

Marginal leakage in permanent teeth after dentin treatment with air abrasion and adhesive systems

Infiltração marginal em dentes permanentes após tratamento dentinário com abrasão a ar e sistemas adesivos

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ABSTRACT

Due to doubts related to the application and association of techniques for appropriate adhesion, as the air abrasion system and last generation adhesive systems, the objective of this study was to evaluate the marginal leakage in Class V composite restorations in permanent teeth prepared with rotating instruments and then submitted to air abrasion and adhesive systems. Cavities were prepared with burs in high speed in facial and lingual surfaces of 25 human third molars. The specimens were divided into 5 groups of 10 preparations each: G1 (air abrasion and Scotchbond Multi Purpose), G2 (phosphoric acid and Scotchbond MP), G3 (Clearfil SE Bond self-etching system), G4 (air abrasion, phosphoric acid and Scotchbond MP) G5 (air abrasion and Clearfil SE Bond). All groups were restored with Z100 composite resin. The teeth were subjected to thermal cycling and immersed in 50% silver nitrate solution. After sectioning, the specimens were analyzed with a stereomicroscope for assessment of microleakage according to the degree of dye penetration. The Kruskal-Wallis test followed by Dunn Multiple Comparison test were performed in order to evaluate the differences among the experimental groups. Air abrasion groups demonstrated the greatest leakage. Scotchbond MP with phosphoric acid produced the least leakage, with greater leakage in gingival margins than occlusal margins in all experimental groups. It was concluded that dentin treatment with air abrasion should not be used in permanent teeth to reduce the marginal leakage.

UNITERMS

Dental leakage; dental air abrasion; dentin-bonding agents.

INTRODUCTION

The air abrasion system uses a high-speed stream of purified aluminum oxide particles propelled by air pressure. In 1945, Black² reported on the airbrasive technique for nonmechanical cavity preparation in response to the need to increase patient comfort by reducing pressure, heat, vibration, and noise during the mechanical preparation of teeth with rotating bur.^{8,26}

Good results have been gotten by combining air abrasion with acid etching in some studies.^{7,10,26} Even so, other studies demonstrated that air abrasion system does not substitute acid etching and the association of these methods is necessary to obtain adequate adhesion to the substrate.^{3,9,20,25,29}

The conventional adhesive systems, which use the total-etch technique, generally indicate the phosphoric acid fosfórico as acid conditioning agent. The self-etching materials eliminated the acid conditioning step by use of a primer containing an acid monomer. The smear layer components are probably incorporated within the bonding layers, since the dissolved matter is not rinsed away.¹⁹

Li et al.¹⁶ reported that Clearfil SE Bond, a self-etching adhesive system, simultaneously etches and primes the dentin, allowing the adhesive resin to fully penetrate the demineralized dentin surface, and this reduces the possibility of susceptible porosity to hydrolytic damage.

The objective of this study was to evaluate the marginal leakage in gingival and occlusal margins of Class V composite restorations in permanent teeth prepared with rotating instruments and then submitted to air abrasion and adhesive systems.

MATERIAL AND METHOD

Twenty five human non-carious third molars stored in physiological saline containing 0.1% timol were used. This study was approved by Committee on Human Research of Araraquara Dental School.

The teeth had Class V cavities prepared in facial and lingual surface, with a carbide bur (245/K.G. Sorensen, Barueri, SP, Brazil) in a high-speed handpiece (Kavo). The cavity preparations had an occlusal-cervical height of 2.0 mm, a mesiodistal length of 3.0 mm, and a buccolingual width of 2.0 mm.

Fifty cavities were prepared (2 per tooth), and then randomly distributed into five groups (n=10): group 1 (air abrasion and Scotchbond Multi Purpose), group

2 (phosphoric acid and Scotchbond Multi Purpose), group 3 (Clearfil SE Bond self-etching system), group 4 (air abrasion, phosphoric acid and Scotchbond Multi Purpose) and group 5 (air abrasion and Clearfil SE Bond). All groups were restored with composite resin. The protocols applied on dental surfaces were described in Table 1. The components, manufacturers and batch numbers of the materials used in this study are shown in Table 2.

