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Air Abrasion: Effect on cavity preparation and on microleakage in primary teeth

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Abstract

Objective: To compare the effects of air abrasion and high speed diamond bur on the topography of cavity preparations and the microleakage on primary teeth.

Methods: in this in vitro study, the cavities were prepared on the occlusal surfaces of 60 teeth using both techniques on each tooth. Twenty teeth were randomly chosen for a descriptive analysis of the topography. Half of the remaining teeth (20) were treated with a total-etching adhesive system and the other half treated with a self-etching adhesive system and all samples were restored with composite resin. After that the samples were prepared for microleakage tests and assessed by scores. The statistical data was evaluated and a 5% significance level was adopted for all tests.

Results: the air abrasion technique produced different topographies and increased the formation of the smear layer (stuart-maxwell chi-square, p=0.03). Microleakage was not influenced by either of the adhesive systems used for cavity preparations (wilcoxon test, p=0.08). However, high speed diamond bur showed more microleakage regardless of the adhesive used (mann-whitney test, p=0.04; p=0.01).

Conclusion: the air abrasion technique appears to be a good alternative for preventing microleakage during cavity preparation in primary teeth.

Key words: Deciduous tooth; dental air abrasion; dental cavity preparation; dental leakage; scanning electron microscopy.

Abrasão a ar: efeito no preparo cavitário e na microinfiltração em dentes decíduos

Resumo

Objetivo: Comparar os efeitos da abrasão a ar e ponta diamantada de alta rotação sobre a topografia de preparos cavitários e a microinfiltração em dentes decíduos.

Métodos: Neste estudo in vitro, as cavidades foram preparadas nas superfícies de 60 dentes, utilizando ambas as técnicas em cada dente. Vinte dentes foram escolhidos aleatoriamente para uma análise descritiva da topografia. Metade dos dentes restantes (20) foram tratados com um sistema adesivo de condicionamento total e a outra metade tratada com um sistema adesivo auto-condicionante e todas as amostras foram restauradas com resina. Depois disso, as amostras foram preparadas para os testes de microinfiltração e avaliadas por dezenas. Os dados estatísticos foram avaliados e um nível de significância de 5 % foi adotado para todos os testes.

Resultados: A técnica de abrasão a ar produziu topografia diferenciada e aumentou a formação da camada de smear layer (Test qui-quadrado Stuart -Maxwell, p=0,03). Infiltração não foi influenciada por qualquer um dos sistemas de adesivos usados para preparações de cavidade (teste de Wilcoxon, p=0,08). No entanto, a ponta diamantada de alta rotação proporcionou mais infiltração independente do adesivo utilizado (Mann-Whitney, p=0,04; p=0,01).

Conclusão: A técnica de abrasão a ar demonstrou ser uma boa alternativa para a prevenção de infiltração durante a preparação da cavidade em dentes decíduos.

Palavras-chave: dente decíduo; abrasão dental a ar; preparo da cavidade dentária; infiltração dental; microscopia eletrônica de varredura.

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Introduction

The preparation of dental cavities must take into consideration the topography, on which, the adhesive agent will play a significant role for a successful restoration or quality sealing at the tooth/restoration interface. The treatment of the cavity surface is of crucial importance in any adhesive procedure if a perfect bond is to be achieved [1].

Most adhesive systems using acid solutions for conditioning the enamel and dentine also take into consideration the removal of the smear layer formed during cavity preparation, thus allowing a better bonding [2]. Some adhesive systems have been introduced in the market in order to make the clinical application easier and to reduce the acid conditioning time without endangering the quality of the treatment, an important factor in pediatric dentistry [3]. The self-etching adhesive systems use weaker acids to remove the smear layer and smear plugs, which results in thin hybrid layers [4].

Some studies have evaluated the microleakage of adhesive systems [5,6], sealants [7] and glass ionomer cements [8] on permanent teeth. However, there are few studies concerning the microleakage of adhesive systems on primary teeth [9,10], especially with cavity preparations using the air abrasion technique.

The development of bonded restorations in combination with air abrasion dentistry provides truly minimal intervention dentistry [11]. Therefore, this study aims to compare the effect of air abrasion and high speed diamond bur on the topography, regarding the cavity preparations, in primary teeth and to evaluate the microleakage of the adhesive systems. The null hypotheses state that no differences between topography and smear layer formation would exist regarding the techniques used for the cavity preparations and that the adhesive materials would have a similar behavior regarding microleakage.

Methods

Ethical approval

This study was submitted and approved by the Federal University of Rio de Janeiro Committee for Ethics in Research (#088/05).

