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ORIGINAL RESEARCH

Effect of Different Base Materials and Techniques on Microleakage in Class II Composite Open Sandwich Restorations: An *in vitro* Study

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ABSTRACT

Aims: This study was performed to compare microleakage in class II composite restorations with flowable composites and dual cure composite resin as intermediate material and also to evaluate the effect of delayed light polymerization of dual cure composite base on microleakage.

Materials and methods: Class II box cavities were made with air water spray and divided into four groups. Group 1 was restored without base, group II with flowable composite base, group III with a dual cure composite base which was immediately cured and group IV with 60 seconds delayed cure, dual cure composite base. Remaining cavity was restored with composite resin Specimens were immersed in methylene blue dye after thermocycling and sectioned through mesiodistal center of tooth and observed for leakage pattern. Microleakage was evaluated using dye penetration with methylene blue. Microleakage pattern was observed under a stereomicroscope.

Kruskal-Wallis test and Mann-Whitney test were used for statistical analysis.

Results: Results of the study showed that application of a composite resin base below a class II composite restoration significantly decreased microleakage as compared to restorations without a base. The least and comparable microleakage scores were seen in groups with flowable composite and dual cure composite (delayed cure) as a base, followed by dual cure composite which was immediately cured.

Keywords: Open sandwich restoration, Flowable composite, Dual cure composite, 2% methylene blue, Stereomicroscope.

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INTRODUCTION

The rising demand for esthetic procedures, along with the advantage of conservative preparation and bonding to tooth structure has significantly increased the popularity of composite resin restorations. The incorporation of new monomers, new initiation systems and filler technologies have drastically improved the physical properties of these materials, expanding their use as direct and indirect restorations.[1]

Nevertheless, a major drawback of resin based materials is polymerization shrinkage that causes gap formation permitting bacterial penetration. As a result, this imperfect bonding causes postoperative sensitivity, marginal discoloration, secondary caries and even restoration loss.[2] Marginal adaptation remains an unavoidable problem in composite restorations, especially at the gingival wall of a class II restoration.

Diverse materials and techniques have been developed to decrease shrinkage and surmount its consequences. One such procedure developed to overcome the difficulties with class II composite resin restorations is the open sandwich technique where an intermediate material exposed to the oral environment is placed between the dentin gingival margins and the occlusal composite restoration. These sandwich restorations are less sensitive to technique than composite restorations and show a higher percentage of gap free interfacial adaptation to dentin.[3]

Glass ionomer cements, and resin modified glass ionomer cements have been used as intermediate materials in sandwich restorations to decrease shrinkage stresses and its effects. But, glass ionomer cements presented with the disadvantage of moisture sensitivity during placement and early set, and also dehydration after setting, resulting in crazing and cracking.[4] On the other hand, resin modified glass ionomers also show dissolution after a certain period of time thus questioning their longevity.[5]

Therefore, the search for an intermediate material below a composite restoration to counteract the contraction forces continued. To offset this problem, Bayne in 1998 suggested the use of a flowable composite liner beneath packable composites in class II situations.[4] Flowable resin composite liners act as a flexible intermediate layer and help to relieve stresses during polymerization shrinkage of the overlying restorative resin (stress absorber).[6] However, contradictory studies suggest that flowable resins used as liners do not

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decrease shrinkage as these resins have lower filler load and more resin content.

Dual cure composites also present a good alternative in open sandwich restorations as these materials act as dentin substitutes. The dual cure composites can be placed in bulk, in addition they also polymerize more slowly resulting in lower contraction stresses. Moreover, it is reported that they improve the marginal and internal adaptation of composite restorations.[3]

Conventionally, dual cure composites are cured immediately. But immediate curing of a dual cure composite in fact deters the chemical polymerization reaction to occur completely. Hence, recent studies suggest delayed curing of the dual cure composite as another effective way to reduce polymerization shrinkage stress without compromising the polymer network structure.[7]

Hence, the purpose of this study was to compare marginal microleakage in posterior composite open sandwich restoration (A) by using different composite base materials like flowable composite and dual cure composite resin and also (B) to evaluate the effect of delayed curing of dual cure composite resin base on microleakage.

MATERIALS AND METHODS

Forty recently extracted and sound human molars were collected, cleaned stored in distilled water. The samples were mounted to establish mesial and distal contact areas. Standardized class II mesio-occlusal and disto occlusal cavities were prepared on mesial and distal surface of each tooth with following dimensions –2.0 mm mesiodistal extension, 3.0 mm buccolingual extension and 5 mm occlusocervical extension. The preparations were made with a no. 245 carbide bur in a high speed handpiece, under copious water coolant. A sectional metallic matrix (palodent) was placed and adapted to the cavosurface margins.

