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The effect of an intermediate layer of flowable composite resin on microleakage in packable composite restorations

D. ZISKIND[1], I. ADELL[1], E. TEPEROVICH[1] & B. PERETZ[2]
[1]*Department of Prosthetic Dentistry and* [2]*Department of Pediatric Dentistry, The Hebrew University Hadassah School of Dental Medicine, Jerusalem, Israel*

Summary. *Objectives.* The aim of the present study was to evaluate the effect of a thin layer of flowable composite on microleakage in Class II direct packable composite resin restorations on young permanent teeth *in vitro*.
Methods. Twenty sound human premolars and molars extracted for orthodontic reasons were selected for this study. The teeth were randomly assigned into two groups of 10 teeth each (groups A and B). Class II cavities were prepared as uniformly as possible in the mesial and distal aspects of each tooth. The gingival margin extended apically approximately 0·5 mm beyond the cemento-enamel junction, in the dentin. Cavities in group A were restored with packable composite and Alert®/Flow-it® flowable composite, while groups B cavities were restored with Pyramid®/Aeliteflo®. The control cavities in groups A1 and B1 were restored with only packable composite. The teeth were immersed in 2% methylene blue solution for 24 h to allow dye penetration into possible existing gaps between the tooth substance and the restorative material. All teeth were subjected to thermocycling.
Results. The dye penetration ranged between 6·6 and 7·2 mm. No significant difference was found between the control and the experimental groups.
Conclusion. The use of flowable composite resin as intermediate material does not reduce microleakage.

Introduction

Composite materials undergo contraction during curing [1]. Under some circumstances, the shrinkage may result in debonding from tooth structure and gap formation. Weak proximal contact point and gap formation in the tooth–restoration interface are the major clinical disadvantages associated with the use of composite resin in the direct technique for class II cavities. Efforts to overcome these problems are directed towards improving treatment techniques and developing new materials [2–5].

Preservation of the bond to the cavity walls depends, among other factors, on the cavity configuration and the viscoelastic behaviour of the composite resin [6,7]. Recently, several condensable composites have been introduced. Some of these systems suggest usage of an intermediate layer of flowable composite between the floor of the box and the restorative material. Because of low filler loading, flowable composite resin materials shrink more than traditional composites [8]. However, these materials may exhibit a stress-reduction-by-flow property.

Recent microleakage tests of this technique have given contradictory results. The use of four different flowable composite resin, i.e. Aeliteflo®, Revolution®, UltraSeal XT® and Flow-It®, in combination with OptiBond FL® dentin bonding agent and Prodigy® hybrid resin-based composite did not reduce microleakage in the short term [9]. When used as a liner in combination with a packable resin, a reduction of microleakage was noted [10]. The influence

Correspondence: Dr B. Peretz, Department of Pediatric Dentistry, The Hebrew University Hadassah School of Dental Medicine, PO Box 12272, Jerusalem, Israel. E-mail: benny@cc.huji.ac.il

of the flowable materials, i.e. Dyract Flow®, Filtek Flow® and Tetric Flow®, on the microleakage of Class II cavities restored with microhybrid and packable resin (SureFil®, Filtek P60® and Tetric Ceram®) was tested. A significant reduction of the gingival microleakage was found by using 1-mm-thick gingival increment.

The purpose of the present study was to evaluate the effect of a thin layer of flowable composite in combination with packable composite on the microleakage below the amelo-cemento junction in Class II restorations *in vitro*.

Materials and methods

Twenty clinically sound young human premolars and molars, free of restorations, caries or other defects, were selected for the present study. The age range of the children was 12–14 years. All teeth were extracted for orthodontic reasons. The teeth were stored in 0·1% thymol solution at room temperature, immediately after extraction. They were cleaned of all debris with an aqueous slurry of pumice and a soft polishing brush at low speed, and were washed with tap water.

