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ORIGINAL RESEARCH

Does the use of a novel self-adhesive flowable composite reduce nanoleakage?

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Objective: The aim of the study reported here was to evaluate the performance of a self-adhesive flowable composite and two self-etching adhesive systems, when subjected to cyclic loading, in preventing the nanoleakage of Class V restorations.

Methods: Wedge-shape Class V cavities were prepared (4×2×2 mm [length × width × depth]) on the buccal surfaces of 90 sound human premolars. Cavities were divided randomly into three groups (n=30) according to the used adhesive (Xeno® V [self-etching adhesive system]) and BOND-1® SF (solvent-free self-etching adhesive system) in conjunction with Artiste® Nano Composite resin, and Fusio™ Liquid Dentin (self-adhesive flowable composite), consecutively. Each group was further divided into three subgroups (n=10): (A) control, (B) subjected to occlusal cyclic loading (90N for 5,000 cycles), and (C) subjected to occlusal cyclic loading (90N for 10,000 cycles). Teeth then were coated with nail polish up to 1 mm from the interface, immersed in 50% silver nitrate solution for 24 hours and tested for nanoleakage using the environmental scanning electron microscopy and energy dispersive analysis X-ray analysis. Data were statistically analyzed using two-way analysis of variance and Tukey's post hoc tests ($P \leq 0.05$).

Results: The Fusio Liquid Dentin group showed statistically significant lower percentages of silver penetration (0.55 μ) compared with the BOND-1 SF (3.45 μ) and Xeno V (3.82 μ) groups, which were not statistically different from each other, as they both showed higher silver penetration.

Conclusion: Under the test conditions, the self-adhesive flowable composite provided better sealing ability. Aging of the two tested adhesive systems, as a function of cyclic loading, increased nanoleakage.

Keywords: Class V, flowable composite, nanoleakage, cyclic loading, self-adhesive

Introduction

Class V cavities are mainly caused by dental caries and incorrect brushing technique, and usually are deprived of enamel at the margins located cervically. Recently, flowable composite resins have become very appealing to daily practice and are usually recommended for the restoration of these cavities as an effective replacement for conventional composite resin restorative materials. These materials are superior in esthetic properties and have low viscosity,[1–3] which makes them easier to place and more self-adaptable than conventional resin composites.[4,5] Also, flowable materials are widely used as gingival liners in Class II composite resin restorations, as they may act as stress breakers. Unfortunately, these materials have a higher rate of polymerization shrinkage, a higher coefficient of thermal expansion,[6,7] and inferior mechanical properties,[3] which is due to their lower filler content. Polymerization

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shrinkage creates stresses that adversely affect the adhesive bond, and decrease the bond to cavity walls, and is thus considered one of the main reasons for microleakage and, subsequently, marginal failure.[6–8] The lack of enamel at the gingival margin in cervical lesions is a big challenge.[9] Moreover, the importance of a perfect seal for the success and longevity of Class V resin restorations should be taken into consideration at the restorative treatment time.[2,10] Miyasaka and Okamura found that the shrinkage ratio was less than 1.5% in conventional composites, but more than 2.0% in flowable ones.[1] Nevertheless, some studies have shown that, compared with hybrid composites, flowable composite resins exhibit similar polymerization contraction stresses.[11,12]

Ideally, adhesive systems should bond evenly with both enamel and dentin without being technique sensitive.[13] However, this is not the case in composite restorations, where the bonding to enamel varies from that to dentin, with the former still believed to be more reliable than the latter,[14,15] as reduction in micro- and nanoleakage is obvious, but not yet completely eliminated.[16,17]

For many years, the longevity of bonded restorations has been expressed in terms of microleakage extent measurements.[18] This leakage around resin composite restoration decreases restoration longevity, as it might lead to postoperative sensitivity, marginal discoloration, secondary caries, pulpal inflammation, and eventually partial or complete loss of that restoration.[19,20] However, the latter may be due to either imperfections or improper cavity preparation. “Nanoleakage”, which is a different pattern of leakage occurring within the hybrid layer in nanometer-scaled spaces,[21] may be due to the presence of residual water around collagen fibrils, collagen network collapse, or incomplete resin infiltration into the exposed collagen network and polymerization.[22] This pattern may arise within the adhesive layer and likewise within the hybrid layer,[23] causing bacterial product or oral fluid penetration across the interface, compromising the stability of the resin–dentin bond through hydrolytic breakdown of the adhesive resin or collagen in the hybrid layer.[24] Therefore, nanoleakage assessment could be considered an important indicator of the sealability of a restorative material[25] and hybrid-layer quality, which consequently affect the longevity of the restoration.[26]