The cavities were etched with 35% phosphoric acid (Etchant gel S-Coltene Whaledent) for 15 seconds, thoroughly washed with water for 15 seconds and blot dried. The dentin was kept moist. Bonding agent (One Coat Bond SL-Coltene Whaledent) was applied with applicator tip and light cured for 20 seconds with Translux power LED (Heraeus Kulzer) kept at a distance of 1 mm.

All samples were randomly divided into four groups each containing 10 teeth or 20 cavities.

RESTORATIVE PROCEDURE

Group 1: Restored with light cure composite resin (Synergy D6-Coltene Whaledent) (Control Group).

Group 2: Base of 2 mm flowable composite (Swiss Tec Flow-Coltene Whaledent) followed by restoration with light cure composite.

Group 3: Base of 2 mm dual cure composite (Para Core-Coltene Whaledent) (immediately cured) followed by restoration with light cure composite.

Group 4: Base of 2 mm dual cure composite (cured after delay of 60 seconds) followed by restoration with light cure composite.

After the restorations were complete, the metallic matrices were removed and finishing and polishing of the samples was done. The surfaces of the teeth were covered with 2 layers of nail varnish, except for the restoration and 2 mm around it. The apical foramen were sealed with acrylic resin, and the samples were stored in saline at 37°C and 100% humidity for 24 hours.

The specimens were thermocycled for 1,000 cycles at 5 ± 1°C and 55 ± 1°C with 30 seconds dwell time and were then immersed in 2% methylene blue dye for 24 hours at 37°C. They were sectioned mesiodistally through center of restoration with diamond disk, polished and analyzed with a stereomicroscope at ×10 magnification. Dye penetration was scored according to scores described below:

- 0—No dye penetration (Fig. 1A).
- 1—Dye penetration up to enamel/cementum (Fig. 1B).
- 2—Dye penetration into gingival seat dentin (Fig. 1C).
- 3—Dye penetration into axial wall (Fig. 1D).

RESULTS

Null hypothesis: There is no significant difference between the four groups with respect to microleakage, i.e. $\eta_1 = \eta_2 = \eta_3 = \eta_4$.

Alternate hypothesis: There is a significant difference between the four groups with respect to microleakage, i.e. $\eta_1 \neq \eta_2 \neq \eta_3 \neq \eta_4$.

Level of significance: $\alpha = 0.05$.

Statistical technique used: Kruskal-Wallis test.

