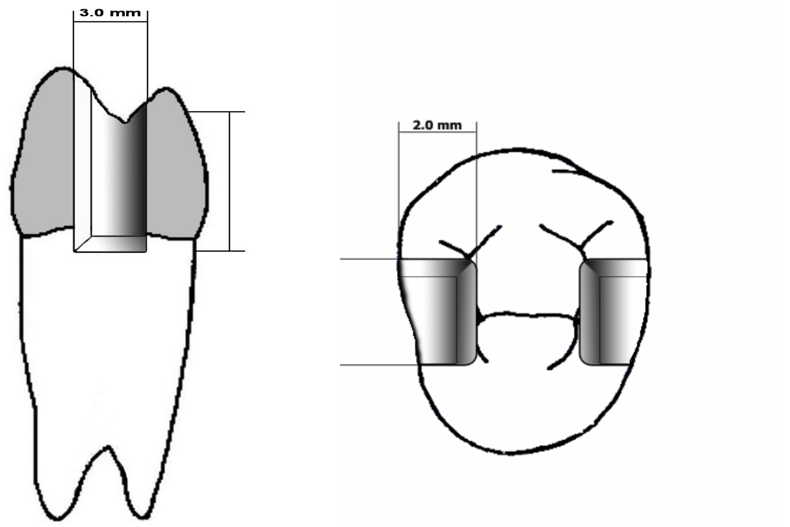


**Figure 1. Schematic representation of the cavity preparation dimensions, at occlusal and proximal views**

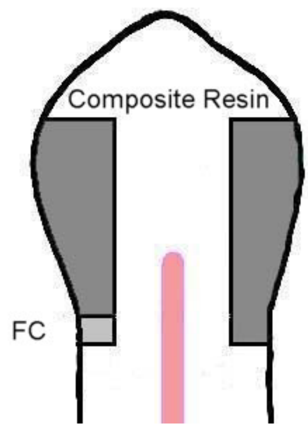


**Figure 2. Diagram shows the design of six groups in this study.**

packable, microhybride, and/or fiber-reinforced composites
fluid composites

**Figure 3. Dye penetration under the layer of fluid composite. Score 0 = no dye penetration (right), score 4 = dye penetration past the axial wall (left).**

Fluid layers may provide better adaptation. They may also act as a flexible intermediate layer, which helps relieve stresses during polymerization shrinkage of the restorative resins [11, 13]. The flowability and injectability of fluid composites make them very attractive when placing in difficult areas such as the proximal boxes of class II restorations [2]. The use of fluid layer may have lower C-factor. The lower C-factor, the lower the internal stresses. When the internal stresses are low, there is less competition between the contraction forces arising from monomer conversion and the efforts of the adhesive agent to keep the composite bonded to the surface [7]. However, fluid composites are reported to shrink more than traditional composites because they have less filler loading. Perhaps the relatively thin layer can minimizes this effect [11]. Therefore, many researchers have recommended the use of fluid composites beneath packable composites and have claimed that this application may reduce microleakage [1, 14].

The results of this study are in disagreement with some studies. Tredwin [6] reported that for gingival margins of dentin, the conventional (Z250) and packable composites (Filtek P60) with a fluid layer (Filtek Flow) had significantly higher leakage scores than Z250 and Filtek P60 alone, respectively ($P<0.001$). The data of their study and some other studies do not support the use of fluid layers in class II composite restoration [17, 18]. Malmstrom´ reported neither the thickness nor the presence of fluid composite gingival layers significantly changed the extent of leakage in sub-CEJ class II composite restorations. In this study, although there were not statistical differences among the packable composite with and without fluid layer but there was a clear tendency for reducing microleakage with the fluid layer.

The results of this study showed that there were not statistical differences between the microhybrid and fiber-reinforced composites with and without fluid layer. According to claim of manufacturer, Nulite F is ideal as a directly bonded cusp repair in failed amalgam restorations and for using in the construction of composite bridges using Fibrebind reinforcing fibers. This material has twice the fracture toughness of existing composites, and half the volumetric shrinkage of other posterior composites resulting in better marginal seal and exceptional handling properties. Nulite F is a carvable and packable material which doesn't stick to instruments, and extremely low wear rates yet kind to the antagonist. Benefits of Nulite F include: high performance BIS-GMA hybrid, micro-rod reinforced, radio opaque, three patented reinforcing mechanisms that results in almost three times the fracture toughness of conventional composites, and availablity in syringes and cartridges [16].

A clinical study showed that in class II cavities, the cumulative failure frequencies for Nulite and Alert were 4.8% and 2.2%, respectively. These frequencies increased in 6 years to 25.0% and 12.8%. Reasons for failure were secondary caries, and material and cusp fractures. The majority of the failures occurred after 3 years. After 3 years, the occurrence of most failures indicated the necessity of long term evaluations of new materials [19].

Other materials are used as gingival layers, such as fluid composite or glass-ionomer cement. Glass-ionomer material (Fuji II LC) led to the beat sealing of the gingival margins based upon the lowest degree of microleakage [20]. Light cured glass-ionomer, when used as a layer under composite restorations, has the best sealing capability [21]. Packable system with fluid compomer beneath yielded significantly less overall microleakage compared to the other material combinations where a fluid composite was used as a layer [10].

Much of the current literatures focus on elimination of microleakage, which is one of the major factors determining the long term success of restorations. Within the limitations of this study, it can be concluded that the use of a fluid composite as gingival layer of class II restorations with packable, microhybrid, and fiber-reinforced composites decreases gingival microleakage. However, further clinical research is needed to support the use of these materials.

## Conclusion

Within the limits of this study, the followings can be concluded:

1- None of the tested materials were able to completely eliminate the marginal microleakage on the gingival floor.

2- The packable composite with and without fluid layer, significantly reduced microleakage than microhybrid and fiber-reinforced composites.

3- The use of fluid composite beneath microhybrid and fiber-reinforced composites significantly reduced microleakage.

4- The fluid composite did not significantly reduce marginal microleakage underneath packable composite, but there was a clear tendency for reducing microleakage with the fluid layer.

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