Assessment of Marginal Seal: A Comparative Study of Two Self-Adhesive Flowable Composites with Different Restorative Techniques in Class V Lesions

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ABSTRACT

Background: In restorative dentistry, self-adhesive flowable composites (SAFCs) have been developed as an alternative to conventional bonding techniques. However, when utilised in accordance with the manufacturer's directions, they have demonstrated significant microleakage and poor bonding performance. Uncertainty exists over how prerestorative methods affect SAFCs' marginal sealing capacity in Class V restorations.

Aims: The purpose of this study was to assess the effects of air abrasion, bevel location, and acid etching on SAFCs' marginal sealing capacity when utilised in Class V restorations.

Materials and Methods: A total of 80 human mandibular premolars were chosen, and the buccal side of each was prepped with typical Class V cavities. The samples were split into four groups: Group A, the control, which employed SAFC alone; Group B, which used a gel containing 37.5% phosphoric acid to acid-etch the samples; Group C, which applied a 1 mm bevel to the occlusal edge; and Group D, which underwent air abrasion. Each group was then split into two smaller groups, with half of each group being restored using Dyad Flow (Kerr) and the other half using Constic (DMG). The samples were subjected to thermocycling, and microleakage was measured with an ultraviolet spectrophotometer and the dye extraction technique.

Statistical Analysis: Microleakage values were analyzed using analysis of variance (ANOVA) and post hoc analysis.

Results: Between the two SAFCs, there were variations in absorbance values that were statistically significant. Results were deemed statistically significant if P 0.05. Groups B and D were significantly different for Dyad Flow, whereas Groups A and B and Groups B and D were significantly different for Constic.

Conclusions: The least amount of microleakage was seen with air abrasion compared to acid etching, which had the highest values. Additionally, compared to Dyad Flow, Constic showed less microleakage. These results imply that prerestorative methods like air abrasion may be able to enhance SAFCs' marginal sealing performance in Class V restorations.

Keywords: Acid etching, air abrasion, bevel, Class V, self-adhering flowable composite, self-adhesive flowable composite.

INTRODUCTION

In order to provide a single product that bridged the gap between adhesive and restorative material technologies, self-adhering flowable composites (SAFC) were created as a sort of "stepless" solution.[1,2] As a result, they ensure shorter clinical times for patients needing many restorations in a single visit and allow for fewer processes and handling mistakes.[3,4,5]

They are now employed in a modest number of therapeutic treatments, including tiny Class I, Class III, and Class V restorations, pits and fissures, and fillings.[6] However, despite following the manufacturer's instructions, a research examining its clinical effectiveness in Class V lesions discovered that 66% of restorations failed due to inadequate retention.[7]

There are several SAFCs that may be purchased commercially, and their clinical effectiveness varies by product. In order to enhance its sealing performance at the tooth restorative interface, this study evaluated the in vitro microleakage of two commercially available SAFCs with additional restorative procedures such acid etching, bevel implantation, or air abrasion.

The underlying assumption was that the extra restorative methods wouldn't have any impact on SAFC microleakage.

MATERIALS AND METHODS

The institutional ethics committee gave its approval to the present in vitro study's procedure. The study utilised 80 human mandibular premolars, with periodontitis- or orthodontic-extracted teeth being the inclusion criterion. Before usage, they were kept in distilled water containing 0.2% thymol for around 3 months. Teeth having decay, fractures, restorations, attrition, abrasion, fluorosis, or other enamel abnormalities were excluded. To get rid of any last-remaining soft tissue tags, plaque, calculus, or stains, the removed teeth were ultrasonically scaled and cleaned with a slurry of pumice and water.

Each premolar tooth had its buccal surface subjected to a standardised Class V preparation. Each preparation had a mesiodistal width of 4 mm, an occlusogingival breadth of 3 mm, and an axial depth of around 2 mm. The occlusal edges were inserted in enamel, and the preparations were created parallel to the cementoenamel junctions with the gingival half reaching 0.5 mm apical to the cementoenamel junction. A periodontal probe was used to measure the dimensions. A carbide fissure bur (009; Dentsply Maillefer Instruments, Ballaigues, Switzerland) was used in a high-speed handpiece with water spray to complete all preparations. Each time there were five preparations, a new burst was employed.