All specimen margins were finished and polished with Sof-Lex™ Pop-on (3M Dental Products, Brazil) 24 hours after manufacture. The root apices of each tooth were sealed with Z100 composite resin and the entire tooth, except for an area 1 mm adjacent to the bonded interface, was coated with epoxy resin and two coats of nail varnish. The specimen were subjected to a thermocycling regimen of 500 cycles between 5°C and 55°C waterbaths. Dwell time was twenty seconds.

The teeth were then immersed in a 50% silver nitrate solution (Tec-Lab, Hexis Científica Ltda) in total darkness for 24 hours, rinsed in running water for five minutes, immersed in photo-developing solution and exposed to a fluorescent light for eight hours to reduce silver ions metallic silver. After removal from the developing solution, the teeth were rinsed thoroughly in running water for five minutes and the epoxy resin and nail varnish were removed with a sharp instrument.

Table 1 - Procedures used in experimental groups

Material	Procedure
Air abrasion system (Groups 1, 4 and 5)	Prep Star air abrasion system (Danville Engineering - USA), aluminum oxide particles (50 µm), air pressure (80 psi), nozzle angle (45°), tip orifice diameter (0.48 mm), distance (2 mm), 3 overlapping horizontal passes at occlusal margin (5s) and 3 overlapping horizontal passes at cervical margin (5s). Rinse 30s, air dry.
35% phosphoric acid (Groups 2 and 4)	30 s on enamel and 15 s on dentin, rinse for 30 s and air dry
3M Espe Scotchbond Multi Purpose (Groups 1, 2 and 4)	Primer, air dry for 5 s, bonding, light-cure for 10 s
Clearfil SE Bond (Groups 3 and 5)	Primer for 20 s, mild air dry, bonding, thin air dry, light-cure for 10 s
Z100 composite resin (Groups 1, 2, 3, 4 and 5)	3 increments, light-cure for 40s each increment

Table 2 – Materials, manufacturers, batch numbers, and compositions

Material	Composition	Manufacturer	Batch
Phosphoric acid	35% Phosphoric acid	3M Dental Products, Brazil	3GM 2006-04
3M ESPE Scotchbond Multi Purpose	HEMA, polyalkenoate copolymer HEMA; Bis-GMA	3M Dental Products, Brazil	3AH 2006-05
Primer			3NJ 2006-07
Bonding			51396
Clearfil SE Bond	MDP, HEMA, hydrophilic dimethacrylate, di-camphorquinone, N,N-Diethanol-p-toluidine, water	Kuraray Medical Inc., Japan	51396
Primer	MDP, Bis-GMA, HEMA, hydrophilic dimethacrylate, di-camphorquinone, N,N-Diethanol-p-toluidine, silinated colloidal silica		
Bonding			
3M ESPE Z100	Bis-GMA, TEGDMA, zirconium, silica	3M Dental Products, Brazil	1LB 2004-05

The specimen were sectioned in a mesiodistal direction with a diamond disc in a Isomet sectioning machine (ISOMET 1000 – Buehler Ltda, USA). The separated buccal and lingual halves were sectioned in a buccolingual direction, providing cuts 0.7 mm thick for each tooth.

Two or three sections of each restoration were evaluated using a stereomicroscope Carl Zeiss at 40X magnification. Scores (0-4) were used to evaluate the extent of leakage at the cervical and occlusal margins.²⁴ The greatest score was selected to be analyzed by statistical tests.

Data were analyzed by Kruskal-Wallis and Dunn tests ($\alpha = 0.05$).

RESULTS

Table 3 presents the scores' median, mean and standard deviation for cervical and occlusal margins from the different experimental groups.

When cervical and occlusal margins of each group were compared, it was verified that leakage values were greater in cervical margin for all groups, without statistically significant difference only in the groups 1 and 2 (Table 4).

