Microleakage Around Aged Packable Composite Restorations Cured Independently Or Simultaneously With The Flowable Composite Liner

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Introduction

New composite resins specifically developed for posterior use have recently been introduced; and marketed as packable[1]. It has higher filler content, larger particle size, and higher viscosity [2]. Higher viscosity is a help in anatomical replacement; as it facilitate placement without adhering to the condensing instrument [3]. The new packable resin based composite are virtually non-sticky when clean, scratch free instrument are used [1], stickiness can result in porosity and voids as materials are manipulated. They also does not slump, slumping increases the difficulty of creating proper anatomical form [1]. The combination of this new material, matrices, and contact forming instruments has made it possible to achieve predictable high quality contacts in class II direct composite restorations [1]. However, higher viscosity also could increase the possibility of voids at the margin and in the body of the restoration [3].

Marginal leakage is reported to be the most common cause of failure in posterior composites [4, 10].

Marginal leakage is reported to be the most common cause of failure in posterior composite; results suggested placing flowable composite as liner beneath it [6].

The first generation of flowable composite was introduced in late 1996, retaining the small particle sizes of traditional hybrid composite, but reducing the filler content and allowing the increased resin to reduce the viscosity of the mixture creating flowable composites [(5)]. A popular application for these systems would seem to be used as liners in areas of difficult access or flow especially proximal boxes of class II preparations [(5)]. The assumption by many clinicians may be that these materials easily flow into, adapt to, and fill the line angles of class II cavity preparations, but that has not yet been carefully demonstrated [(5)].

Of equal concern is that flowable composites are low-viscosity, primarily because they have less filler loading. Therefore, they should be expected to shrink more and potentially create more stress on the bonding agents during composite curing than traditional composites might [(5)]. At the same time, their greater toughness might mean that they absorb sufficient energy to help postpone interfacial failures caused by cyclic loading [(6)]. However, it also could be argued that the lower modulus of the flowable liner might prematurely allow deflection of the overlying high modulus conventional composite [(5)].

This is clearly a complex situation. Long-term clinical studies are not yet available to support the use of a flowable composite as a liner at this time [(5).] Moreover, the present available investigations neglect the role of oral environment on durability of such a liner, which has low in-organic filler content and weak organic matrix. So this investigation was designed to demonstrate the effect of flowable composite on microleakage around packable composite restorations and to assess the stability of this liner when aged in oral-simulating fluids.

Review of Literature

D. Ronald et al (2000) [1] Have proposed a simplified placement technique for direct resin restorations that involves the use of new posterior heavy body resins. They stated that the better handling characteristics that allow a shorter, simplified placement technique will be the reason dentists will use these new heavy-body resins.

FF Tung, et al (2000) [6] studied microleakage of a packable resin composite: when placed with or without a liner and two different dentin-bonding agents. They concluded that to limit microleakage, a flowable composite should be used as a liner when a packable composite material is used.

A one-year clinical evaluation of one step adhesive in non –carious cervical lesions is reported by **F Burrow Michel. et al (1999)** [11] they have shown that the use of a flowable resin based composite material has the potential to reduce microleakage when used as a liner between bonded dentin and a hybrid resin based composite. So far, no microleakage, seen as staining beneath the restorations, has been detected in this study. However, marginal discoloration was noticed in some restorations but this was believed to be caused by a slight excess of material on unetched enamel.

Belli S. et al (2001) **[12]** reported that the use of a flowable composite produced significantly more gap-free resin-dentin interfaces than teeth restored without the flowable composite. However, both flowable composite and enamel etching couldn't prevent gap formation at enamel-resin interfaces and crack formation on enamel walls.

Chuang SF. et al (2001) [7] investigated the effects of flowable composite lining on microleakage and internal voids. They found that there is no significant reduction in microleakage. They concluded that when flowable composite lining was placed at the gingival floor of composite restoration, voids in the restored interface were reduced, gingival marginal sealing was not improved by the same technique

Payned JH 4th et al (1999) [9] investigated the marginal seal of restorations: flowable composite resin compared to injectable glass ionomer. It appears that the use of a flowable composite resin plus a bonding agent significantly reduce microleakage of cavo-surface margin when compared with an injectable glass ionomer with or without bonding agent.

