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Evaluation of Microleakage in Class V Cavities Filled with Methacrylate-based versus Silorane-based Composites

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Abstract

Statement of Problem: Despite the increasing demand for tooth-colored restorations in dentistry, polymerization shrinkage and marginal microleakage still remains a problem.

Objectives: The purpose of the present study was to evaluate microleakage in three different resin composites, P90, Z250 and Z250 XT, in class V cavity of permanent human premolars.

Materials and Methods: Standardized class V cavities were prepared on the buccal surface of 45 extracted human premolars. The occlusal margins of cavities were prepared at the enamel and gingival margins extending 1mm below the cementoenamel junction. The teeth were randomly assigned into three groups (N=15) and preparations restored with three different composites following the manufacturer instructions: Group A, Filtek Z250 (microhybrid composite) with Adper Single Bond total etch adhesive system; Group B, Filtek Z250 XT (nanohybrid) with Adper Single Bond total etch adhesive system;Group C, Filtek P90 (silorane) with its self-etch adhesive system (P90 system adhesive). Its adhesive system (P90 system adhesive). The teeth were then subjected to thermal cycles (1000 cycle, 5° and 55°C ± 2°C) with a dwell time of 30 seconds, and immersed in 2% basic fuchsine for 24 hours. Longitudinally sectioned teeth were examined under the stereomicroscope. Kruskal-Wallis and Mann-Whitney U test at 95% significance level were used.

Results: Filtek Z250XT showed significantly higher microleakage than the other two composites ($p<0.001$). However, there was no statistically significant difference between P90 and Filtek Z250 ($p=0.217$).

Conclusions: Although all of the restorative systems had microleakage, silorane-based composite showed less microleakage compared to two other methacrylate-based composites.

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Introduction

Dental resin composite restoration materials have been used in dentistry for nearly 50 years[1]. Due to their good aesthetic value, absence of mercury, being thermally nonconductive, and ability to make acceptable bond to the enamel and dentin, they are widely popular as the material of choice for most restorations [1, 2]. Despite the increased demand for tooth-colored restorations in the modern dentistry, their polymerization shrinkage upon curing is still a major drawback [3]. Volumetric contraction produces stress between the tooth/restoration interface, disrupts the bond to the cavity walls, and leads to gap formation and microleakage [4,5].

Microleakage is defined as the permeability to bacteria and chemical ions which leads to postoperative sensitivity, staining around the margins of restoration, recurrent caries, restoration fracture, and eventually failure of the restoration [2,4,6]. Many strategies have been used to diminish the negative effects of polymerization shrinkage in resin based composites [7]; they include changing the type of fillers or filler size [8] ,placing a thicker adhesive layers beneath the composite [5], and using various incremental placement techniques [9]. Also, the good bond strength between composite and dental hard tissues with a suitable adhesive system is a vital factor withstanding microleakage [10].

Studies show that polymerization shrinkage in hybrid composites varies from 1.9% to 3.5% [11]. Recently, a new class of composite materials based on silorane chemistry, which is a combination of “siloxane” and “oxirane”, have been approved [2,5]. In this, polymerization takes place by cationic “ring–opening” mechanism, leading to reduction of polymerization shrinkage to less than 1% [1]. Development in manufacturing of resin composites led to production of the nano-composites that are asserted to have better mechanical properties, higher aesthetic aspects, and decreased polymerization shrinkage [12,13].

