Effect of Air Abrasion on Tensile Bond Strength of a Single-Bottle Adhesive/Indirect Composite System to Enamel

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This study evaluated the efficiency of air abrasion alone and associated with phosphoric acid etching on tensile bond strength of a single-bottle adhesive/indirect composite restorative system (Bond 1/Alert) to human enamel. Forty enamel surfaces from extracted human third molars were assigned to 4 groups (n= 10). Mach 4.1 (Kreativ Inc.) air abrasion equipment was used for 20 s. A special system of rod pairs aligned in a specific apparatus was used for tensile strength tests, according to ISO/TR 11405 standard (1994) with some modifications. Bond strength means were: G1 (air abrasion + rinsing + condensable composite resin Alert) = 3.46 ± 0.83 MPa; G2 (air abrasion + rinsing + Bond 1 adhesive system + Alert) = 4.00 ± 1.60 MPa; G3 (air abrasion + rinsing + 37% phosphoric acid + rinsing + Bond 1 + Alert) = 20.80 ± 3.95 MPa; and G4 (37% phosphoric acid + rinsing + Bond 1 + Alert) = 17.00 ± 2.74 MPa. The statistical analysis by Kruskal-Wallis test revealed that G1 and G2 presented statistically significant difference ($p < 0.05$) from G3 and G4 ($p < 0.01$) and G1 and G3 did not differ significantly ($p > 0.05$) from G2 and G4, respectively.

Key Words: tensile bond strength, air abrasion, enamel.

INTRODUCTION

In 1895, Greene Vardiman Black introduced revolutionary concepts of restorative treatment, turning the empirical Dentistry at that time into a scientifically based science. Starting from a new point of view, these concepts are under study up to the present days, in a continuous search for more conservative and effective procedures on dental treatments.

Therefore, the use of the aluminum oxide stream at high speed for removing dental structure was first described by Black (1) previous to the advent of acid conditioning, the basis of adhesive dentistry developed by Buonocore (2). Cavity preparation was performed by handpieces at a lower speed than that currently achieved nowadays. Such equipments produced heat, vibration and so much noise, which generated far too much discomfort to patients (3,4). The use of air abrasion was first suggested to diminish or even to eliminate these inconveniences (5).

Due to the advent of the high and low speed rotations, which were considerably less expensive, the air abrasion technique was not widespread. In addition, the restorative materials available at that time (e.g.: amalgam, gold, silicate) demanded cavities prepared with defined angles and mechanical retentions, which are difficult to be accomplished with air abrasion devices. In spite of that, the idea of particle flow at high speed persisted in sodium bicarbonate prophylaxis and prosthodontic laboratories.

Thus, air abrasion was reintroduced focused on clinical procedures, such as initial preparation of dental surfaces for adhesive cementation, laboratorial preparation of the inner metal surfaces of Maryland

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bridges and prostheses for adhesive cementation, porcelain crowns, veneer cementation, porcelain repairs, orthodontic band cementation, bracket bonding, amalgam and resin repairs, inlays and onlays fixation, removal of dental pigments, among others (6-9).

However, the literature does not offer well based information about the alterations caused to dental structure after the use of air abrasion (10-13). This study evaluated the efficiency of air abrasion alone and associated with phosphoric acid etching on tensile bond strength of a single-bottle adhesive/indirect composite restorative system (Bond 1/Alert) to human enamel.

MATERIAL AND METHODS

The buccal enamel surfaces from 40 extracted human maxillary third molars (1-6 month storage) kept in 0.5% chloramine aqueous solution under refrigeration were used to conduct the tensile bond strength tests. A microhybrid packable composite resin (Alert Resin Restorative System; Pentron Clinical Technologies, Wallingford, CT, USA; shade: A2) and a single-bottle adhesive system (Bond 1, Pentron Clinical Technologies) were selected for the study. The compositions of the materials are the following: *composite resin* - Bis-GMA + PCDMA, methacrylate groups, silica, silicate dioxide, glass fibers; *adhesive system*: PMGDM, HEMA, initiator, acetone. The study design was based on the methodology specified by ISO/TR 11405 standard for tensile strength tests (14) with some modifications to make it possible for use in a universal testing machine.

The teeth were decoronated 2 mm below the cementoenamel junction, the crowns were sectioned mesiodistally and the buccal enamel surfaces were used for the experiment. To conduct tensile tests, a special system of rod pairs aligned in a specific apparatus was used. It allowed fabricating specimens in a defined longitudinal axis to be loaded in the universal test machine (MEM 2000; EMIC - Equipamentos e Sistemas de Ensaios Ltda, São José dos Pinhais, PR, Brazil).