JOHN R. et al (2000) [12] demonstrated the effect of composite formulation on polymerization stress. They found that a significant relationship between higher filler volume and increased polymerization stress among the commercial materials.

They concluded that composites that contain lower levels of inorganic filler particles are less likely to produce high levels of polymerization stress during placement.

Manhart J. et al (2001) [13] studied marginal quality and microleakage of adhesive class V restorations. They found that significant differences among the groups at dentin and enamel margins. They concluded that marginal quality and sealing ability of adhesive systems to dentin, using a wet-bonding procedure, is still inferior compared with enamel margins.

Salvoljub Zivkovic, et al (2000) [14] stated that the use of an adhesive system and the corresponding resin composite doesn't eliminate microleakage completely when the cavity margins are in dentin.

A 75% v/o ethanol water solution (the so-called "Wu solvent") has been the solvent of choice to simulate accelerated ageing of restorations. According to the Food and Drug Administration Guidelines of the Unites States, this solution is also a recommended food simulator and may be considered clinically relevant [17].

Lin CT, et al (2000) [15] studied the effect of immersion in 75% ethanol as an oral simulating fluid for 0-30 days on the diametral tensile strength and compressive strength of the composites samples. They found that diametral tensile strength and compressive strength showed a significant decrease after immersion in 75% ethanol. They concluded that increasing the filler fraction improves the mechanical properties of aged composite restorations.

SY-LEE, et al (1994) [17] studied the effect of food and oral simulating fluids on dentin bond and composite strength of three adhesive /composite systems. Shear bond strength and diametral tensile strength were measured after aging in 75% ethanol solution and in an artificial saliva (Moi-Stir) for 30 days. Two control series were stored either in 100% humidity or in air.

They found that shear bond strength for all systems stored in (Moi-Stir) and air was not influenced by length of storage. Scanning electron microscope revealed that failure had primarily occurred through the dentin. Significant decreases (30-50%) in the shear bond strength of all systems occurred after immersion in 75% ethanol. There was no significant difference among brands. The diametral tensile strength of the composites showed significant decreases as a function of ethanol exposure. They concluded that the decrease in both shear bond strength and diametral tensile strength after storage in ethanol was a function of the square root of time, suggesting that alcohol attack in shear bond strength specimens occurred primarily in the composite system around the filler particles, or with in the bonding agent, but not in the dentin.

Alkaline medium has been used to simulate corrosive wear of composite resin. The medium choice is based on the rationale that in vivo degradation arises from reaction with the OH ,and can be enhanced by raising the PH of the medium . The NaOH solution satisfies this condition. They added that corrosion is likely to play an important role in the intraoral wear of resin composites, the following sequence of events associated with the corrosive-wear of resin composites. The first step in this process is absorption of water as the resin restorations are placed in the oral environment. The water-sorption leads mainly to hydrolytic degeneration (corrosion) of silane coupling and reinforcing fillers . The absorbed water diffuses internally through resin matrix , filler interfaces , pores and other defects , slowly dissolves the filler particles, and compromising their reinforcing effect. The water damage is expected to be most intense in the outer periphery of the restoration in proximity to the oral fluid. The long-term effect is the creation of microscopically identifiable internally corroded subsurface layer [(8)].

Fujishima A, et al (1989) [(10)] evaluated the chemical durability of posterior composite resins when stored in sodium hydroxide (0.1 mol, 1 mol) and distilled water at 37 degrees C for a week and subjected to the direct tensile test, measurement of surface roughness and SEM observation. They found that sodium hydroxide caused the degradation of composite resins, decrease of tensile strength and increase of surface roughness. The SEM photograph of fractured surface of tensile specimens revealed the degradation zone under the surface. They concluded that sodium hydroxide caused the hydrolysis of silan coupling of composite resins.