Nowadays, efforts are being made to simplify and shorten bonding procedures[27] while retaining the effectiveness of dentin adhesives. Self-etching adhesive systems were developed to eliminate operator variables and minimize clinical operating time.[28] Self-etching adhesive systems use acidic adhesive comonomers that simultaneously demineralize and infiltrate the dentin.[29] All-in-one single-bottle self-etching adhesive systems were then introduced, combining etching, priming, and bonding in a single bottle.[30] Owing to the fact that these single-bottle systems are highly hydrophilic polymers, which means they are permeable to water movement, it was claimed they were the most promising adhesive approach.[31] Following this, solvent-free self-etch adhesive was introduced, with the solvent that is contained in all other adhesive systems having been removed.[32] This adhesive has made it possible to create an interactive ionic bond between the tooth minerals and the resins of the bonding agent[32,33] without the use of water, acetone, or alcohol. More recently, self-adhering flowable composite was introduced to address the time-consuming procedure used with traditional materials.[34] Self-adhering flowable composite combines the merits of both adhesive and restorative material technologies in one product, bringing novel horizons to restorative techniques, as it is a direct composite resin restorative material that has an adhesive resin together with a flowable composite resin.[35] It is based on the bonding technology that uses glycerophosphate dimethacrylate (GPDM)[36] to etch enamel and dentin, and hydroxyethyl methacrylate (HEMA) to enhance wetting and penetration by resin into dentin. This resin bonds chemically between the phosphate groups of a GPDM monomer and the hydroxyapatite of tooth structure and, also, micromechanically between the polymerized monomers of the self-adhering flowable composite resin and the collagen fibers and smear layer of dentin.[35,37]

During normal function and parafunctional habits, teeth are subjected to stresses.[38] Food bolus can induce vertical loading between antagonistic teeth, which is equally disseminated over the entire occlusal surface to alleviate stresses.[39] Compressive stresses arise on the tooth aspect being bent, while tensile stresses are generated simultaneously on the opposite tooth aspect.[40] The same scenario occurs with restorations placed cervically in teeth when those teeth are subjected to occlusal loading, which may lead to dislodgement of such restorations at their cavo-surface margin.[41] Thus, the integrity of the margins of resin composite restorations is highly affected by cyclic loading, in terms of leakage.[42]

Unfortunately, as long-term clinical trials are impractical due to the constant evolution of new adhesive systems and restorative materials, the in vitro simulation of masticatory forces is necessary to study the effect of cyclic loading on nanoleakage at the resin–dentin interface.[43] Moreover, the outcome of increased cyclic loading on the nanoleakage of different adhesive systems used in cervical composite restorations has not been yet fully analyzed. Therefore, the study reported here aimed to compare the sealability of self-adhesive flowable composite with that of two Class V composite restoration adhesive systems, to evaluate the longevity of the composite restoration seal in response to mechanical stresses and to assess the effect of increasing the number of load cycles, in terms of nanoleakage.

Materials and methods

Preparation of the cavities

A total of 90 intact, non-carious human premolars, extracted for orthodontic reasons, were utilized in this research. Before any treatment, teeth were cleaned, explored, uncontaminated with chloramine-T compound, and cool-stocked, to be used within a maximum period of 1 month following their extraction. Wedge-shaped Class V cavity preparation was performed on the buccal surface of each tooth, with half of the cavity above the cementoenamel junction and the other half below it.[9] For the purposes of standardization, a stainless-steel matrix band, with a window simulating the desired prepared cavity in width and length, was used in order for all cavity preparations to have uniform dimensions of 4 mm occlusogingival height and 2 mm mesiodistal width. Finally, the depth was set at 2 mm, and this was checked in each cavity using a calibrated periodontal probe.