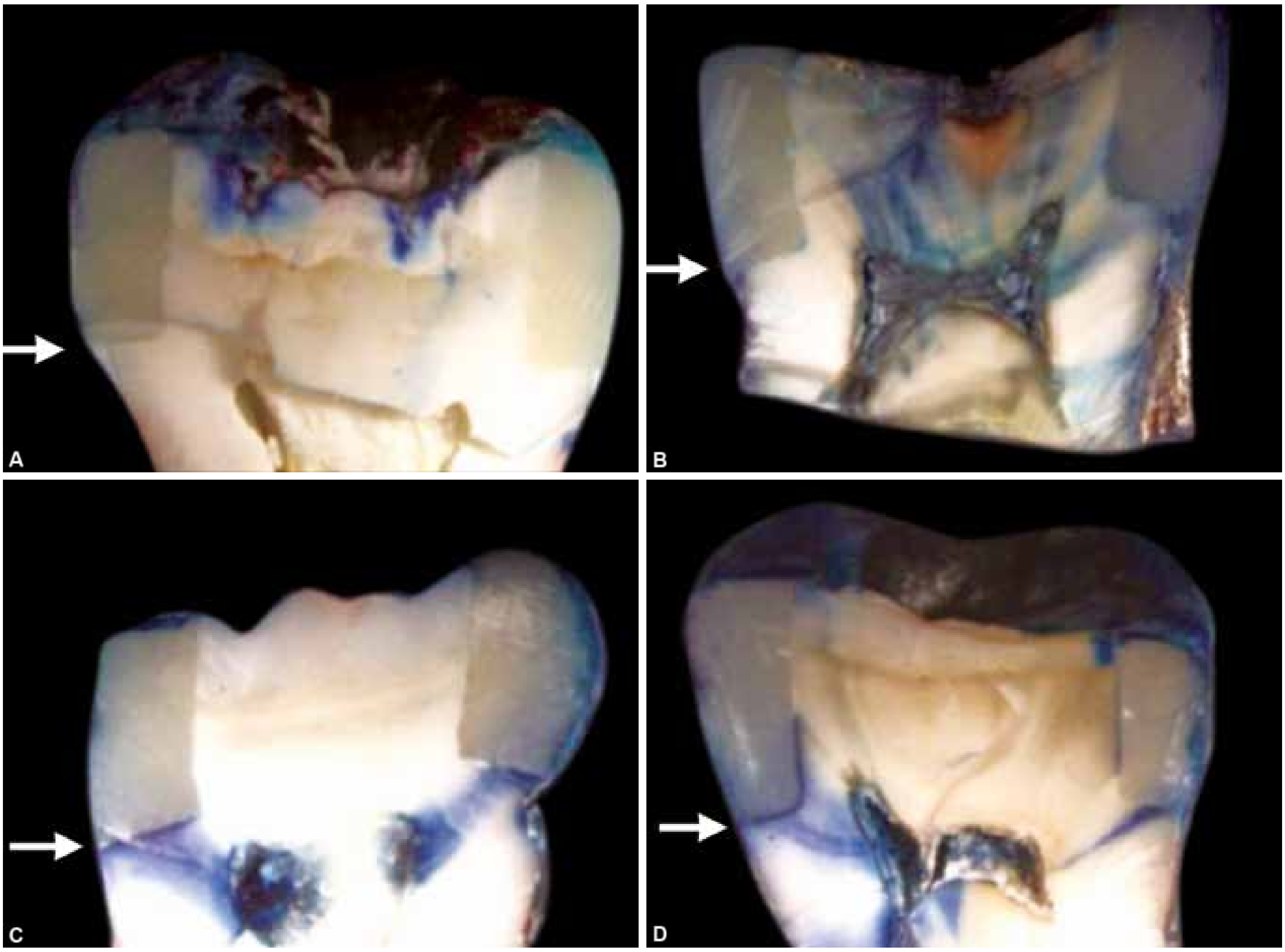
Decision Criterion

We compare the p-value with the level of significance. If $p < 0.05$, we reject the null hypothesis and accept the alternate hypothesis. If $p \geq 0.05$, we accept the null hypothesis. If there is a significant difference, we carry out multiple comparisons using Mann-Whitney test.

Table 1 shows the scores for each group.

The mean score (Graph 1) was found to be higher in group 1 followed by groups 3, 2 and 4 respectively. The difference in scores between the four groups was found to be statistically significant ($p < 0.01$).

In order to find out among which pair of groups there exist a significant difference, we carried out multiple comparisons using Mann-Whitney test (Table 2). We observed that there was a significant difference in microleakage scores between



Figs 1A to D: (A) No dye penetration, (B) dye penetration up to enamel/cementum, (C) dye penetration into gingival seat dentin and (D) dye penetration into axial wall

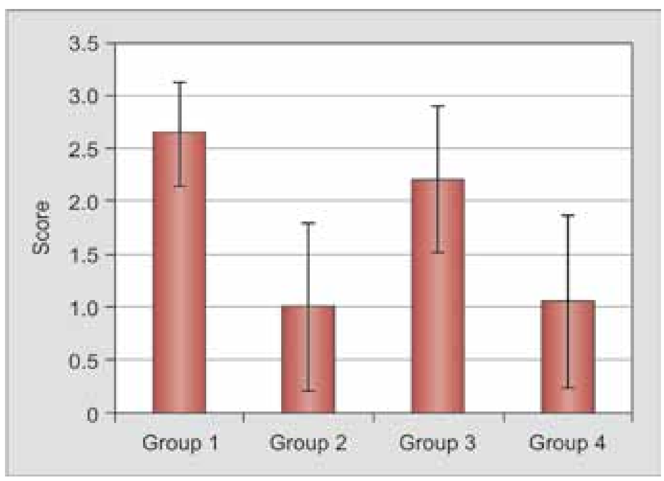
groups 1 and 2, groups 1 and 3, groups 1 and 4, groups 2 and 3 and groups 3 and 4 ($p < 0.001$).

No significant difference was observed between groups 2 and 4 ($p > 0.05$).