In cervical margin, the leakage values were higher for the groups 1, 4, 5 and 3 respectively, without statistically significant difference among them. On

Table 3 – Median, mean and standard deviation of scores leakage in cervical and occlusal margins

Margin		Groups				
		G1	G2	G3	G4	G5
Cervical	Median	4.0	0.0	2.0	2.5	2.0
	Mean	3.4	1.0	2.3	2.8	2.7
	Standar Deviation	1.3	1.6	1.5	1.1	1.2
Occlusal	Median	2.0	1.0	1.0	1.0	1.0
	Mean	2.0	0.8	1.1	1.5	1.3
	Standard Deviation	0.7	0.6	0.6	1.0	0.9

Table 4 – Dunn Test application

Group	Margin		Comparison
	Cervical	Occlusal	
G1	79.4	56.1	0.073
G2	29.3	26.7	0.838
G3	59.7	33.8	0.046*
G4	70.1	42.9	0.036*
G5	68.3	38.9	0.024*
Comparison			
G1xG2	0.000*	0.023*	
G1xG3	0.128	0.086	
G1xG4	0.471	0.309	
G1xG5	0.390	0.185	
G2xG3	0.019*	0.582	
G2xG4	0.002*	0.210	
G2xG5	0.003*	0.345	
G3xG4	0.423	0.483	
G3xG5	0.507	0.694	
G4xG5	0.890	0.758	

* p<0.05

the other hand, the leakage value of group 2 was significantly smaller than all the other ones. In occlusal margin, the greatest leakage was observed in group 1, even so with statistically significant value just in relation to group 2.

DISCUSSION

According to Goldstein and Parkins,⁸ the surface of enamel and dentin after preparation may permit the effective placement of composite restorations without chemical etching. However in this study, the greatest leakage was observed when the phosphoric acid was substituted by air abrasion. Evaluationg shear bond strength, Borsatto et al.³ and Chaves et al.,⁵ found the worst results in aluminum oxide jet used alone. The

lower bond strengths for air abrasion groups not associated to acid conditioning possibly were nonremoval of the smear layer, thus not allowing adequate adhesion and penetration of the resin component into the dentin surface,²⁵ besides not conditioning the enamel in an appropriate way.⁶ Microscopically roughened surfaces and apparent closure of dentinal tubules were observed in permanent teeth after air abrasion treatment.¹³

This study demonstrated no leakage reduction after air abrasion application. Other researches, however, showed a better marginal leakage after the association of in aluminum oxide jet and phosphoric acid.^{7,29}

The results of this experiment agree with other studies, wich found fewer leakage in occlusal margin than in cervical region.^{27,28}

The conventional system promoted the lowest leakage in cervical margin, with statistically significant difference when compared to the other groups. No statistically significant difference was found between Scotchbond Multi Purpose and Clearfil SE Bond in occlusal margin. Different results were found by Osório et al.²¹ who observed no differences in microleakage between the adhesive systems tested at the occlusal margin, but significant differences were found at the gingival margin, where the Clearfil SE Bond group had lower dye penetration scores than Scotchbond Multi Purpose group. Scotchbond Multi Purpose adhesive system presents vast use so much in clinic as in scientific researches.^{6,9,21,22,25,27} The high water content of the SBMP primer seems to achieve good rewetting of the collapsed collagen network after overdrying, and the authors reported that the main reason for the commercial success of simplified adhesives is the easy handling, convenience and lack of confusion with these products rather than improved bonding.⁶ The single bottle systems not presented good performance as presented the multiple steps systems in Li et al.^{14,15} researches. According to the authors, the different leakage patterns are most likely due to the composition of each adhesive system and the relative ability of the adhesives to infiltrate the demineralized dentin.

When self-etching adhesive systems are used, the inorganic components present in the dentin substrate are demineralized and the smear layer is incorporated into the hybrid layer. At the same time, the resin monomers infiltrate the collagen network and both intertubular and intratubular dentin, also sealing the tubules and providing resin retention.^{4,22}

Self-etching adhesive systems are applied directly to the tooth without rinsing or drying, thus eliminating potential problems related to collagen fiber collapse after conditioning.^{1,18} Since self-etching materials do not completely remove the smear plugs, they may have the potential to promote less post-operative sensitivity and be less disturbed by moisture changes of the dentin substrate, without sacrificing shear bond strength.¹⁹