Class V cavity specimens were prepared for this study for four reasons. First, this type of cavity involves different dental hard structures, enamel, dentin, and cementum. Second, a Class V cavity simulates the clinical situation of higher stress due to higher C-factor. Third, to make the studies of adhesive systems more relevant, since samples prepared in this manner involve the difficulties in achieving the suggestive width of the adhesive layer with a higher C-factor and higher stress contraction area.[29,44] Finally, the corresponding restorative procedure concerning Class V lesions is minimal and comparatively simple, thus lowering, to a great extent, operator variability.[45]

Grouping of the specimens

Teeth were subjected to random division into three equal groups (n=30) according to the tested adhesive materials (Table 1): cavity walls were treated either with Xeno® V self-etching adhesive system (Dentsply Caulk, Milford, DE, USA) (Group 1), or BOND-1® SF solvent-free self-etching adhesive system (Pentron Clinical, Orange, CA, USA) (Group 2), and then filled with Artiste® Nano Composite resin (Pentron Clinical) using oblique incremental technique, or restored directly with Fusio™ Liquid Dentin self-adhesive flowable composite (Pentron Clinical) (Group 3), according to manufacturers' instructions. After restoration of the cavities, each group was further subdivided into three equal subgroups (n=10): Subgroup 1 – control, Subgroup 2 – subjected to occlusal cyclic loading (90N for 5,000 cycles), and Subgroup 3 – subjected to occlusal cyclic loading (90N for 10,000 cycles) (Table 2).

Cyclic loading

Aluminum foil was used to cover the root and the restoration of each tooth before cyclic loading, then each tooth was inserted into self-curing resin mold, with the long axis perpendicular to the acrylic resin base, around which was a specially fabricated split cylindrical Teflon® mold (15 mm internal diameter and 20 mm height).

A Lloyd LRX Plus II universal testing machine (Ametek, Inc., Berwyn, PA, USA) was used to apply occlusal cyclic loading. Each specimen was subjected to occlusal cyclic loading of 90N for 5,000 cycles[46] and for 10,000 cycles, in the form of a sine wave at a rate of 1 Hz. The used rate was equal to the average cycles of mastication of 0.8–1.0 seconds. A specially designed stainless-steel loading tip was used to apply the force on the middle of the occlusal surface of each tooth for standardization.

Table 1 Compositions and manufacturers of the used restorative systems

Material	Main constituents	Manufacturer	Expiry date	Batch number
Xeno® V (self-etching adhesive system)	Bifunctional acrylate, acidic acrylate-functionalized phosphoric ester, acrylic acid, water, tertiary butanol, initiator, and stabilizer	Dentsply Caulk, Milford, DE, USA	March 2015	0705001035
BOND-1® SF (solvent-free self-etching adhesive system)	Resin matrix: UDMA, TGDMA, HEMA, 4-META, and photocuring system Filler: silane-treated barium glass, silica (amorphous)	Pentron Clinical, Orange, CA, USA	June 2014	5627
Fusio™ Liquid Dentin (self-adhesive flowable composite)	Resin matrix: 4-META-based flowable composite Filler: Nano-sized amorphous silica and glass	Pentron Clinical	November 2014	02541

Abbreviations: 4-META, 4-methacryloxyethyl trimellitic acid; HEMA, hydroxyethyl methacrylate; TGDMA, triethylene glycol dimethacrylate; UDMA, urethane dimethacrylate.

Table 2 Sample groupings

Adhesive group	Xeno® V[a] with Artiste® Nano Composite[b] resin			BOND-1® SF[b] with Artiste® Nano Composite resin			Fusio™ Liquid Dentin[b]		
Subgroup	1	2	3	1	2	3	1	2	3
Loading cycles	Control (no cyclic loading)	90N for 5,000 cycles	90N for 10,000 cycles	Control (no cyclic loading)	90N for 5,000 cycles	90N for 10,000 cycles	Control (no cyclic loading)	90N for 5,000 cycles	90N for 10,000 cycles
Number of samples (N=90)	10	10	10	10	10	10	10	10	10

Notes: [a]Manufactured by Dentsply Caulk, Milford, DE, USA; [b]manufactured by Pentron Clinical, Orange, CA, USA.
Abbreviation: N, newton.

Nanoleakage assessment

For nanoleakage testing, sticky wax was used to seal the root apex of each tooth, together with the whole tooth except for the restoration and a 1 mm margin apical to the restoration, which was then coated with two nail varnish layers. After this, teeth were immersed in 50% silver nitrate solution for 24 hours in light-sealed container. Running water was used to rinse each specimen for 5 minutes, and then each was immersed for 8 hours in photo-developing solution while being exposed to fluorescent light to allow the silver ions to transform into metallic silver. Finally, specimens were rinsed under running water for 5 minutes to remove all traces of photo-developing solution. Longitudinal sectioning of teeth buccolingually was performed through the restoration center to be subjected to electron microscopy analysis.