In this test system, each pair of rods, at one of the ends, has a rod with a circular metal matrix connected to it. The enamel surfaces were included in the circular metal matrix and planned with wet 100- to 600-grit sandpaper until getting a circular 5-mm diameter area. The other end, or the other rod, was connected to a transparent acrylic cylinder containing the resin in a central cylindrical hole (5 mm in diameter; 5 mm high).

The flat, ground enamel surfaces (central area Ø=5mm) were randomly assigned to 4 groups (n=10), according to the surface treatment: G1: air abrasion + rinsing + Alert; G2: air abrasion + rinsing + Bond 1 + Alert; G3: air abrasion + rinsing + 37% phosphoric acid (15 s) + rinsing + Bond 1 + Alert; and, G4: 37% phosphoric acid (15 s) + rinsing + Bond 1 + Alert.

The air abrasion system used in this study (Mach 4.1; Kreativ Inc., New Image Industries Pty Ltda, Victoria, Australia) was adjusted at 60 psi particle energy, pulse mode, 27.5 µm mean aluminum oxide particle size 0.018-inch tip diameter, 5 g/min jet intensity, 20-s application, 5-mm distance and 90-degree impingement angle. The particle reservoir was frequently agitated to homogenize the size distribution.

The air-abraded enamel surfaces were treated according the experimental groups and the manufacturers' instructions and were attached to one of the rods. This first rod was then fixed in the alignment apparatus to be adhered to the other rod connected to the acrylic cylinder. At this stage, the pair of rods were both fixed in the alignment block under controlled load in order to permit the enamel surface contact with the composite resin and so that the adhesive interface could be established. Finally, the specimens were light-cured (XL 3000, 3M/ESPE, St Paul, MN, USA) for 40 s at three different radial positions and then removed from the alignment apparatus. Thus, a longitudinal axis between the two rods was achieved. Figure 1 illustrates specimen fabrication.

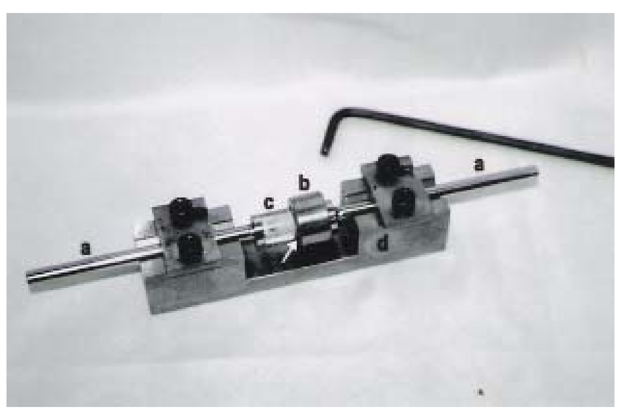

Figure 1. Tensile bond strength apparatus. (a) = pair of metal rods; (b) = circular metal matrix including the enamel surface; (c) = transparent acrylic cylinder containing the composite resin; (d) = alignment block; Arrow = adhesive interface.

Thereafter, the specimens were submitted to a thermocycling regimen of 500 cycles of 1-min immersions in water at 5ºC and 55ºC (Termocycling Machine; Ética Equipamentos Científicos S.A., São Paulo, SP, Brazil) and tested in tensile strength at a crosshead speed of 0.5 mm/min and using a 200 kg load cell.

Means (± SD) were submitted to statistical analysis. As data had a non-normal distribution, Kruskal-Wallis non-parametric test was used at 5% significance level. The enamel bonding areas were observed under a stereomicroscope (25X) to assess the failure mode.

RESULTS

Tensile bond strength means for the four groups and the statistical analysis are given on Table 1. G1 and G2 differed significantly from G3 and G4 ($p<0.01$). However G1 and G3 did not differ from G2 and G4, respectively ($p>0.01$).

The failure modes (adhesive, cohesive in the enamel, cohesive in the resin, mixed) and correspondent percentages are plotted on Table 2. Groups 1 and 2 had 100% of adhesive failures, which was expected in view of the tensile bond strength means shown on Table 2.

Table 1. Tensile bond strength means (in MPa) (± SD) of the experimental groups and statistical analysis.