Aim of the Study

To study microleakage at enamel and cementum/dentin margins of packable composite restorations pre-cured or co-cured simultaneously with a flowable composite liner and aged in 3 different oral simulating fluids; 75% ethanol , 0.1 M sodium hydroxide and saline for 3 different time intervals.

The principle objectives of the work are:

1. To assess the effect of lining the packable composite restorations with a flowable composite on microleakage at enamel and cementum/dentin margins for class v cavities.

2. To assess the effect of pre-curing versus co-curing the flowable composite liner with the overlying packable composite restoration on microleakage for various test levels.

3. To compare the effect of aging in 3 different oral simulating fluids; 75% ethanol, 0.1 M sodium hydroxide and saline on microleakage phenomenon.

Materials and methods

Packable composite resin was inserted in mixed class V cavities of human molars with and without application of flowable composite as a liner beneath it. The lining flowable composite was cured independently or simultaneously with overlying packable composite restoration. The specimens was stored for different periods in oral simulating fluids subsequently assessed for relative sealing ability at both the enamel and dentin margins.

❖ Selection of teeth:

A total of 180 freshly extracted, non –restored and non-carious human molars were used. Teeth were stored in deionized water with 0.2% sodium azide bactericidal agent [19] . Residual tissue tags were scraped off and the teeth were thoroughly rinsed under running tap water for 15 minutes to remove sodium azide solution [19] .

❖ Cavity preparation: -

Cylindrical class V cavities[20,30,24] 4 mm wide and 2mm [55] deep were wet prepared on the buccal surface of each tooth [19,20,25] at the cemen to enamel junction using tungsten carbide[21] bur No 245 in high-speed hand piece then finished by tungsten carbide[21] bur No 60 in a low-speed hand piece. Each bur will be used for five preparations [20] .

The preparations were so located such that cavity margins terminate occlusally in enamel and gingivally in dentin /cementum to form a mixed class V [14,19,29,31,32,25] cavity Preparation. The margins were not be beveled [22,23]

❖ Bonding:

A compatible universal adhesive system was applied according to the manufacturer's instructions.

❖ Composite Application: -

According to the method used for restoration the specimens were divided in to 3 groups.

Group (1) received restoration with packable composite only. The composite was packed into the prepared cavity from the center to the periphery to allow maximum adaptation to the cavity walls. The excess was removed using a plastic instrument then cured for 80 seconds.

Group (2) 0.01ml of flowable composite was dispensed into the cavity using an insulin syringe and spread evenly by a probe to uniformly line the cavity, then was cured for 20 seconds .The packable composite was packed into the prepared cavity from the center to the periphery to allow maximum adaptation to the cavity walls . The excess was removed using a plastic instrument then cured for 60 seconds.

Group (3) was lined with 0.01ml of flowable composite which was dispensed into the cavity using an insulin syringe and spread evenly by a probe to uniformly line the cavity . The packable composite was packed into the prepared cavity from the center to the periphery to allow maximum adaptation to the cavity walls and in the same time allowing extrusion of the maximum amount of the flowable composite liner. The excess of flowable and packable composite was removed together simultaneously using a plastic instrument then cured simultaneously for 80 seconds.

❖ Finishing & polishing of the restoration:

The restorations were finished with a 12- fluted finishing bur, followed by polishing with abrasive disks (Sof-Lex; 3M Dental products) [25].

❖ Aging:

The teeth were aged in 75% ethanol solution[15,16,17,18,19,33,34,35,36] ,0. 1 M sodium hydroxide[8,10].

and saline and were further divided in to two subgroups:

Group (1) : will be aged for 1 month

Group (2) : will be aged for 3 months.

Assessment of the effectiveness of the adhesive resin joint:

Preparation of the teeth for dye penetration testing

The apices of the teeth were sealed with sticky – wax. All tooth surfaces, except a one mm-wide zone around the margins of each restoration, were sealed with a double layer of transparent nail polish, and then covered with sticky –wax [26] to minimize dehydration of the restorations, the teeth were replaced in water as soon as nail polish dries [27].