Nanoleakage was assessed, in this study, using a Quanta environmental scanning electron microscope (QESEM; FEI Company, Hillsboro, OR, USA). The QESEM is an analytical device that provides a unique depth of field with minimum preparation of the specimen, as it allows the specimen to be tested with neither gold nor carbon coating. To demonstrate the presence of silver particles, energy dispersive analysis X-ray (EDAX) analysis was used. This combination provided clear images, together with accurate silver-ion penetration quantification,[47] through permitting element composition analysis of the square area scanned, thus accurately identifying the existence of silver particles along the tooth–restoration interface. Scanning and EDAX quantification were performed at three fixed points on each specimen: at the middle of the cervical tooth–restoration interface, near the cavity margin, and midway between these two places.

Nanoleakage analysis results were conveyed in terms of silver deposition percentages at the three representing points, then the extent of silver penetration was calculated to work out the total silver nitrate penetration of the tested interface, which represents the most commonly used material for nanoleakage, owing to its easy migration within the interface zone as a result of its nano-scaled diameter molecule (0.059 nm).[18,48] Also, it induces a contrast that gives a clear electron microscopic picture presenting the degree of penetration into the interface. Finally it has the potential to prevent any further penetration that might occur while preparing a specimen, due to its immobilization potentiality.[25,49] On the other hand, other organic dyes (including methylene blue and basic fuchsin) commonly used for evaluation of leakage have larger molecules and hence a tendency to bond to tooth structure, which can demonstrate an exaggerated gap in terms of width and depth that is larger than actually exists.

Statistical analysis

After calculation of the means and standard deviations of weight percentages of silver accumulation at the gingival margin of each group, SPSS (v 20, IBM Corporation, Armonk, NY, USA) was used for statistical analysis. The significance of the effect of adhesive systems, cyclic loading, and their interactions on nanoleakage was determined using repeated measures analysis of variance (ANOVA). In cases when the ANOVA test was significant between the mean values, Tukey's post hoc test was utilized for pair-wise comparison. The significance level was set at $P \leq 0.05$.

Results

The results revealed that adhesive systems, cyclic loading, and also the interaction between these two variables had a statistically significant effect on mean nanoleakage, as shown in Tables 3 and 4.

Effect of adhesive systems

Results showed no statistically significant difference between Xeno V self-etching adhesive and BOND-1 SF solvent-free self-etching adhesive; both showed the statistically significantly highest mean nanoleakage. Fusio Liquid Dentin showed the statistically significantly lowest mean nanoleakage, as shown in Table 5 and Figures 1–4.

Table 3 Descriptive statistics for nanoleakage – analysis of variance results

Adhesive	Cyclic loading	Mean	SD
Xeno® V[a] (self-etching adhesive system)	Before	1.88	0.47
	After 5,000 cycles	4.49	0.57
	After 10,000 cycles	5.09	0.72
BOND-1® SF[b] (solvent-free self-etching adhesive system)	Before	1.44	0.47
	After 5,000 cycles	3.95	0.29
	After 10,000 cycles	4.97	0.52
Fusio™ Liquid Dentin[b] (self-adhesive flowable composite)	Before	0.49	0.23
	After 5,000 cycles	0.54	0.21
	After 10,000 cycles	0.61	0.23

Notes: [a]Manufactured by Dentsply Caulk, Milford, DE, USA; [b]manufactured by Pentron Clinical, Orange, CA, USA.
Abbreviation: SD, standard deviation.

Table 4 Effect of different variables on nanoleakage regression model results

Source	Type III sum of squares	*df*	Mean square	*F*-value	*P*-value
Adhesive system	32.2	2	16.1	179.2	<0.001*
Cyclic loading	42.6	2	21.3	131.2	<0.001*
Adhesive system × cyclic loading	19.6	4	4.9	30.1	<0.001*

Note: *Significant at $P\leq 0.05$.
Abbreviation: *df*, degrees of freedom.

Table 5 Comparison between nanoleakage values with different adhesive systems

Xeno® V[a] (self-etching adhesive system)		BOND-1® SF[b] (solvent-free self-etching adhesive system)		Fusio™ Liquid Dentin[b] (self-adhesive flowable composite)		*P*-value
Mean	SD	Mean	SD	Mean	SD	
3.82[c]	1.5	3.45[c]	1.6	0.54[d]	0.21	<0.001*

Notes: [a]Manufactured by Dentsply Caulk, Milford, DE, USA; [b]manufactured by Pentron Clinical, Orange, CA, USA. *Significant at $P\leq 0.05$, different letters (ie, c and d) are statistically significantly different.
Abbreviation: SD, standard deviation.