The teeth were assigned randomly into two groups of 10 teeth each (groups A and group B). Class II cavities were prepared as uniformly as possible in the mesial and distal aspects of each tooth. The gingival margin extended apically approximately 0·5 mm beyond the cementoenamel junction and was located in the dentin. All preparations were completed with D1 diamond fissure burrs (Strauss Ltd, Raanana, Israel) in a high-speed hand piece, cooled with air water spray.

Restorative procedure

The mesial aspect of each tooth was marked with an indentation along the root approximately 7 mm apically to the gingival aspect of the box. The indentation was prepared with a D1 diamond fissure burr. This divided the cavities into two subgroups. The marked cavities (groups A and B) served as controls and the unmarked cavities (groups A1 and B1) were the experimental cavities. The distributions of groups, restorative materials and adhesive systems are described in Table 1. All cavities were restored with two different brands of packable composite resins.

Cavities in groups A and A1 were restored with Alert® (Jeneric/Pentron Inc., Wallingford, CT, USA), while the cavities in groups B and B1 were restored with Pyramid® (Bisco Inc., Schaumburg, IL, USA). Etching and bonding were used, excess material was removed with a super-fine finishing diamond burr and polished with disks (Sof-Lex®, 3M Dental Products, St Paul, MN, USA).

Groups A1 and B1 were treated in exactly the same manner regarding material application, curing and finishing procedure. The only difference in restorative procedure between the distal and mesial restorations in each tooth was the inclusion or preclusion of the flowable composite resin, respectively. In the experimental cavities, an additional thin layer (1 mm) of low-viscosity flowable composite resin was placed between the bonding agent and the packable composite: Flow-it® (Jeneric/Pentron Inc.) in group A1 and Aeliteflo® (Bisco Inc.) in group B1. Between the procedures, the teeth were wrapped in wet gauze and restored in a tightly closed container at room temperature for 24 h.

Table 1. Restorative and bonding materials used in the experiment.

Material	Manufacturer	Etching and bonding procedure	Lot number
Group A			
Alert®	Jeneric/Pentron	37% etching gel	830982
		Bond 1 primer/adhesive	840920
			830902
Group A1			
Flow-it®	Jeneric/Pentron		830911
Group B			
Pyramid	Bisco	UNI ETCH® 32%	9900000342
		Phosphoric acid etchant with benalkonium chloride	9800001775
		One-step®/Resinomer®	9800001814
Group B1			
Aeliteflo®	Bisco		9800001698

Thermocycling procedure

All teeth were subjected to thermocycling between 4 ± 2 and 60 ± 2 °C for 750 cycles. The dwell time in each bath and the time interval at room temperature between baths was one minute. After thermocycling, the surfaces of the teeth, apart from the restorations and approximately 1·5 mm beyond the margins, were coated with a layer of nail varnish, melted utility wax and a second layer of nail varnish. The coated teeth were immersed in 2% methylene blue solution for 24 h to allow dye penetration into possible existing gaps between the tooth substance and the restorative material. After removal from the dye, the coating was stripped off and the teeth were embedded in self-curing resin.

Dye penetration evaluation

Three mesio-distal sections were obtained by grinding off the embedded teeth buco-lingually parallel to their axes. The depth of the dye penetration was evaluated under a binocular microscope (Model XT, Olympus, Tokyo, Japan) at × 200 magnification. Scores were assigned to each individual sample in accordance with the depth of penetration in millimetres. Two examiners measured the depth of dye penetration. In cases of a difference of more than one millimetre, the examiners discussed the gap and a decision was made on a consensual basis. The mean values of the dye penetration for the three sections were recorded separately in millimetres for the occlusal and the cervical interfaces. Data was analysed using a paired *t*-test ($\alpha = 0{\cdot}05$).

Fig. 1. Pyramid® flowable composite resin with Aeliteflo® (right) compared to Pyramid® alone (left).

Results

Both packable composite materials tested with or without intermediate flowable composite resin presented microleakage. The mean depths of dye penetration, based on the agreement between examiners, for the occlusal and cervical areas for each group are shown in Table 2. All restorations in all groups showed dye penetration at the tooth–restoration interface. The dye penetration ranged between 6·6 and 7·2 mm. No significant difference was found between the control and the experimental groups.

