

Influence of Erosive and Abrasive Cycling on Bonding of Different Adhesive Systems Enamel: An *In situ* Study

Marina Ciccone Giacomini¹, Leslie Caroll Casas-Apayco², Camila Moreira Machado³, Maria Cristina Carvalho de Almendra Freitas⁴, Maria Teresa Atta¹, Linda Wang¹

¹Department of Operative Dentistry, Endodontics and Dental Materials, Bauru Dental School, USP - Universidade de São Paulo, Bauru, SP, Brazil

²School of Dentistry, Universidad Peruana de Ciencias Aplicadas, Lima, Peru

³Department of Prosthodontics, Bauru Dental School, USP - Universidade de São Paulo, Bauru, SP, Brazil

⁴FACID-DeVry, - Faculdade Integral Diferencial, Teresina, PI, Brazil

Correspondence: Profa. Dra. Linda Wang, Alameda Octávio Pinheiro Brisolla, 9-75 17012-901, Bauru, SP, Brazil. Tel: +55-14-32358323. email: wang.linda@usp.br/ wang.linda@uol.com.br

This study evaluated the impact of orange juice on the bond strength (BS) of dentin bonding systems (DBSs) to enamel surface after simulation with an *in situ/ ex vivo* erosive cycling. One hundred and ninety two bovine enamel fragments (4x4x2 mm) were obtained and randomized regarding superficial microhardness and distributed to palatal devices for 8 volunteers, in three phases (one for each DBS), containing 8 blocks, which were, allocated in 4 pairs. Daily, these pairs were subjected extraorally to the following conditions: CONT- neither erosive nor abrasive challenge; ERO- erosive challenge only; ABR- abrasive challenge only and ERO + ABR- with erosive and abrasive challenges. Erosive cycles (immersion in orange juice, 3 times/day/5 min/5 days) or/and abrasive challenges (electric toothbrush, 3 times/day/1 min/5 days) were performed. After these cycles, all specimens were restored with the adhesive systems Adper Scotchbond Multi Purpose (MP), Adper Single Bond 2 (SB) or Clearfil SE Bond (SE), and the composite resin Filtek Z250. After 7 days, sticks (area $\cong 1 \text{ mm}^2$) were obtained and subjected to the microtensile bond strength test (μTBS) at 0.5 mm/min. Data was statistically analyzed by ANOVA and Tukey tests ($\alpha=0.05$). Failure modes were determined using a digital microscope (40x). DBS was the only statistical significant factor. SE was the unique DBS not affected in any challenge, whereas MP and SB performed according to the scenario. The adhesive and mixed failures were predominant in all groups. Overall performance suggested that BS to enamel after erosive /abrasive challenged by orange juice was not affected and it was material-dependent.

Key Words: dental enamel, dentin-bonding agents, tooth abrasion, tooth erosion

Introduction

The increased prevalence of erosion that affects dental hard tissues has stimulated the development of strategies and agents to prevent or control its effect (1). Erosion is primarily the result of the non-bacterial chemical attack usually involving acidic substances by intrinsic or extrinsic etiologies, which ultimately provokes the loss of dental hard tissue (2). In the beginning, it causes the softening of the surface (3) and its progression turns it more vulnerable to mechanical processes, and dental subsequent wear if not stopped (1-4)

In the consequence of an excessive or unusual increasing of the consumption of acidic beverages, erosive lesions have also been more evident (1,5,6). As it is a multifactorial process, the compromising level of this event depends on the balance between chemical, behavioral and biological risk factors (2,6).

In particular, dental erosion by orange juice has been the subject of numerous studies (5,7). Its erosive potential is determined by several factors, including its pH and triattibility, chelating properties, and calcium, phosphate and fluoride concentration, frequency of exposure and duration of each episode of erosive exposure (5,7).

De Carvalho Filho et al. (8) showed that the orange juice was able to significantly reduce Ca and P content of enamel, based on energy dispersive X-ray spectrometry analysis. Studies have been pointed out that enamel demineralization can provoke structural damage with negative impact to bonding orthodontic brackets (7). Also, when eroded lesions present significant dental compromising, restorations of composite resin are commonly performed (9). With respect of this scenario, there is a lack of information if these alterations would be actually of concern in composition and structure of enamel in terms of erosive effects on interventions upon it (2,10).