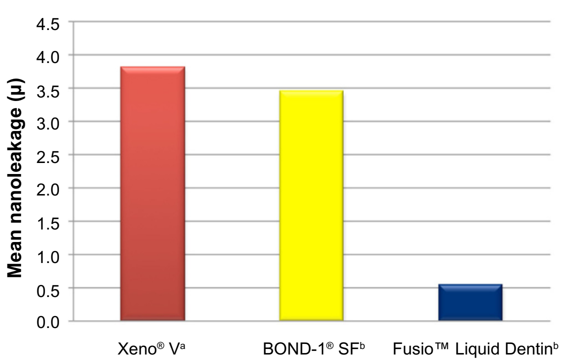

Figure 1 Bar chart representing comparison between mean nanoleakage.
Notes: [a]Manufactured by Dentsply Caulk, Milford, DE, USA; [b]manufactured by Pentron Clinical, Orange, CA, USA.

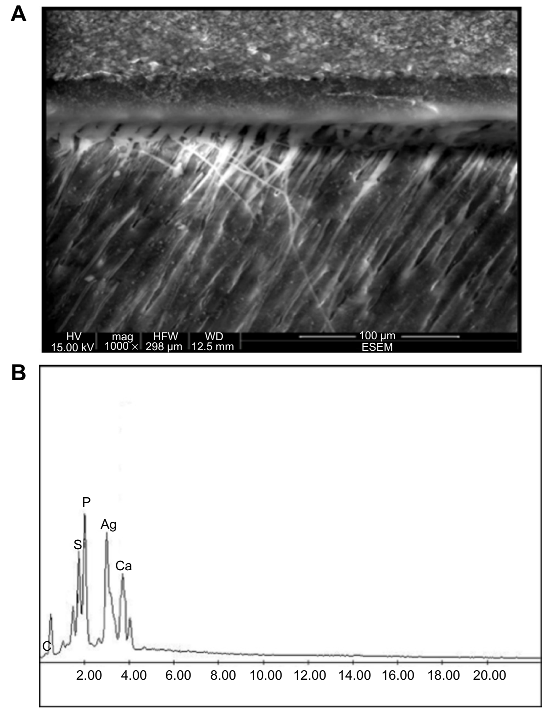

Figure 2 Scanning electron micrograph (**A**) and its corresponding electron-dispersive analytical X-ray spectrum curve (**B**) at one point at the gingival tooth–restoration interface representing Xeno® V adhesive (self-etching adhesive system; Dentsply Caulk, Milford, DE, USA) after 5,000 load cycles.
Note: Scale bar in (**A**) is 100 µm.

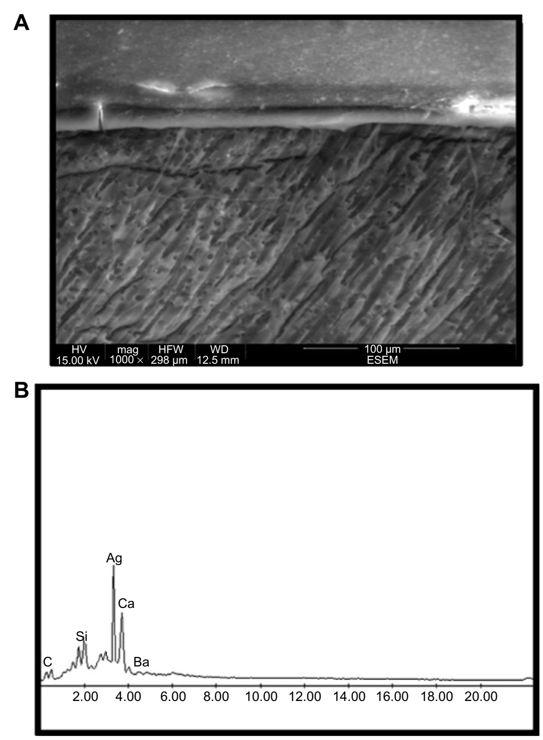

Figure 3 Scanning electron micrograph (**A**) and its corresponding electron-dispersive analytical X-ray spectrum curve (**B**) at one point at the gingival tooth–restoration interface representing BOND-1® SF (solvent-free self-etching adhesive system; Pentron Clinical, Orange, CA, USA) after 5,000 load cycles.
Note: Scale bar in (**A**) is 100 µm.