Group A: Following the manufacturer's instructions, specimens were directly repaired with SAFC. A tiny amount of SAFC was applied to the cavity and rubbed for 25 seconds with the manufacturer's provided brush to create a thin coating (0.5 mm). The excess was then scraped off and allowed to dry. The cavity was then entirely filled. Thus, the control group was created.

Group B: Kerr, Sybron dental speciality, USA, used a 37.5% phosphoric acid gel for the acid etching procedure. Dentin was etched for 10 seconds, and enamel for 20 seconds. The dentin was left noticeably moist after the acid had been properly washed for 15 seconds and then blot dried to eliminate extra water.

Group C: The enamel on the occlusal boundary of the lesion was bevelled using a coarse tapered diamond (Piranha Diamond SE8F, SS White). A 1 mm bevel was the standard.

Group D: Cavities were subjected to air abrasion using 50 m silica particles at a 45° angle and 60 psi air pressure at a distance of 2 mm for 5 s. Using a sandblasting machine (Microetcher ERC, Danville Materials, San Ramon, CA), aluminium oxide air abrasion was carried out.

Dyad Flow (Kerr, Sybron dental speciality, USA) and Constic (DMG, Germany) were used to further split and restore each group. With an LED curing device (3M ESPE Elipar Deep Cure LED Curing device; Seefeld, Germany) set to a standard power of 1000 mW/cm2, all materials tested were applied in accordance with the manufacturer's instructions. The identical light-curing apparatus was utilised throughout the investigation, with the tip kept no closer to the specimen's surface than 1 mm. Using ultra fine grade Diamond burs at high speed and discs (Super Snap; Shofu Inc., Kyoto, Japan) to smooth the margins, all restorations were completed. After that, test specimens were kept at 37°C for 24 hours in distilled water.

As a method of artificially ageing, samples were put through a thermocycling process that included 1500 cycles of alternating between 52 degree Celcius and 55.2 degree celcius with a dwell duration of 30 s. The dye extraction technique was then used to conduct a microleakage examination. To stop the testing dye from penetrating, the apices of every tooth were wax-sealed. The whole tooth surface, with the exception of a window containing the restoration and a 1 mm margin all around it, was then coated with two coats of quick-drying nail polish. To allow the varnish to fully cure, the specimens were untouched for 24 hours. Then, for 24 hours at 37°C, each group was submerged in a neutral buffered 2% methylene blue solution. To remove the excess surface dye without putting pressure on the stained specimen's window, teeth were then gently washed under running water for 10 minutes. After that, polishing discs placed on a handpiece were used to remove the varnish.

For three days, each tooth was kept in a hermetically sealed vial with 600 ml of pure (65 wt%) nitric acid. The recovered dye was then separated from any composite or debris using a 5-minute centrifugation at 14,000 rpm on the vials. Using concentrated nitric acid as the blank and 200 ml of the supernatant as the sample, each vial was analysed in an automated spectrophotometer (ultraviolet [UV]-1800 Spectrophotometer, Shimadzu, Kyoto, Japan) at 670 nm. Readings were recorded as absorbance units.

Statistic evaluation

Software from IBM Corp., released in 2011, called SPSS version 20.00 was used for the statistical study. Armonk, New York: IBM Corp., IBM SPSS Statistics for Windows, Version 20.0. The threshold for statistical significance for each test was set at $p = 0.05$. The normalcy was examined using the Shapiro-Wilk test. The data was determined to be regularly distributed since $P > 0.05$. To compare the absorbance levels for each kind of SAFC amongst the four various restorative procedure groups, one-way analysis of variance (ANOVA) was employed. For the purpose of comparing the groups in pairs, Tukey's honestly significant difference multiple comparisons test was applied.

RESULTS

By comparing the mean absorbance values Table 1, the microleakage was the least for air abrasion and highest for acid etching while no treatment and bevelling showed similar results for both SAFCs.