Sample

Sixty primary molars (30 first molars and 30 second molars) with no carious lesions and no structural anomaly were selected. In order to facilitate manipulation, the radicular portion of the tooth was attached to an acrylic apparatus so that their occlusive surfaces were exposed.

Cavity preparation with high speed diamond bur and air abrasion techniques

The methodology for both techniques (air abrasion and high speed diamond bur) was standardized. Class I cavities were made, randomly, on the occlusive-distal and occlusive mesial sulcus. So, two cavities were made on each tooth, one by each technique. The cavity size was standardized as 2.0 × 2.0 × 2.0 mm; the depth was measured with a millimetric probe (Hu-Friedy, Zweigniederlassung Deutschland, Germany), and the width and length were measured with a digital caliper (Mitutoyo, Tokyo, Japan).

The high speed instrument (605 extra-torque, Kavo, Joinville, Brazil) was coupled to a diamond bur. This diamond bur presented an average granulation grade (#1061, KG Sorensen São Paulo, Brazil). The air abrasion instrument (Rondoflex 2013, Kavo, Biberach Riss, Germany) used a 90o tip with a 0.46 mm inner diameter to be used at a distance of 1mm from the tooth using 50 µm aluminum oxide particles at 80 psi.

The cavities prepared with the high speed diamond bur were always the first to be made; after which, the tooth was protected with a lead film in order to prevent aluminum oxide contamination from the air abrasion preparation. On average, 10 cavities were made by the same operator a day. The diamond burs were replaced after every five cavities and the air abrasion device was cleaned after every two cavities.

Evaluation of topography and presence of smear layer

After the cavity preparations, 20 teeth were randomly selected and were mesial-distally sectioned with a flexible double-faced diamond disc (#7020, KG Sorensen, São Paulo, Brazil). The samples were coated with gold/palladium before being examined in a scanning electron microscope (JEOL, Model JSM, 5310, Tokyo, Japan) at 15 Kv.

The cavosurface angle contour, enamel and dentine topography (13x magnification), and smear layer formation (2000x magnification) were described in the qualitative analysis of each technique used for the preparation of the cavities in primary teeth.

The semi-quantitative analysis was carried out by two examiners investigators (Kp=1) who observed microphotographs (2000× magnification) to evaluate the presence of smear layer according to scores by Rome et al. (12) (1985): (0) No smear layer, dentinal tubules open and free of debris; (1) Moderate smear layer, if outlines of dentinal tubules are visible or partially filled with debris; (2) Heavy smear layer, cannot distinguish outlines of tubules.

Microleakage analysis

The remaining 40 samples were divided in two groups. In the first group (n=20), a total-etching adhesive system – Scotch Multiuso Plus (3M, ESPE, Dental Products, St Paul, MN, USA), was used after tooth conditioning with 37% phosphoric acid (3M, Dental Products, St Paul, MN, USA). In the second group (n=20), a self-etching system – Clearfill Protect Bond (Kuraray Medical Inc., Tokyo, Japan), was used in two phases: the first involved the acid primer and the second, the adhesive material itself. In both groups the manufacturer's recommendations were followed.

After the conditioning procedures for each adhesive system, all teeth were restored with the composite Filtek

TP Z250 (3M, ESPE, Dental Products, St. Paul, USA), shade A3, which was applied into the cavities also according to manufacturer's recommendations. The restorations were finished with a diamond tip with extra-fine granulation (# 1190, KG Sorensen, São Paulo, Brazil) and polished with Enhance-type burs (Dentsply Ltd., Hamm Morr Lane, Weybridge, UK), which were replaced every three teeth.

The next step prepared the samples for the microleakage test in aqueous solution of 50% wt acid silver nitrate. Radicular portions of the teeth were removed from the acrylic apparatus and roots were sealed with cyanoacrylate in order to impede silver nitrate penetrating into this part of the tooth. The bonded specimens were then coated with nail varnish and immersed in silver nitrate for 24 hours. After that, specimens were placed in a photo developing solution to reduce the diamine silver ions into metallic silver grains. Finally the teeth were mesio-distally sectioned with a flexible double-faced diamond disc (#7020, KG Sorensen, São Paulo, Brazil).

The marginal leakage infiltrating enamel and dentin was evaluated according to the Raskin et al. (2003) [13]: (0) No penetration; (1) Penetration into the enamel; (2) Penetration towards the dentin; (3) Penetration towards the pulp. It was done by two double-blind examiners (weighted Kappa ranging from 0.92 to 1.0) scores using a stereoscopic magnifying glass (45× magnification).