Dye penetration test: -

The test tooth was then placed in a freshly prepared 2% methylene blue solution for 24 hours [28].

The specimen will be then removed from the methylene blue dye, washed under running water, air – dried, then sticky wax will be removed and the tooth will be polished [26].

Tooth Sectioning:

Teeth will be sectioned longitudinally through the center of the restorations [27].

Scoring the depth of leakage: -

The tooth was examined under a stereomicroscope [86,17,30] to assess the depth of penetration of the dye and a score was given to designate the amount of enamel and dentin leakage separately according to the following scoring system [88].\

Score	Depth of dye penetration
0	No dye penetration
1	Dye Penetration along the enamel wall or first half of the cementum/ dentine wall
2	Dye Penetration beyond the enamel wall but not reaching the pulpal wall or along the second half of the dentin wall but not reaching the pulpal wall.
3	Dye Penetration along the pulpal wall.

Table (1)

Levels of investigation

Level	*Design*		*Referred*
Lining	*A*	a_1	***No lining***
		a_2	***Liner pre-cured independently before restoration***
		a_3	***Liner co-cured simultaneously with the restoration***
Aging Period	*B*	b_1	***One month***
		b_2	***Three months***
Aging Solution	*C*	c_1	***Saline***
		c_2	***75% Ethanol.***
		c_3	***0.1 M Sodium hydroxide***
Leakage	*D*	d_1	***Enamel margin***
		d_2	***Cementum/ dentin margin***

Table (2)

Factorial Design of experiment

X10	***A***	***B***	***C***	***D***
	A_1	$a_1 b_1$	$a_1b_1c_1$ $a_1b_1c_2$ $a_1b_1c_3$	$a_1b_1c_1\ d_1$ $a_1b_1c_1\ d_2$ $a_1b_1c_2\ d_1$ $a_1b_1c_2\ d_2$ $a_1b_1c_3\ d_1$ $a_1b_1c_3\ d_2$
		a_1b_2	a_1b2c_1 $a_1b_2c_2$ $a_1b_2c_3$	$a_1b_2c_1\ d_1$ $a_1b_2c_1\ d_2$ $a_1b_2c_2\ d_1$ $a_1b_2c_2\ d_2$ $a_1b_2c_3\ d_1$ $a_1b_2c_3\ d_2$
	A_2	$a_2\ b_1$	$a_2b_1c_1$ $a_2b_1c_2$ $a_2b_1c_3$	$a_2b_1c_1\ d_1$ $a_2b_1c_1\ d_2$ $a_2b_1c_2\ d_1$ $a_2b_1c_2\ d_2$ $a_2b_1c_3\ d_1$ $a_2b_1c_3\ d_2$
		$a_2\ b_2$	$a_2b_2c_1$ $a_2b_2c_2$ $a_2b_2c_3$	$a_2b_2c_1\ d_1$ $a_2b_2c_1\ d_2$ $a_2b_2c_2\ d_1$ $a_2b_2c_2\ d_2$ $a_2b_2c_3d_1$ $a_2b_2c_3\ d_2$
	A_3	$a_3\ b_1$	$a_3b_1c_1$ $a_3b_1c_2$ $a_3b_1c_3$	$a_3b_1c_1\ d_1$ $a_3b_1c_1\ d_2$ $a_3b_1\ c_2\ d_1$ $a_3b_1c_2\ d_2$ $a_3b_1c_3\ d_1$ $a_3b_1c_3\ d_2$
		$a_3\ b_2$	$a_3b_2c_1$ $a_3b_2c_2$ $a_3b_2c_3$	$a_3b_2c_1\ d_1$ $a_3b_2c_1\ d_2$ $a_3b_2c_2\ d_1$ $a_3b_2c_2\ d_2$ $a_3b_2c_3\ d_1$ $a_3b_2c_3\ d_2$
Total	***30 a***	***60 ab***	***180 abc***	***360 abcd***

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