Treatments			
(G1) Air abrasion + rinsing + Alert	(G2) Air abrasion + rinsing + Bond 1 + Alert	(G3) Air abrasion + rinsing + Acid + rinsing + Bond 1 + Alert	(G4) Acid + rinsing + Bond 1 + Alert
3.46 ± 0.83a	4.00 ± 1.60a	20.80 ± 3.95b	17.00 ± 2.74b

Kruskal-Wallis test (H=30.448; p=0.01); MSD (1%) = 16.277; MSD (5%) = 13.431; Different letters indicate statistically significant difference at 5%. MSD= minimum significant difference.

Table 2. Distribution of failure modes (%).

	Adhesive	Cohesive/resin	Cohesive/enamel	Mixed
G1	100	--	--	--
G2	100	--	--	--
G3	--	30	--	70
G4	80	20	--	--

DISCUSSION

As regards the treatment with abrasive air applied to enamel surfaces and its influence on tensile bond strength, the results revealed that the highest means obtained refered to the association of the air abrasion to phosphoric acid and subsequent bonding agent application (G3 = 20.80 ± 3.95 MPa). Other authors have also found best results for bonding strength when they associated the air abrasion with conventional acid conditioning (15-17).

High bonding strength means could be ascribed to the improvement of the "wetting" of dental surface produced by air abrasion (18), or rather, there would be higher efficacy of acid etching and hence a better micromechanical retention of the adhesive agent on the surface substrate, resulting in an adhesive interface with higher quality. Thus, the capability of enamel wetting by the adhesive seems to be one of the most important factors leading to a successful bonding process.

Based on the means of G1 (3.46 ± 0.83 MPa) and G2 (4.00 ± 1.60 MPa), the use of air abrasion alone or associated with a bonding agent yielded the lowest tensile bond strengths of the resin to enamel, which suggests that air abrasion may not be efficient for a good bonding. The results of G3 (20.80 ± 3.95 MPa) and G4 (17.0 ± 2.74 MPa) confirmed the need of conventional acid etching as the treatment of choice for enamel.

It must also be considered that others factors related to the dental substrate, to the methodology and to the restorative material may interfere with the test results. The adhesive process is subject to multi-factorial influence as already established and accepted (19). As for dental enamel, it is a highly reactive substrate due to its composition and structural arrangement and it behaves very favorably to the bonding process (20).

Regarding the air abrasion technology, many professionals introduced its use in their daily practice based on a few number of regular studies, using it during several clinical procedures, such, as a final or an intermediary step in adhesive practices. They felt so stimulated due to the easy management and low cost of many types of equipment.

Based on the obtained results, it may be concluded that the association of air abrasion and conventional acid etching showed the highest tensile bond strength means of Bond 1/Alert composite system to enamel and the use of air abrasion alone should be avoided as a conditioning enamel step during adhesive procedures.

Then, the objective of this brief study was attained: it really observed, in a simple manner, the influence of air abrasion on tensile bond strength to enamel of a resin restorative system. These findings may contribute to dentists who are using the air abrasion to enamel as a pre-treatment during adhesive procedures and reaffirms the good result presented by the conventional acid etching as a unique conditioning enamel step.

RESUMO

O objetivo deste estudo foi avaliar a eficiência da abrasão a ar associada ou não ao condicionamento com ácido fosfórico na resistência à tração de um sistema restaurador composto por adesivo frasco único/resina composta indireta (Bond 1/Alert) ao esmalte humano. Quarenta superfícies de esmalte de terceiros molares humanos extraídos foram alocadas em 4 grupos (n=10). Foi utilizado o sistema de ar abrasivo Mach 4.1 (Kreativ Inc.) durante 20 s. Um sistema especial de pares de hastes alinhadas em um equipamento específico foi usado para realização dos testes de tração, de acordo com a Norma ISO/TR 11405 (1994) com algumas modificações. Os valores médios obtidos foram: G1 (ar abrasivo + lavagem + resina condensável Alert) = 3,46 ± 0,83 MPa; G2 (ar abrasivo + lavagem + adesivo Bond 1 + Alert) = 4,00 ± 1,60 MPa; G3 (ar abrasivo + lavagem + ácido fosfórico 37% + lavagem + Bond 1 + Alert) = 20,80 ± 3,95 MPa; e G4 (ácido fosfórico 37% + lavagem + Bond 1 + Alert) = 17,00 ± 2,74 MPa. Pela análise estatística (teste Kruskal Wallis), G1 e G2 apresentaram diferença estatisticamente significante em relação a G3 e G4 (p<0,01) e G1 e G3 não diferiram dos grupos G2 e G4, respectivamente (p>0,05).

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