Figures 1 and 2 represent two slices from each group. Figure 1 shows Pyramid® flowable composite

Table 2. Mean depth of dye penetration (mm) in the occlusal and cervical areas for groups A (Alert®) and B (Pyramid®).

	Group A (mean ± SD)		Group B (mean ± SD)	
Area	(A1) Flowit®	(A) Control	(B1) Aeliteflo®	(B) Control
Occlusal	6·5 ± 1·1	7·0 ± 1·7	6·6 ± 1·0	6·6 ± 1·3
Cervical	7·1 ± 2·2	6·7 ± 2·6	7·0 ± 1·7	7·2 ± 1·0

Fig. 2. Alert® flowable composite resin with Flowit® (left) compared to Alert® alone (right).

resin with Aeliteflo® compared to Pyramid® alone, and Fig. 2 shows Alert® flowable composite resin with Flowit® compared to Alert® alone. Small voids and the inhomogeneous interface between increments can be observed. Indentations on the cervical areas of the teeth marked the control groups.

Discussion

Because of its low filler content, the flowable composite resin presents remarkable flow characteristics compared to a restorative composite resin. As a result, enhanced wetting of the tooth surface and a low modulus of elasticity can be achieved. Two clinical benefits are expected: reduction of marginal microleakage in the short term as a result of its stress-reduction-by-flow property and reduction of marginal microleakage in the long term because of improved durability under flexural load. The latter is an important characteristic in the treatment of Class V cavities.

Restoring a Class II cavity with a gingival margin located in dentin presents a clinical challenge in achieving reliable bonding. Difficulties in isolating the working field and contraction of the material during polymerization may affect adhesion to the floor of the cavity box. A gap is formed when the forces of polymerization contraction exceed dentin bond strength [7]. Better material adaptation during placement and reduced polymerization shrinkage stress by flow may decrease gap formation at the floor of the box [11]. This may be achieved by applying an intermediate layer of low-viscosity flowable composite resin.

The present results indicate that the use of flowable composite in combination with packable composite resin did not significantly influence microleakage. These results are in agreement with those of Jain *et al.* [9], who described similar findings in Class II restorations, and with those of Swift *et al.* [12], who reported that the use of an intermediate low viscosity resin did not have any consistent effect on microleakage in Class V composite restorations. Leevailoj *et al.* [10] tested microleakage with autoradiographs, using calcium as the tracer, and showed that flowable liners reduced microleakage in the proximal box of Class II preparations. They also found that the microleakage rates of Alert® and Pyramid® with flowable liner were significantly greater than the control hybrid composites (Renew®) with flowable liner. It has also been shown that restorative material classified as a packable composite presents higher contraction stress in comparison to hybrid composite [13]. In the above study, severe leakage and some voids were observed in most restorations. Benzos [14] compared different restorative techniques, and concluded that the tested techniques did not result in microleakage at the cervical enamel area, while cervical cementum and dentin did not eliminate microleakage.

However, the ability of the flowable composite resin to control microleakage may be influenced by additional factors. It was found that a thick lining of P60® restorations with flowable composite resin may impair the marginal sealing, especially after thermocycling [15].

The results of these experiments can help to explain the contradictory results found in the literature. It can be assumed that the effect of the restorative material at the cervical margin appear to be the dominant factor in gap formation and subsequent microleakage at the floor of the box in Class II restorations.

What this paper adds
• This paper describes an investigation of the effect of an intermediate layer of flowable composite resin on microleakage in packable composite restorations.
• The addition of the flowable composite had little effect on microleakage.

Why this paper is important for paediatric dentists
• Composite restorative materials are now very widely used in paediatric dentistry. The results of this study suggest that adding an intermediate layer of flowable composite in an attempt to improve adaptation may be of little benefit in improving marginal microleakage.