DISCUSSION

Inspite of reports of good clinical performance and longevity, one of the most compelling problems associated with the use of composites is polymerization shrinkage. This is caused due to the fact that monomer molecules are converted into polymer network, thus exchanging van der wall spaces in covalent bond spaces which ultimately results in shrinkage.[8] Polymerization shrinkage stresses have the potential to initiate failure of the restoration at composite–tooth interface, producing interfacial gaps which can lead to microleakage.[9]

Microleakage is defined as clinically undetectable passage of bacteria, fluids, molecules or ions between the cavity wall and the applied restorative material. It is a dynamic phenomenon which results in two consequential manifestations. A compromised marginal seal causes hydrodynamic fluid movement through a degraded smear layer into the patent dentinal tubules underneath to result in hypersensitivity to thermal and osmotic stimuli and is referred to as sensory component of microleakage. Penetration of bacteria and their products through such potential gap accounts for



Graph 1: Mean scores in the recorded groups

Table 1: Scores of each group

Groups	*Score 0*	*Score 1*	*Score 2*	*Score 3*
1. Composite restoration	0	3	10	7
2. Flowable composite	2	10	6	2
3. Dual cure base	1	7	9	3
4. Delayed dual cure	3	9	5	3

Table 2: Statistical analysis for each group

Groups (I)	*Groups (II)*	*Mean difference*	*Z*	*p-value*
Group 1	Group 2	1.550	–4.495	<0.001*
	Group 3	0.450	–2.134	0.033*
	Group 4	1.600	–4.867	<0.001*
Group 2	Group 3	–1.100	–3.465	0.001*
	Group 4	0.050	–0.058	0.954
Group 3	Group 4	1.150	–3.863	<0.001*

*Denotes significant difference

pathologic component of microleakage that results in recurrent caries and subsequent pulpal pathosis. Clinically, it is evident as staining around the margins of the restoration, postoperative sensitivity, secondary caries, restoration failure, pulpal inflammation and even pulpal death.[10]

Among the techniques advocated for assessment of microleakage like dye penetration, chemical tracers, radioactive tracers, scanning electron microscope, air pressure, neutron activation analysis, and electrical conductivity, the use of dyes as tracers is one of the oldest and most common method of detecting microleakage *in vitro*. The advantage of the staining technique includes precision in evaluation of marginal seal and its ability to reveal an existing microgap. In addition to its capability to give data on linear penetration and direct reading of the penetrated marker by microscope, the main advantage of this method is its simplicity.[11]

Employing the dye penetration test, the results of the present study were in accordance with those previously done by Ozel et al, Periz et al, Peutzfeldt and Chuang et al who stated that placing a flowable composite at the gingival margin significantly decreases the microleakage in class II composite restorations.[6,11-13] Flowable composites are 44 to 54% filled by volume and have an average particle size ranging from 0.04 to 1 micrometer. Their decreased viscosity is achieved by reducing the filler volume so they are less rigid.

Packable composites have a relatively higher modulus of elasticity and employing an immediate layer of flowable composite provides better adaptation. They also act as a flexible intermediate layer which helps to relieve stresses during polymerization shrinkage. Also, 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. The use of flowable materials as a liner underneath the composite resin may also reduce the effects of C-factor. All these factors ultimately decrease polymerization shrinkage.[14]

On the contrary, some studies by authors like Tredwin, Ziskind and Belcher showed that conventional and packable composites with a fluid gingival layer had significantly higher leakage scores than when used alone. The data of these studies do not support the use of fluid layers in class II composite restoration. This increased microleakage is attributed to the higher resin content and less filler loading of these composite resins which causes more polymerization shrinkage.[15,16] Malmstrom also reported that neither the thickness nor the presence of fluid composite gingival layer significantly changed the extent of leakage in sub CEJ class II composite restorations.[17]

When dual cure composite was placed as a base and cured immediately in the present study, the leakage pattern observed were similar to that obtained by Shirani F et al.[18] Both studies confirmed that placing a dual cure composite as the gingival increment significantly reduced the gingival microleakage as compared to a restoration without a liner. These composites polymerize more slowly as compared to light cure composites resulting in lower contraction stresses. Also they show more predictable polymerization in deeper cavities where the depth of the cavity is more and complete light polymerization cannot take place.[3] Thus, the portions of resin that initially receive too low an intensity of light to initiate adequate curing, can be polymerized by the delayed chemical reaction that forms free radicals, consequently decreasing microleakage.[19]

Furthermore, the microleakage scores obtained in the present study by delaying polymerization of dual cure were similar to that done by Atlas et al who stated that delayed polymerization of the dual cure composite base reduces microleakage at the gingival margin. The study also showed that the samples that were cured after a 60 seconds delay showed the least microleakage.[7]

Traditionally, dual cure composites are cured without delay after being placed in the cavity. But this immediate initial light exposure causes a rapid increase in conversion of the resin, resulting in a very viscous gel. This rapid increase in viscosity hinders the migration of active radical components that would be responsible for further chemically induced polymerization.[19]