Table 1: Mean absorbance levels of individual groups

Groups	*n*	Mean±SD	95% CI for mean	
			Lower bound	Upper bound
Dyad flow				
No treatment	10	0.022±0.01	0.01	0.02
Acid etching	10	0.034±0.02	0.02	0.05
Bevel	10	0.029±0.03	0.02	0.03
Air abrasion	10	0.021±0.01	0.01	0.02
Total	40	0.031±0.0	0.02	0.03

Constic				
No treatment	10	0.019±0.01	0.01	0.02
Acid etching	10	0.034±0.02	0.02	0.04
Bevel	10	0.031±0.01	0.01	0.03
Air abrasion	10	0.018±0.01	0.01	0.02
Total	40	0.021±0.01	0.02	0.04

For both SAFCs, there was a statistically significant difference ($p<0.05$) between the four major groups. Dyad flow ($P = 0.038$) and Constic ($P = 0.015$) demonstrated a significant difference during the intragroup comparison, according to one-way ANOVA [Table 2]. According to pairwise comparison [Table 2], Groups B and D for dyad flow and Groups A and B and Groups B and D for Constic showed statistically significant variations in the microleakage.

Table 2: One-way analysis of variance and post hoc multiple comparisons between individual groups

Groups	Mean square	*F*	Significance	Multiple comparisons	*P*
Dyad flow					
Between groups	0.01	3.1	0.02	No treatment versus acid etching	0.2
				No treatment versus bevel	0.8
				No treatment versus air abrasion	0.7
				Acid etching versus bevel	0.4
				Acid etching versus air abrasion	0.01
				Bevel versus air abrasion	0.5
Within groups	0.01				
Total					
Constic					
Between groups	0.01	3.9	0.01	No treatment versus acid etching	0.03
				No treatment versus bevel	0.8
				No treatment versus air abrasion	1.0
				Acid etching versus bevel	0.06
				Acid etching versus air abrasion	0.01
				Bevel versus air abrasion	0.8
Within groups	0.01				
Total					

DISCUSSION

A recently developed material called SAFC, which combines a flowable composite with an all-in-one adhesive system, claims to ease the restoration process.[1] In the lack of macro retention, Poitevin et al.'s conclusion from their study [6] was that SAFC should not be used clinically since it has a low bonding efficacy. The lesser etching ability of the restoration was thought to be the cause of the poorer bonding effectiveness, which was ascribed to insufficient removal of the smear layer and insufficient micromechanical retention between the restoration and tooth surfaces. They exhibit just a little acidity, which was validated by transmission electron microscopy and suggests that SAFC only interacts with the tooth structure on a surface level.[6]

The bonding and retention of composite resins in Class V cavities are improved by cavity modifications such the addition of bevels, retention grooves, or surface pretreatments including micro air abrasion, acid etching, and the application of bonding agent. Pretreatments that increase tooth roughness may improve the interfacial contact between the dentin and the adhesive surface, which may have an impact on bond strength.[8,9]

A review of the literature reveals no information on a comparative analysis of early restorative methods to enhance SAFCs' bonding capacity in Class V cavities.

In this investigation, Class V cavity preparation was carried out for a number of reasons. First off, because to their complicated morphology, where the edges are partially in enamel and partially in dentin/cementum, these cervical lesions have been a restorative problem for any sort of restorative material.[10,11] Second, they mimic a clinical scenario where there is more stress because the C-factor is higher. The associated restorative process for Class V lesions is also brief and rather straightforward, which reduces operator variability.[12,13]

The effectiveness of adhesive materials was evaluated using thermocycling. By exposing the repaired teeth to extremely high intraoral temperatures, it tries to thermally stress the adhesive connection at the tooth/restoration contact. This procedure demonstrates how the restoration and tooth structure have variable thermal expansion rates, which leads to different volumetric changes as a result of temperature variations and wear and tear on the adhesive bond with subsequent microleakage.[14]

Since the axis of cutting is randomly selected and the likelihood that the section occurs through the deepest dye penetration is very low, the dye-extraction technique (quantitative method) was chosen over dye-penetration (qualitative method) because it involves recovering all of the dye that has penetrated.[15]

The ratio of UV spectrophotometer light absorption to the concentration of methylene blue dye absorbed in the micro gap at the tooth restoration contact. Based on the equation $A = EC$ (A: absorption, E: molar absorption coefficient, C: concentration), the results are derived.[16] Therefore, a greater absorbance level means a larger microleakage, which points to a poor interface sealing capability.