Statistical analysis

Stuart-Maxwell chi-square test and Wilcoxon test were used to assess, respectively, the presence of smear layer and the microleakage level regarding both cavity preparation techniques. The Mann-Whitney test was used to evaluate the type of tooth conditioning. A 5% significance level was adopted for all tests.

Results

The dental topographies resulting from the air abrasion and high speed diamond bur techniques were found to be distinctive. In cavities made with the high speed diamond bur, cracks and scratches were observed in the topography of the enamel and dentine. Also regular U-shaped cavities with defined inner and cavosurface angles were observed. However, the cavities made with air abrasion showed a rough topography with the presence of aluminum oxide residues in the enamel and dentine. Irregular, V- or W-shaped cavities with rounded inner and cavosurface margins creating a "halo" effect were also observed (Fig. 1).

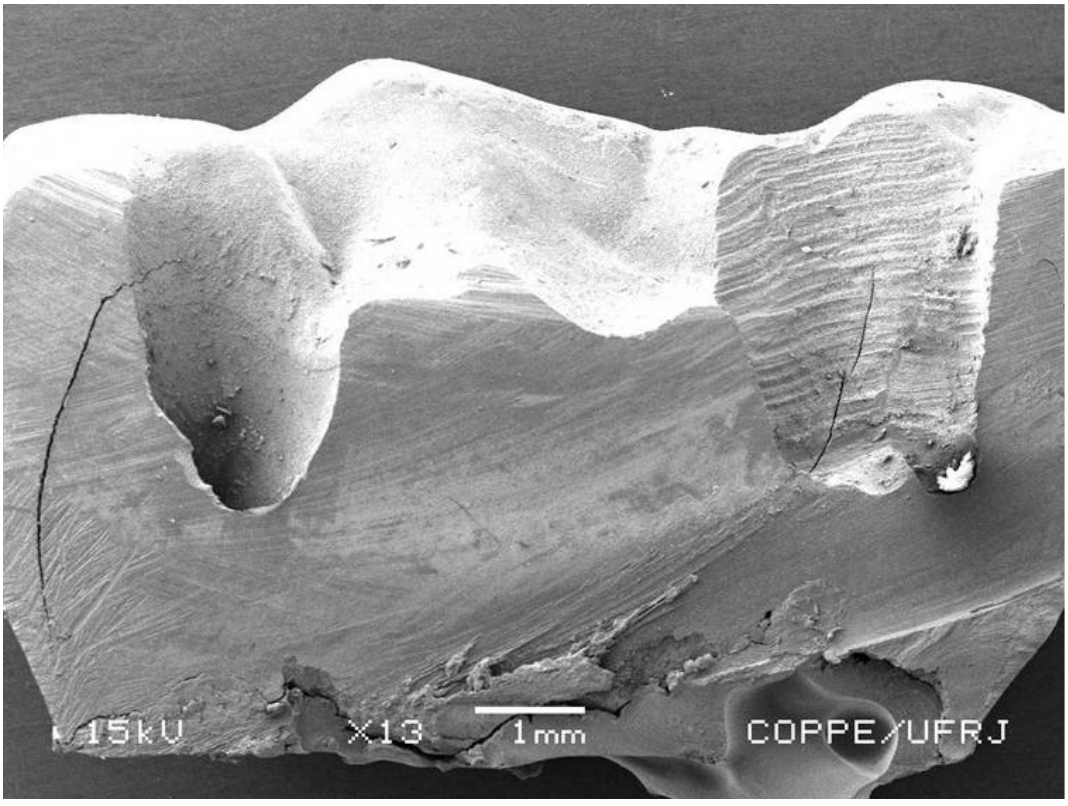

Fig. 1. The dental topographies resulting from both cavity preparation techniques, air abrasion (on the left) vs high speed diamond bur (on the right). Observe distinctive relation to each technique used in relation to inner and cavosurface angles (SEM, 13X).

Both techniques produced smear layers in dentin. In 90% of the cavities made by the air abrasion there was a "heavy smear layer" (score 2), whereas 40% of cavities prepared by high speed diamond bur presented some "visible dentinal tubules or partially filled with debris" (score 1) (Table 1).

In the descriptive analysis each technique presented its own characteristics: the high speed diamond bur produced a smear layer firmly attached to the dentine, whereas the air abrasion yielded a smear layer loosely adhered to the dentine (Fig. 2A and Fig. 2B).