A

B

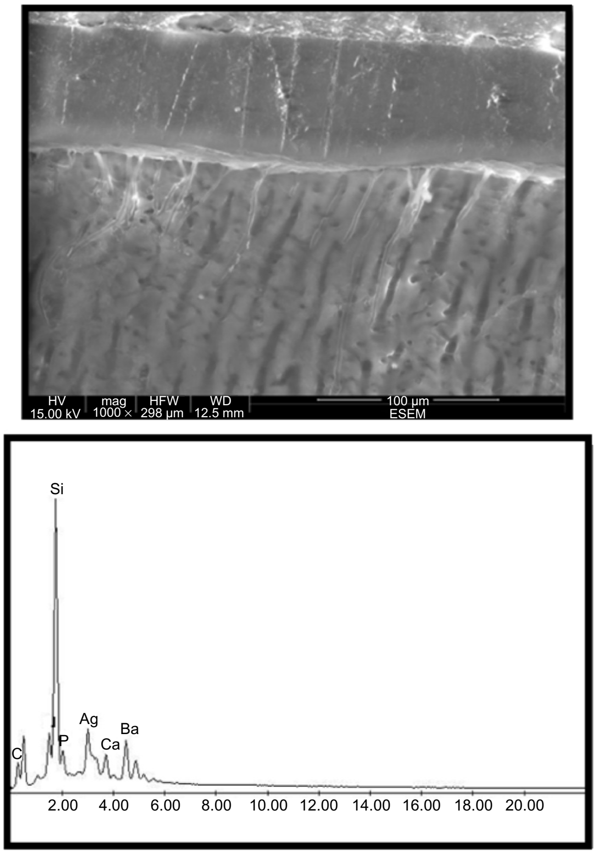

Figure 4 Scanning electron micrograph (**A**) and its corresponding electron-dispersive analytical X-ray spectrum curve (**B**) at one point at the gingival tooth–restoration interface representing Fusio™ Liquid Dentin (self-adhesive flowable composite; Pentron Clinical, Orange, CA, USA) after 5,000 load cycles.
Note: Scale bar in (**A**) is 100 µm.

Effect of cyclic loading

Results showed a statistically significant increase in mean nanoleakage after cyclic loading. The highest nanoleakage was found after 10,000 load cycles, as shown in Table 6 and Figure 5.

Effect of different variable interactions

Results showed no statistically significant difference between Xeno V self-etching adhesive and BOND-1 SF solvent-free self-etching adhesive after 5,000 load cycles; both showed the

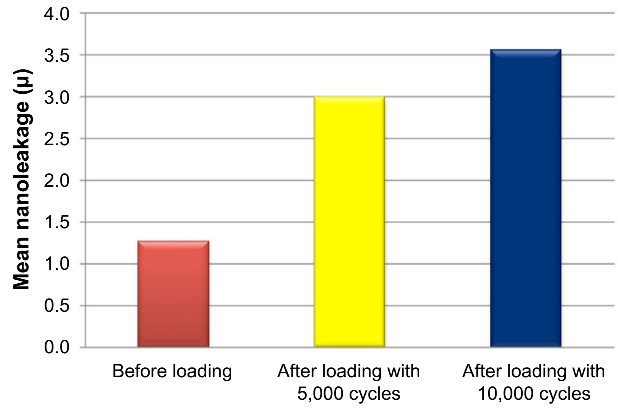

Figure 5 Bar chart representing comparison between mean nanoleakage values before and after cyclic loading.

statistically significantly highest mean nanoleakage values, as presented in Table 7 and Figure 6.

Also, results showed no statistically significant difference between Fusio Liquid Dentin before and after cyclic loading; all revealed the statistically significantly lowest mean nanoleakage values, as shown in Table 7 and Figure 6.