In contrast delayed curing of dual cure composite will let the self cure mode of a dual cure composite initiate and will hence slow the polymerization reaction velocity before the final light polymerization procedure. Thus, they reduce polymerization shrinkage and stresses at final conversion ultimately decreasing the microleakage and enhancing clinical success of posterior composite resin restorations.[7]

In conclusion, the present study showed comparable microleakage scores between flowable composite and dual cure composite base (delayed cure), possibly suggesting that both flowable composite and dual cure composite (delayed cure) and can be used as base materials below class II composite restorations to decrease microleakage and its effects. In view of the fact that there is lack of literature on studies with dual cure composite as a base, further *in vivo* and *in vitro* studies are required to determine its clinical validity.

CONCLUSION

Under the limitations of this *in vitro* study, it can be concluded that:

Microleakage was significantly decreased from gingival margins of class II composite open sandwich restorations after application of a base, although none of the materials used in this study was able to completely eliminate it.

Microleakage scores were least in those teeth where either flowable composite or a delayed dual cure composite base was placed.

Delayed curing of the dual cure composite demonstrated less microleakage than immediate curing.

Both flowable composite and dual cure composite (delayed cure) can be used as intermediate materials to decrease microleakage in class II composite restorations after further *in vitro* and *in vivo* studies.

REFERENCES

1. Bragaa RR, Ballestera RY, Ferracane JL. Factors involved in the development of polymerization shrinkage stress in resin-composites: a systematic review. Dental Material 2005;21: 962-970.
2. Cadenaro M, Marchesi G. Flowability of composites is no guarantee for contraction stress reduction. Dental Materials 2009; 25:649-654.
3. Koubi S, Raskin A. Effect of dual cure composite as dentin substitute on marginal integrity of class II open sandwich restorations. Operative Dentistry 2009;34-2:150-156.
4. Beznos C. Microleakage at the cervical margin of composite class II cavities with different restorative techniques. Operative Dentistry 2001;26:60-69.
5. Wenckert A. Modified class II open sandwich restoratins. Evaluation of interfacial adaptation and influence of different restorative techniques. European J Oral Sciences 2002;110: 270-275.
6. Ozel E, Soyman M. Effect of fibre nets, application techniques and flowable composites on microleakage and the effect of fibre nets on polymerization shrinkage in class II MOD cavities. Operative Dentistry 2009;34-2174-2180.
7. Atlas AM, Raman P. Effect of delayed light polymerization of a dual cured composite on microleakage of class II posterior composite open sandwich restorations. Quintesence International 2009:471-476.
8. Ferracane JL. Placing dental composites–a stressful experience. Operative Dentistry 2008;33(3):247-257.
9. Stockton W. Microleakage of class II posterior composite restorations with gingival margins placed entirely within dentin. JCDA 2007;73(3):255-258.
10. Attar N, Turgut MD, Gungor HC. The effect of flowable resin composites as gingival increments on the microleakage of posterior resin composites. Operative Dentistry 2004;29(2): 162-167.
11. Chuang SF, Liu JK, Chao CC, Liao FP, Melody Chen YH. Effects of flowable composite lining and operator experience on microleakage and internal voids in class II composite restorations. J Prosthet Dentist 2001;85:177-183.
12. Peutzfeldt A, Asmussen E. Influence of flowable and self curing linings on microleakage in vitro. Operative Dentistry 2002;27: 569-575.
13. Periz. Evaluation of marginal microleakage in class II cavities effect of microhybrid, flowable and compactable resins. Restorative Dentistry 2003;34(2):93-98.
14. Sadeghi M. The effect of flowable materials on the microleakage of composite cavities that extend apical to the CEJ. Operative Dentistry 2009;34(2):174-180.
15. Tredwin CJ, Stokes A, Moles DR. Influence of flowable liner and margin location on microleakage of conventional and packable class II resin composites. Operative Dentistry 2005;31(1):32-48.
16. Ziskind D, Adell I, Teperovich E, Peretz B. The effect of an intermediate layer of flowable composite resin on microleakage in packable composite restorations. Int J Paediatr Dent 2005;15: 349-354.
17. Malmstrom H, Schlueter M, Roach T, Moss ME. Effect of thickness of flowable resins on marginal leakage in class II composite restorations. Operative Dentistry 2002;27:373-380.
18. Shirani F. The effect of flowable and dual-cure resin composite liners on gingival microleakage of posterior resin composite. J Dent Med 2008;21(2):116-123.
19. Rueggeberg FA. The influence of light exposure on polymerization of dual cure resin cements. Operative Dentistry 1993;18: 48-55.