Conclusion

The packable composite combination with flowable composite tested in the present study demonstrated leakage below the amelo-cemento junction in Class II restorations *in vitro*. The use of flowable composite resin as intermediate material does not reduce microleakage.

Résumé. *Objectifs*. Evaluer in vitro l'effet d'une mince couche de composite fluide sur les micro-percolations dans les restaurations de classe II en composite compacté dans les dents permanentes jeunes.
Matériels et Méthodes. 20 prémolaires et molaires humaines saines extraites pour raisons orthodontiques ont été sélectionnées pour cette étude. Les dents ont été réparties au hasard dans deux groupes de dix dents (Groupe A et B). Les cavités de classe II ont été préparées de façon la plus uniforme au niveau mésial et distal de chaque dent. Le bord gingival allant apicalement approximativement 0,5 mm de la jonction cémento-dentinaire, dans la dentine. Les cavités du groupe A ont été restaurées à l'aide de composite compact et fluide : Alert® / Flow-it® (Jeneric/Pentron Inc, Wallingford, CT USA), tandis que les cavités du groupe B ont été restaurées à l'aide Pyramid® / AELITE FLO® (Bisco Inc., Schaumburg, IL USA). Les cavités témoins Groupe A1 et Groupe B1 ont été restaurées à l'aide des composites compacts respectifs. Les dents ont été immergées dans une solution de bleu de méthylène à 2% pendant 24 heures pour permettre au colorant de pénétrer dans les vides potentiels entre dent et matériau de restauration. Toutes les dents ont été soumises à un thermocyclage.
Résultats. La pénétration du colorant est allée de 6,6 mm à 6,2 mm. Aucune différence significative n'a été trouvée entre les groupes contrôle et expérimentaux.
Conclusion. L'utilisation de composite fluide comme matériau intermédiaire ne réduit pas la micro-percolation.

Zusammenfassung. *Ziele*. Bestimmen des Effektes einer dünnen Schicht fließfähigen Komposites auf die Farbstoffpenetration von direkten Klasse-II-Restaurationen aus stopfbarem Komposit an jugendlichen bleibenden Zähnen in vitro.
Methoden und Materialien. 20 gesunde humane Prämolaren und Molaren, welche aus kieferorthopädischen Gründen extrahiert worden waren, wurden für diese Studie ausgewählt. Die Zähne wurden zufällig in zwei Gruppen zu je zehn Zähnen aufgeteilt (Gruppe A und B). Die Klasse II Kavitäten wurden so gleichförmig wie möglich präpariert in der mesialen und der distalen Seite an jedem Zahn. Der gingivale Rand wurde rund 0.5mm über die Schmelz-Zement-Grenze hinaus in das Dentin gelegt. Die Kavitäten der Gruppe A wurden mit dem stopfbaren/fließfähigen Komposit Alert® / Flow-it® (Jeneric/Pentron Inc, Wallingford, CT USA) versorgt, während die Kavitäten der Gruppe B mit Pyramid® / AELITE FLO® (Bisco Inc., Schaumburg, IL USA) versorgt wurden. Die Kontrollkavitäten (Gruppen A1 und B1) wurden jeweils mit dem stopfbaren restauriert. Die Zähne wurden für 24 h in 2% Methylenblau eingelegt um Farbstoffpenetration in Undichtigkeiten von Zahn und Füllungsmaterial zu ermöglichen. Alle Zähne wurden einem Thermozyklus unterzogen.
Ergebnisse. Die Farbstoffpenetration lag zwischen 6.6 mm und 7.2 mm. Es wurden keine signifikanten Unterschiede zwischen den Gruppen gefunden.
Schlussfolgerungen. Die Verwendung von fließfähigem Komposit scheint die Farbstoffpenetration nicht zu beeinflussen.

Resumen. *Objetivos*. evaluar in-vitro el efecto de una fina capa de composite fluído en el microfiltrado de restauraciones directas de clase II de composite condensable en dientes permanentes jóvenes in-vitro.