Another significant factor to be considered is the presence of fillers in some of the self-etching adhesive systems, like Clearfil SE Bond, which produces a thicker adhesive layer and the ability of the interfaces to maintain adhesion during the critical early stages of polymerization is better, improving the resistance to dimensional changes. In general, self-etching systems have a pH of around 2 (Clearfil SE Bond pH=2.2) and demineralize the dentin to a depth of only 1 µm. Residual hydroxyapatite crystals remains attached

to the collagen, enabling more intimate chemical interaction with the functional monomers on a molecular level and they may also help prevent or retard marginal leakage.¹

Self-etching adhesive systems can be presented in one-bottle and two-bottles. All-in-one, self-etching adhesive systems combine etching, priming, and adhesive in one solution. The two-bottle, self-etching adhesive systems seem to present better adhesive properties, since the lack of a separate primer of all-in-one systems may reduce the infiltration depth or the wettability of dentin adhesives, thereby reducing adhesion and sealing capacity.^{17,30} Some self-etching adhesives present a very low pH, mainly those of only one bottle. The acidity of these systems seem to interfere with the polymerization of the composite, and it is also possible that the high acidity of unpolymerized monomers remaining after light curing in a relatively high concentration at the oxygen-inhibited layer causes a separation at the adhesive-composite interface.¹¹

Yazici et al.³⁰ and Kubo et al.¹² affirmed that self-etching adhesives promote such good sealing as acid conditioning with phosphoric acid. They reported also that these adhesives can be applied in enamel with the same safety that a conventional system. Santini et al.²⁸ observed that self-etching materials produced a shallower depth of etch, and a less abundant resin tag complex than a material using a separate phosphoric acid gel. Even so, the authors verified no significant difference in microleakage between the adhesives.

Analyzing the literature, it is noticed divergence related to results of the different studies, probably due to the application technique of the adhesive systems. Most of dentists and researchers follow the manufacturer's instructions, although in some cases, the technical norms present doubtful points, as the subjectivity in the indications as "gentle" dry or "mild" dry. A standardization becomes difficult, since it is not established the distance, time and potency of application of air jets. Pioch et al.²³ affirmed that the manufacturer should define the dentin air dry instructions according to the adhesive system for nanoleakage reduction.

CONCLUSION

After observing that air abrasion system not reduced the marginal leakage of composite restorations in permanent teeth, this study not indicate the increase of one more technical step and, consequently greater clinical time.

RESUMO

Devido às dúvidas relacionadas à aplicação e associação de técnicas para a obtenção de uma adesão adequada, como o sistema de abrasão de ar e os sistemas adesivos de última geração, o objetivo deste estudo foi avaliar a infiltração marginal em restaurações Classe V de resinas compostas em dentes permanentes, preparados com instrumentos rotatórios e submetidos posteriormente à abrasão a ar e sistemas adesivos. As cavidades foram preparadas nas faces vestibular e lingual de 25 terceiros molares permanentes utilizando fresas em alta rotação. Os espécimes foram divididos em 5 grupos de 10 restaurações cada: G1 (abrasão a ar e sistema Scotchbond MU), G2 (ácido fosfórico e Scotchbond MU), G3 (sistema auto-condicionante Clearfil SE Bond), G4 (abrasão a ar, ácido fosfórico e Scotchbond MU) e G5 (abrasão a ar e Clearfil SE Bond), todos restaurados com resina Z100. Os dentes foram submetidos à termociclagem e imersos em solução de nitrato de prata a 50%. Depois de seccionados, foram analisados em lupa estereoscópica para avaliação da infiltração de acordo com o grau de penetração do agente traçador. Os testes de Kruskal-Wallis e de Dunn foram aplicados para avaliar as diferenças entre os grupos experimentais. Os grupos tratados com abrasão de ar demonstraram a maior infiltração. O sistema Scotchbond MP com aplicação de ácido fosfórico produziu a menor infiltração, e em todos os grupos experimentais, os valores de infiltração foram maiores na margem cervical do que na oclusal. Concluiu-se que o tratamento dentinário com o sistema de abrasão a ar não deveria ser utilizado em dentes permanentes com o objetivo de redução da infiltração marginal.

UNITERMOS

Infiltração dentária; abrasão dental por ar; adesivos dentinários.

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