Several studies have been performed on these composites, their clinical properties and performances. According to Al-Boni (2010), silorane-based composites have much less microleakage in comparison to other methacrylate resine-based composites [5]. Soldo reached the same results in their study, as well [14]. Other studies have shown significantly improved marginal integrity in silorane compared with methacrylate composites [10]. However, some other studies showed that silorane-based composite did not have a significantly better performance in comparison with methacrylate resine-based composites [4]. Bogra in his study compared Filtek P90 and Ceram X (One type of nanocomposite) and found that P90 had better sealing ability and lower microleakage [1]. In 2012, Agrawal achieved a highly significant decrease in microleakage scores in silorane composite when compared to nanoceramic composite [15]. In another study in 2011, it was shown that microhybrid composites exhibited less microleakage than nanocomposite resins [16]. The aim of this study was to compare the microleakage scores between microhybrid, silorane-based and new nanohybrid composite, while using different etching and bonding protocols. We tested the hypothesis that lower polymerization shrinkage in silorane composite would lead to lower microleakage scores at the tooth restoration interface.

Materials and Methods

45 freshly permanent human premolar caries which were restoration-free without any visible cracks, extracted for orthodontic purposes, were selected. The roots of the teeth were scrubbed and soaked in hypochlorite solution for disinfection and stored in physiological saline solution at room temperature for 3 months before use to prevent dehydration. The cemento- enamel junction (CEJ) of each specimen was demarcated with an indelible pen and the apices mounted in self-cure resin (Acropars, Tehran, Iran) up to 3 mm below the CEJ. Straight fissure diamond bur (Diamond fissure 330; SS White, Washington, USA) in a high speed handpiece and an air/water spray were used to prepare a standardized class V cavities (3mm mesiodistal width, 2 mm occlusogingival height and 2 mm axial depth) on the buccal surfaces of each tooth. The occlusal margins of cavities were prepared at the enamel and gingival margins extending 1mm below the cementoenamel junction (CEJ). Each bur was used for five preparations. After cavity preparation, the teeth were randomly divided into three groups (n=15). All groups (except C) were etched with 37.5% phosphoric acid for 15 seconds, and then rinsed with water jet for 20 seconds. Then, each group was restored with one type of composite in normal consistency with the application of bonding used on an etched enamel and dentine, as shown in Table 1.

Table 1: The restoration used in each study group			
Group	**Type**	**Adhesive**	**Composite**
A	Conventional particulated filled	Adper Single Bond (3M ESPE,USA)	Filtek Z250 (3M ESPE,USA)
B	Nano filled	Adper Single Bond (3M ESPE,USA)	Filtekz Z250XT (3M ESPE,USA)
C	Silorane based	self-etch adhesive (3M ESPE,USA)	Filtek P90 (3M ESPE,USA)

Adper Single Bond adhesive system (a total etch adhesive system) used for Z250 and Z250XT composites and silorane self-etch adhesive system were applied for silorane-based composite according to the manufacturer's instructions (Table 2).

Restorations

Each prepared cavity was bulk filled (one increment) with the proposed resin composite(3) and cured for 20 seconds with the QTH curing system with an intensity of 600 mW /cm2 and 470nm wavelength (Bisco, Japan). The teeth were thermocycled at 1000 cycles, between 5 and 55°C ± 2°C, with dwell time of 30 seconds at each temperature. All the specimens were sealed with a coating of nail varnish, except margins of 1mm around the restoration and then immersed in 2% basic fuchin dye solution for 24 hours. The teeth were washed under running water and then dried. The teeth were sectioned longitudinally in a buccolingual direction through the center of the restoration with a slow speed diamond disk. The cut surfaces were then measured with a stereomicroscope (Nikon Eclips E600, Tokyo, Japan) at X40 (Figure 1a) magnification.

The dye penetration in the specimens was evaluated for gingival surface based on the graded scoring system given in Table 3, Figure 1b [4]. Each sample was observed and separatly scored by three examiners blindly.

Statistical analysis

Microleakage data were described using frequency and median indices. Kruskal-Wallis H and Mann-Whitney U tests were used to compare microleakage values between the 3 groups. SPSS version 18 (Chicago, IL, USA) was used for data analysis.