Discussion

The adhesive-free composites are claimed to chemically and micromechanically interact with tooth structures or other substrates, through the incorporation of an acidic adhesive monomer in their composition.[50–52] They are supposed to omit any need for application of bond in a separate step, thus simplifying the restorative procedure. This is why the self-adhering flowable composite (Fusio Liquid Dentin) can be claimed to be the beginning of the eighth generation of dental adhesive systems, through the representation of a combination of flowable composite resins together with all-in-one adhesive systems.[53]

Table 6 Comparison between nanoleakage values before and after cyclic loading

Before cyclic loading		After 5,000 load cycles		After 10,000 load cycles		*P*-value
Mean	SD	Mean	SD	Mean	SD	
1.27^{c}	0.71	2.99^{b}	1.85	3.56^{a}	2.21	<0.001*

Notes: *Significant at $P \leq 0.05$, different letters (a–c) are statistically significantly different.
Abbreviation: SD, standard deviation.

Table 7 Comparison between nanoleakage with different interactions

Adhesive system	Cyclic loading	Mean	SD	*P*-value
Xeno® V[g] (self-etching adhesive system)	Before	1.88^{d}	0.47	<0.001*
	After 5,000 cycles	4.49^{b}	0.57	
	After 10,000 cycles	5.09^{a}	0.72	
BOND-1® SF[h] (solvent-free self-etching adhesive system)	Before	1.44^{e}	0.47	
	After 5,000 cycles	3.95^{c}	0.29	
	After 10,000 cycles	4.97^{a}	0.52	
Fusio™ Liquid Dentin[h] (self-adhesive flowable composite)	Before	0.49^{f}	0.23	
	After 5,000 cycles	0.54^{f}	0.21	
	After 10,000 cycles	0.61^{f}	0.23	

Notes: *Significant at $P \leq 0.05$, different letters (a–f) are statistically significantly different. [g]Manufactured by Dentsply Caulk, Milford, DE, USA; [h]manufactured by Pentron Clinical, Orange, CA, USA.
Abbreviation: SD, standard deviation.

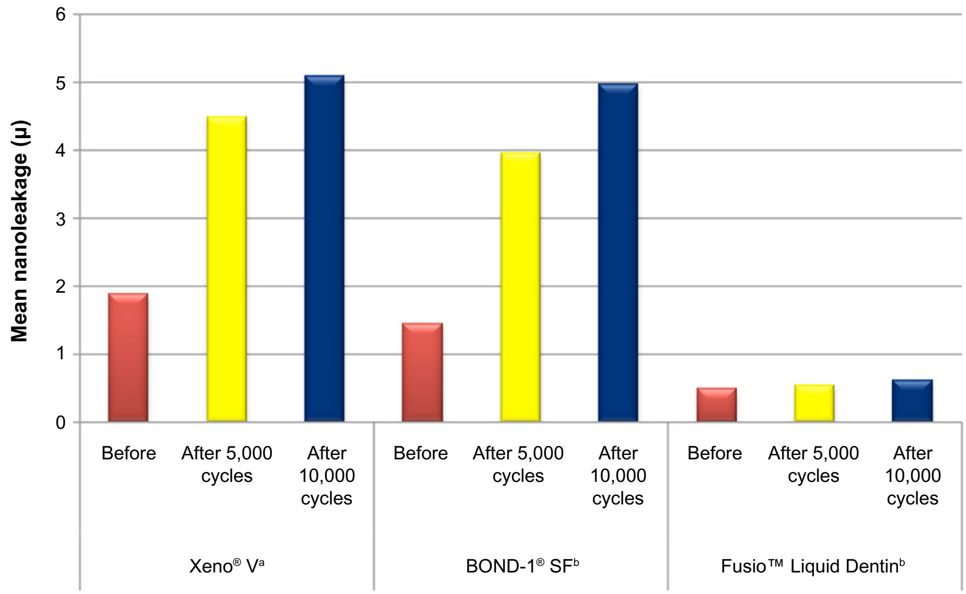

Figure 6 Bar chart representing comparison between mean nanoleakage values of different interactions.
Notes: [a]Manufactured by Dentsply Caulk, Milford, DE, USA; [b]manufactured by Pentron Clinical, Orange, CA, USA.

Although some authors[35] have recommended that using an adhesive resin with self-adhering flowable composite resin would significantly increase dentin bond strength and reduce microleakage to both enamel and dentin, others[54,55] have found that there was no significant difference detected when self adhering flowable composite was applied, according to the manufacturer's instructions, without pretreatment. Owing to the novelty of this new self-adhering flowable composite material, it seemed interesting to investigate further its sealability.

The oblique instrumental technique was used during cavity filling in this research, as it has been agreed by many authors[53,56,57] that this is one of the most reliable methods to reduce the polymerization shrinkage drawbacks of composite materials, compared with other techniques such as the horizontal layering technique.