Table 1. Evaluation of smear layer formation according to the technique used

		Air Abrasion – Smear layer scores			Total
		0	1	2	
High speed diamond bur – Smear layer scores	0	0 (0%)	0 (0%)	0 (0%)	0 (0%)
	1	0 (0%)	2 (10%)	6 (30%)	8 (40%)
	2	0 (0%)	0 (0%)	12 (60%)	12 (60%)
Total		0 (0%)	2 (10%)	18 (90%)	20 (100%)

Stuart-Maxwell chi-square Test (p=0.03).

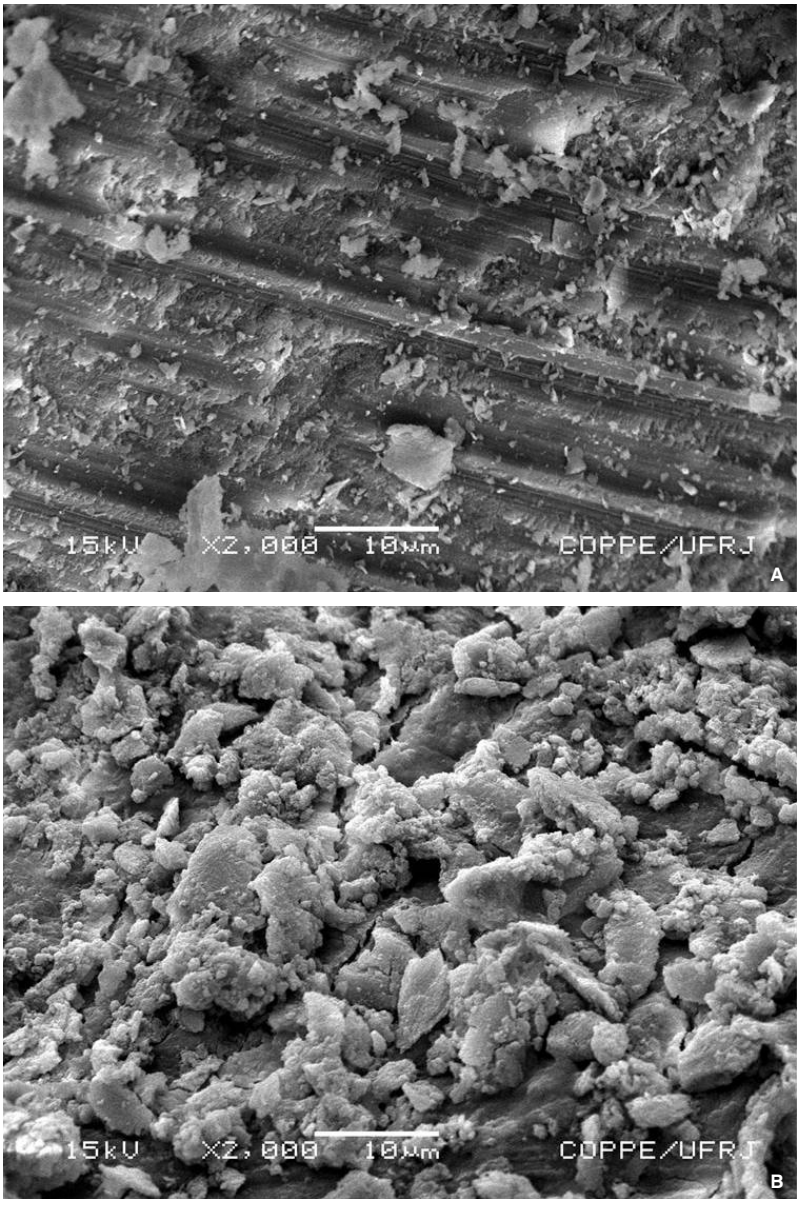

Fig. 2. Dentin topography:
A - distinctive smear layer formation after the use of a high speed diamond bur (SEM 2000X);
B - distinctive smear layer formation after the use of air abrasion (SEM 2000X).

Table 2. Influence of adhesive systems on microleakage according to the technique used

	Microleakage Scores				P*
	0	1	2	3	
High speed diamond bur					
Self-etch (n=20)	9(45%)	3(15%)	5(25%)	3(15%)	
Total-etch (n=20)	14(70%)	3(15%)	2(10%)	1(5%)	0.08
Total (n=40)	23(57.5%)	6(15%)	7(17.5%)	4(10%)	
Air abrasion					
Self-etch (n=20)	17(85%)	1(5%)	0(0%)	2(10%)	
Total-etch (n=20)	19(95%)	1(5%)	0(0%)	0(0%)	0.27
Total (n=40)	36(90%)	2(5%)	0(0%)	2(5%)	

* Mann-Whitney Test.