Material y método. Se seleccionaron para este estudio 20 premolares y molares sanos extraídos por razones ortodóncicas. Los dientes se asignaron aleatoriamente en dos grupos de diez dientes cada uno (Grupo A y grupoB). Las cavidades clase II se prepararon lo más uniformemente posible en las caras mesial y distal de cada diente. El margen gingival se extendió apicalmente aproximadamente 0,5 mm más allá de la unión amelo-cementaria, en la dentina. Las cavidades del grupo A se restauraron con composite condensable y composite fluido. Alert® / Flow-it® (Jeneric/Pentron Inc, Wallingford, CT USA), mientras que las caviades del grupo B se restauraron con Pyramid® / AELITE FLO® (Bisco Inc., Schaumburg, IL USA). Las cavidades control Grupo A 1 y Grupo B 1 se restauraron sólo con composite condensable. Los dientes estuvieron inmersos en solución de azúl de metileno durante 24 horas para permitir la penetración de colorante en posibles gaps existentes entre la sustancia dentaria y el material restaurador. Todos los dientes estuvieron sujetos a termociclado.
Resultados. La penetración del colorante osciló entre 6,6 milímetros y 7,2 milímetros. No se encontró ninguna diferencia significativa entre los grupos control y el experimental.
Conclusión. El uso de composites fluidos como material intermedio no reduce el microfiltrado.

References

1 Bausch JR, De Lange C, Davidson CL, Peters A, De Gee AJ. Clinical significance of polymerization shrinkage of composite resins. *Journal of Prosthetic Dentistry* 1982; **48**: 59–62.
2 Lutz F, Krejci I, Oldenburg TR. Elimination of polymerization stresses at the margins of posterior composite resin restorations: a new restorative technique. *Quintessence International* 1986; **17**: 777–784.
3 Swartz J, Anderson MH, Pelleu JRGB. Reducing microleakage with the glass-ionomer/resin sandwich technique. *Operative Dentistry* 1990; **15**: 186–192.
4 Lutz F, Krejcei J, Barbakow F. Restoration quality to wedge-mediated light channeling. *Quintessence International* 1992; **23**: 763–767.
5 George LA, Richards ND, Eichmiller FC. Reduction of marginal gaps in composite restorations by use of glass-ceramic inserts. *Operative Dentistry* 1995; **20**: 151–154.
6 Davidson CL, Feilzer A, De Gee AJ. The competition between the composite dentin bond strength and the polymerization contraction stress. *Journal of Dental Research* 1984; **63**: 1396–1399.
7 Feilzer AJ, De Gee AJ, Davidson CL. Setting stress in composite resin in relation to configuration of the restoration. *Journal of Dental Research* 1987; **66**: 1636–1639.
8 Tolidis K, Sectos JC. Initial degree of polymerization shrinkage exhibited by flowable composite resins. [Abstract.] *Journal of Dental Research* 1999; **78**: 482, 3015.
9 Jain P, Belcher M. Microleakage of Class II resin-based composite restorations with flowable composite in the proximal box. *American Journal of Dentistry* 2000; **13**: 235–238.
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**: 162–167.
11 Feilzer AJ, De Gee AJ, Davidson CL. Quantitative determination of stress reduction by flow in composite restorations. *Dental Materials* 1990; **6**: 167–171.
12 Swift EJ, Triolo PT, Jr, Barkmeier WW, Bird JL, Bounds SJ. Effect of low-viscosity resins on the performance of dental adhesives. *American Journal of Dentistry* 1996; **9**: 100–104.
13 Chen HY, Manhart J, Hickel R, Kunzelman KH. Polymerization contraction stress in light cured packable composite resins. *Dental Materials* 2001; **17**: 253–259.
14 Benzos C. Microleakage at the cervical margin of composite class II cavities with different restorative techniques. *Operative Dentistry* 2001; **26**: 60–69.
15 Chuang SF, Jin YT, Liu JK, Chang CH, Shieh DB. Influence of flowable composite lining thickness on Class II composite restorations. *Operative Dentistry* 2004; **29**: 301–308.