Results

There was an overall significant difference in microleakage among the three composites (p < 0.001). Pairwise comparisons showed that the amount of microleakage for Z250XT (median= 3) was significantly higher than those of Z250 (median = 1) and Siloran (median = 0) (p=0.001 and p<0.001, respectively). However, the amount of microleakage was not statistically different between Z250 and silorane (p = 0.217). Table 4 shows the frequency of microleakage values and median microleakage for each composite type as well as pairwise comparison results. Interestingly, the microleakage score in most of the samples in silorane showed no microleakage. On the other hand, Z250XT had the worst microleakage score.

Discussion

Microleakage is still a major concern in composite restorations. There are several techniques to evaluate microleakage, but the main, oldest and the most common technique for assessing the microleakage is dye penetration [4]. Basic fuchsine dye was selected because it is easy to manipulate, is economical, and does not require any complex laboratory equipment [16]; also because of its nice contrast with the tooth structures, determining the microleakage score under

Table 2: Mode of application of the adhesive systems used in the study	
Adhesive system	**Mode of application**
Adper Single Bond	Apply bond with microbrush Dry gently with oil-free air system for 5 seconds Light cure for 10 seconds
Self-etch P90	Apply primer using a microbrush Leave for 15 seconds Dry gently with oil-free air system for 5 seconds Light cure for 10 seconds Apply bond and distribute evenly Dry gently with oil-free air system for 5 seconds Light cure for 10 seconds

Table 3: Scoring criteria at occlusal and gingival margins

Description	Score
No dye penetration	0
Dye penetration up to one-half the cavity wall	1
Dye penetration up to total cavity wall	2
Dye penetration up to one-half the axial wall	3
Dye penetration more than one-half the axial wall	4

the stereomicroscope is easy [17]. Class V cavity design was chosen because it is easy to restore and is without any macromechanical undercut during preparation, so the sealing ability of resin composite restorations was compared just based on the bonding effects [4,18]. The samples were thermocycled in order to duplicate the intraoral environment, in which the restorations are subjected to both thermal and mechanical stresses; this contributed to the increase in marginal deterioration that leads to microleakage [19].

The statistical analysis demonstrated that the P90 silorane-based composites exhibit the least microleakage among the two other methacrylate-based composites. This finding could be explained under different polymerization processes of different materials. Methacrylate- based composites undergo free radical curing and polymerization shrinkage occurring in them is due to proximity of monomers that react to establish a covalent bond in the polymerization process [2,20] .However, in cationic curing with the ring-opening chemistry in FiltekP90, acidic cation formed by the fragmentation of the photoinitiator attack the oxiran rings, and polymerization begins with cleavage and opening of the ring systems. The loss of volume is compensated by forming covalent bond in the subsequent step [3,21].

This hypothesis must be taken into consideration that due to the lower polymerization shrinkage of silorane composite, as compared to methacrylate, thermocyclic fatigue tolerance is better than the two other composites tested in the study [5]. As to this point, we agree with Bogra [1] and Parolia [2], who asserted that the microleakage of silorane is lower than methacrylate-based composites. Another probable reason for this may be attributed to the difference in the filler content of each composite. Filtek P90 has higher filler loading (76% v) [1], in comparison with Z250 and Z250XT (60v% and 68v%, respectively [13], and showed the lowest microleakage. This is proved that higher filler loading reduces volumetric shrinkage by lowering the resin volume and, on the other hand, by decreasing the degree of polymerization negatively affecting the microleakage and color stability [13]. This could be responsible for greater microleakage of Z250XT with higher filler content in comparison with Z250.