Table 3. Influence of cavity preparation method on microleakage according to adhesive system

	Microleakage Scores				
	0	1	2	3	P*
Total-etching					
High speed (n=20)	14(70%)	3(15%)	2(10%)	1(5%)	
Air abrasion (n=20)	19(95%)	1(5%)	0(0%)	0(0%)	0.04
Total (n=40)	33(82.5%)	4(10%)	2(5%)	1(2.5%)	
Self-etching					
High speed (n=20)	9(45%)	3(15%)	5(25%)	3(15%)	
Air abrasion (n=20)	17(85%)	1(5%)	0(0%)	2(10%)	0.01
Total (n=40)	26(65%)	4(10%)	5(12.5%)	5(12.5%)	

* Wilcoxon Test.

In relation to the microleakage, the type of adhesive system had no influence on the results, regardless of the technique used (Table 2). Nevertheless, the cavity preparation showed some influence as there was greater microleakage in the high speed diamond bur samples, regardless of the adhesive system used (Table 3).

Discussion

The air abrasion technique may be considered as an alternative for removing carious tissue in terms of minimally invasive dentistry. Interest in this method is increasing, particularly concerning the interaction between the cavity preparation designs and the different adhesive and restorative systems used.

Adhesive restorative materials (e.g. composites) are commonly used in restorations of posterior primary teeth. However, the physical and chemical properties of these materials may affect their clinical performance. Marginal microleakage is the main cause of restoration failure. It could be explained by the polymerization contraction stress occurring at the tooth/restoration interface, which causes gaps around the restoration and consequently results in the penetration of bacteria and dyes [14].

The use of different techniques for cavity preparations may affect their topography and configuration [15,16], which are factors known to influence restorations. This fact was confirmed in the present study as the cavity preparation methods (air abrasion vs high speed diamond bur) produced different smear layers, rejecting the null hypothesis. Regarding the surface topography, the composite restorations of the samples prepared with air abrasion were found to be better. The characteristics involving the air abrasion – such as rounded contours [16,17], roughened surfaces, rounded cavosurface margins and roughened-dispersion halo effects [16,17,18], and absence of microcracks – are considered important for obtaining long-lasting adhesive restorations. Therefore, it is suggested that restorations should have these characteristics in order to promote good adherence of the composite. The gradual transition between tooth and restoration reduces the incidence of fractures, microleakage, and polymerization contraction stress [19,20,21].

The type of instrument and the dentine substrate influence the smear layer morphology [15,16,22,23]. Different treatments may directly affect the quality of adhesion, and the level of microleakages of the adhesive restorations [16]. Despite the fact that 90% of the air abrasion samples presented a heavy smear layer (score 2) in the present study it still allowed better restoration placement since the smear layer produced was a loosely attached smear layer in comparison to that formed using the high speed diamond bur. These aspects have raised questions whether acid solutions (e.g. self-etching system) would be enough to incorporate

this loosely attached smear layer. However this fact was not observed in the present study since microleakage was not influenced by the adhesive systems used.

Refuting the equality hypothesis regarding the instruments, the cavity preparations made with the air abrasion method yielded better microleakage results in comparison to the high speed diamond bur, corroborating with Fu et al. (1994) [24].

In relation to the adhesion techniques, the self-etching adhesive system has advantages such as the reduced chair-time, an important factor in pediatric dentistry. According to the literature, however, total-etching adhesive systems usually have better results in comparison to the self-etching systems [25] since the application of phosphoric acid provides a better sealing of the cavity margins. Etch-and-rinse adhesives are more technique sensitive then self-etching adhesives. The problem with etch-and-rinse adhesive is inadequate penetration of the adhesive resin into the demineralized dentin, resulting in poor sealing with the bonded interface. Nevertheless, the equality hypothesis was confirmed in the present study as the adhesive systems had no influence on the techniques used.

The air abrasion technique doesn't have any scientific evidence to be considered as minimal invasive treatment and not even as an alternative to high speed diamond bur. No clinical trials have been done to check its applicability. However, we suggest that the results obtained in this *in vitro* study should be correlated with *in vivo* results. It is important for odontopediatrics to reduce working time without reducing the quality of treatment. So, longitudinal, laboratory, and clinical studies of composite restorations in primary teeth evaluating the tooth/restoration interface after cavity preparation using air abrasion and self-etching adhesives are still necessary.

Conclusions

So, based on the hypotheses analyzed, we can conclude that performing cavity preparations with air abrasion is good to prevent microleakage in composite restorations. The air abrasion provides topography and smear layer which allow better restoration placement, regardless of the adhesive system used.

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