Despite the fact that clinical trials demonstrate the most reliable evidence, and the translation of in vitro findings to oral conditions has limitations, laboratory tests remain useful for promptly yielding first-hand information.[52]

This study aimed to assess the sealability of self-adhesive flowable composite compared with that of two adhesive systems through examining the nanoleakage of Class V composite restorations. It was found that the sealability of self-adhesive flowable composite was better, as it showed the statistically significantly lowest mean nanoleakage compared with the self-adhesive and solvent-free adhesive. This was in accordance with Mobarak and Seyam,[58] who found that all tested self-adhesive systems showed slight nanoleakage compared with self-etch adhesives.

This could be related to the fact that the chance for nanoleakage is higher when the demineralized dentin is deeper and the hybrid layer is thicker, as silver ions penetrate the partially or fully demineralized dentin and the hybrid layer, or also through partially polymerized adhesive resin.[59] Owing to the fact that the quantity of silver uptake per unit depth or per unit volume is the critical index of hybrid-layer quality[60] and as there was no previous demineralization of dentin due to the self-adhering flowable composite,[18] the depth of the demineralized dentin and the thickness of the hybrid layer was minimal compared with that of the other self-etching adhesive systems used in this research. Also, owing to the fact that self-adhering composite is flowable, it is more self-adaptable than other resin restorative materials.[1–5] Furthermore, there is the possibility of less stress development in flowable composite, compared with in a hybrid one – in stiffer materials, higher polymerization stresses are created as a result of the restricted relative mobility of the formed polymer chains.[53]

These results, however, were not in agreement with Tay et al[61] Hashimoto et al,[62] and El-Badrawy et al,[18] who agreed on the presence of a significant amount of nanoleakage in self-adhesive systems compared with in self-etching systems and claimed that this might be due to the incomplete polymerization of resin due to presence of residual water, which is responsible for the silver uptake, as residual water may be retained due to its low vaporization in the presence of HEMA. Finally, HEMA copolymerizes with low pH resin monomers in the presence of water, forming homologous hydrogels that allow fine silver deposits at the bonded interface.[63]

Although there was no statistically significant difference between the BOND-1 SF solvent-free self-etching adhesive system and Xeno V self-etching adhesive system – as they both showed the statistically significantly highest mean nanoleakage – Xeno V self-etching adhesive system showed the highest mean nanoleakage. This was found in accordance with Ferreira et al,[64] who found that solvent-free adhesive showed less nanoleakage than other self-etch adhesives.

This could be attributed to the presence of HEMA in the composition of BOND-1 SF solvent-free self-etching adhesive system, in contrast to the other self-etch adhesive (Xeno V self-etching adhesive system) and its effect in preventing the phase separation of dental adhesive blends.[65] So the hydrophobic resin component within the residual water can separate into water blisters and resin globules – so-termed resin material phase separation.[65,66] Also it may be explained by the presence of water in the Xeno V composition (leading to water sorption), and incorrect organic solvent evaporation.[64]

This study aimed to assess the aging of tested materials in terms of cyclic loading. It was found that examined materials' aging, in terms of cyclic loading, increased nanoleakage significantly in all tested groups. This was in accordance with Kubo et al[67] and Swathi et al,[68] who stated that nanoleakage of composite restorations occurs because of stress placed along the tooth–restoration interface due to various factors, such as polymerization shrinkage, thermo-cycling in the oral environment, and mechanical fatigue through repetitive masticatory loading. Also, our findings are in agreement with Ameri et al[38] and Bedran-de-Castro et al,[43] who concluded that cyclic loading increased nanoleakage of the margins of Class V composite restorations.

However, our results were not in accordance with Yamazaki et al,[69] who stated that the application of mechanical cyclic loading did not increase nanoleakage.

The diversities in the reported data could be attributed to dissimilarities between preparation types and sizes; operator variability; materials used; and load cycle values, direction, and number.[38,70] On the other hand, a limitation of this study is that it was carried out in laboratory conditions, negating the effect of pulpal pressure on the used restorative systems. Thus, more clinical evaluations should be carried out as such in vitro studies do not eliminate the need for clinical ones.

Conclusion

Under the test conditions, the self-adhesive flowable composite provided better sealability in terms of nanoleakage when compared with different one-step self-etching bonding systems used in combination with a hybrid composite. Also, cyclic loading increased nanoleakage in all tested materials.

Disclosure

The authors report no conflicts of interest in this work.

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