According to the manufacturer's instructions, the resin was applied to Group A (the control group). In Group C, the previously indicated application of resin was followed by an extra step of bevelling the enamel on the occlusal edge of the created cavity. Due to the insufficient etching effectiveness of the functional acidic monomers, neither of these restorative approaches was able to improve the ratings for marginal leakage. They have a pH of 1.9, which is rather hostile.[11] To adhere to the conventional enamel margin designs that are advised for the majority of preparations for posterior composite restorations, a butt joint enamel margin was chosen for Groups A, B, and D.[14]

Phosphoric acid etching increases adhesion to enamel. By increasing surface energy and hence supplying much more micro-retention, etching the surface of enamel increased the binding strength of self-adhesive luting agents.[5,6] Similar to the existence of smear layer and smear plugs in sound dentine, the presence of highly mineralized layer, bacteria, and tubular mineral casts in sclerotic dentine might provide a barrier to the penetration of primer and resin.[17,18] To assess the sealing capacity of SAFC, phosphoric acid etching of enamel and dentin was tried.

According to some writers, SAFC resin has a lower wetability on the restorative surface due to its higher viscosity as compared to an adhesive solution, which results in insufficient collagen mesh hybridization. The etchant gel may have, however, resulted in the loss of hydroxyapatite (HAp) from dentine (surface and deeper), collapsed collagen fibrils, and insufficient infiltration of SAFC resin. This would have created an inadequate interfacial seal and increased the susceptibility to hydrolytic degradation over time, weakening the chemical bond.[5,19] Therefore, it is possible to surmise that the Group B preparatory phosphoric acid etching of dentine reduced the SAFC's seal's quality and increased microleakage.

Air abrasion, sometimes referred to as "micro air abrasion," is a nonrotary, pseudo-mechanical technique for chopping and scraping dental hard tissue. Utilising a stream of aluminium oxide particles produced by compressed air, bottle carbon dioxide or nitrogen gas, or compressed air, is how it works. Depending on the hardness of the tissue being removed and the operating settings of the air abrasion device, the abrasive particles impact the tooth with high velocity and remove minute quantities of tooth structure.[20]

When air abrasion (Group D) was utilised, the microleakage values were found to be reduced. This could have happened because air abrasion, as opposed to traditional carbide burs or acid etching, improved the adhesion between enamel and dentin surfaces.[20] Additionally, it aids in the elimination of the smear layer, which enhances the penetration of adhesive systems into demineralized dentin and might lead to noticeably stronger binding strengths. This suggests that, compared to acid etching, air abrasion enhances the surface area for bonding without significantly depleting HAp. The proposed null hypothesis can thus be rejected in light of the findings of the current investigation.

The functional monomer and the HAp are chemically bonded by SAFC, and the polymerised SAFC is micromechanically bonded to collagen fibres and the smear layer of dentin.[1] Chemical bonding greatly enhances the bond's longevity and strength. Constic achieved a reduced microleakage level in the research when compared to Dyad Flow. These results can be explained in terms of the particular functional monomers that rely on the product. Glycerol phosphate methacrylate (GPDM) and 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) monomers serve as the foundation for Dyad flow and Constic, respectively.

The "Adhesion-Decalcification concept" simulates the interactions between certain functional monomers and HAp-based tissues. While 10-MDP takes the adhesion path, GPDM takes the decalcification route. In order to generate stable complexes of MDP-calcium phosphate salts with higher hydrolytic stability over time and avoid biological degradation, 10-MDP, which has a long and hydrophobic spacer chain, binds firmly to HAp via ionic bonding. The increased hydrophilicity and shorter spacer chain of GPDM, on the other hand, may not favour stable monomer-calcium synthesis, leading to much more HAp demineralisation. When it comes into contact with an aqueous environment, it creates and deposits an unstable compound of dicalcium phosphate dihydrate on the HAp surface, which slowly dissolves and degrades the interfacial integrity.[22,23]

Given that this in vitro investigation was conducted in a static environment, more clinical studies are necessary to assess the repeatability of the findings. The oral cavity is a dynamic environment where the restorations are constantly in touch with oral fluids and under stress from masticatory strains. These circumstances may affect the teeth-composite contact, causing the binding to weaken and the durability to suffer. Therefore, the evaluation of composite adhesion to the teeth would also benefit from shear bond strength testing and cyclic loading under wet circumstances.

CONCLUSION

According to the limitations of the current microleakage study, it can be deduced that preliminary phosphoric acid etching increased the microleakage and may have had a negative impact on the seal's quality, whereas air abrasion decreased the microleakage and enhanced sealing ability in both the Dyad Flow and the Constic.

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