The non-significant statistical differences in the microleakage of cavities restored with P90 (silorane) compared with Filtek Z250 was attributed to the hydrophilic nature of the self-etching adhesives compared to etch and rinsing with less hydrophilic activity. Due to 24-hour dye penetration challenge, increas-

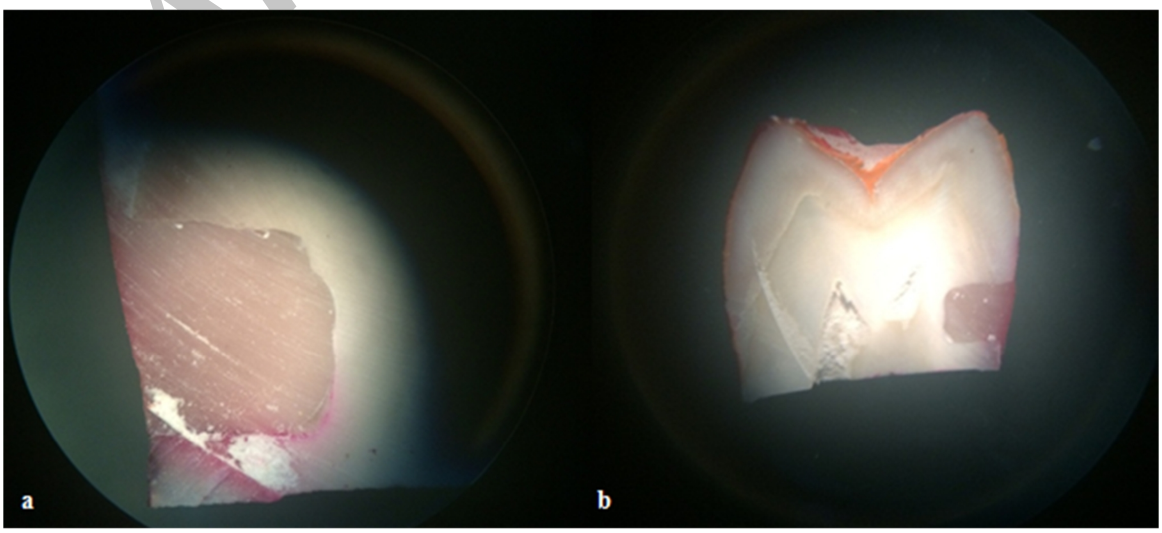

Figure 1a: Dye penetration (Score 3) **b:** Dye penetration (Score 2)

Table 4: The frequency of microleakage values in different composite types

Composite type	The microleakage value					Median	p-value*
	0	1	2	3	4		
P90	10	1	2	2	0	0^A	<0.001
Z250XT	0	1	4	10	0	3^B	
Z250	5	4	4	2	0	1^A	
Total	15	6	10	14	0	2	

*Kruskal-Wallis H test: different letters on superscript show significant difference between groups (pair wise comparison using Mann-Whitney U test).

ed water absorption as well as the dye led to a stained adhesive layer. This might have caused more false negative results, as this layer could have been constructed as a gap causing the microleakage [4].

According to laboratory studies, polymerization shrinkage of silorane composite is much lower (<1% volumetric)(1) in comparison with 1.9% to 3.5% in hybrid composites [22]. These novel low-shrinkage composites need individual two-step self-etching adhesive (SSA), in which the primer is hydrophilic and the bond with hydrophobic monomers makes it compatible with highly hydrophobic silorane composite [2]. However, in the etch and rinse adhesives, phosphoric acid completely eliminates the smear layer because due to the less acidic property of the self-etch monomers, some minerals remain attached to the collagen fibers [23] and cannot dissolve the smear layer but it makes them permeable to monomers due to its pH of 2.5 [18]. We came to the conclusion that despite the low polymerization shrinkage of silorane matrix, there is no sufficient and effective bond at tooth structure and SSA primer [18]. We agree with Schmidt who proved that there is no significant difference between silorane composite and methacrylate-based composite in his several studies [22,24].

Additional laboratory and clinical studies such as performing 6000 cycles (providing oral cavity condition) for resin composite in class V cavities should be conducted to verify our results.

Conclusions

Within the limitations of the present study, it can be concluded that silorane composite with its self-etch bonding system performed lesser microleakage; however, there was no significant difference between silorane and Z250 resin composite. Thus, clinicians can use silorane and Z250 composites in class V cavities.

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