As toothbrushing represents the main oral abrasion process, its impact onto dental surface cannot be ignored. When associated with erosive conditions, both processes can act synergically to modify enamel and dentin, intensifying their wear (2,11).

Thus, the purpose of this study was to evaluate the enamel as bonding substrate after *in situ / ex vivo* erosive and/or abrasive cycling caused by industrialized orange juice, with the different categories of DBS. The null hypotheses tested were: 1. There is no difference on bond strength to enamel according to DBS; 2. There is no

difference on BS to enamel after different challenges.

Material and Methods

Ethical Aspects

The Ethic Committee for Human Studies of Bauru School of Dentistry, University of São Paulo, Brazil approved this study (102/2009) before its beginning. Eight healthy volunteers received verbal and written information about the study and gave signed and witnessed consents to participate.

Experimental Design

This *in situ/ex vivo* study involved the analysis of two factors: DBS, in three levels and erosive/abrasive challenge, in four levels. The response variable was the microtensile bond strength to enamel (μ TBS).

Enrolment of Participants

All volunteers were selected according to inclusion criteria (12), who may present normal salivary flow rate (≥ 1.0 mL/min). Neither active caries nor erosive lesions could be present. The saliva pH was assessed (mean 7.4 ± 0.6) as well. According to the medical history, neither acidic food consumption nor intrinsic acidic unbalanced condition was accepted to avoid confounding factors during the experiment. Also, it was instructed to the volunteers to not eat or drink any kind of food/ beverage, even water, when the appliance was in mouth. Thus, eight volunteers with appropriate general health, good dental health, known fluoride history, normal salivary function, and no medications that affect salivary function were enrolled.

Specimen Preparation and Selection

Bovine incisors were selected and stored in 0.1% thymol solution at room temperature. From them, fragments (4x4x2 mm) were prepared using a digital low speed saw cut machine (Isomet 1000, Buehler, Lake Bluff, IL, USA) and two water-cooled diamond-impregnated disc (Diamond High Concentration. Wafering Blade-102 mm x 0.3 x 12.7 mm/Excet Corp., Enfield, CT, USA / Ref: 12205) with a stainless steel spacer (7 cm diameter, 4 mm thick and 1.3 cm center hole). They were stored in plastic containers and covered with gauze soaked in deionized water at 4 °C temperature. Enamel surface was ground flat using 600-grit and 1,200-grit SiC paper under running water (Politriz APL-4, Arotec, Cotia, SP, Brazil). Between each polishing cycle, blocks were submitted to ultrasound cleaning (Ultrasonic Cleaner Mod. USC 750; Unique Ind. e Com. de Produtos Eletrônicos Ltda., São Paulo, SP, Brazil), for 2 min. In the end, the enamel surfaces were polished with felt paper (Polishing Cloth Buheler, Lake Bluff, IL, USA 40-7618) and diamond suspension (Extec I Water based diamond

permanent polishing suspension, Extec Corp., CT, USA, 1 micron 16.587). Superficial microhardness assessment aided to select one hundred ninety two standardized fragments (Knoop diamond, 25 g, 5 s, HMV-2000; Shimadzu Corporation, Tokyo, Japan). Enamel blocks with a Knoop hardness number around 10% \pm of the media of total hardness (not less than 350 KHN) were selected.

Intraoral/ Ex vivo and Extraoral Phases

Specimens were sterilized in 2% formaldehyde solution (pH=7) at room temperature for 30 days (13). Each of the eight volunteers, worn their palatal devices containing 8 specimens, which were divided into four pairs as shown in Figure 1 and subjected to the challenges as described in Table 1. They were carried out extra orally in a single stage with the aid of a device made with Ethylene Vinyl Acetate (EVA) in accordance to Honorio et al. (14), to delimit the area that would be eroded or/and abraded. The experiment was conducted in three phases in a crossover design. In each phase, volunteers were randomized, in which the specimens would be restored with one of the three tested DBS. The composition of orange juice and used toothpaste are present in the Table 2.

After challenges, all blocks and appliances were then rinsed for 30 s with water supply prior to return them to the oral cavity. This cycle was followed for 5 days. For abrasive challenge an electric toothbrush (Cross action Power; Oral B, São Paulo, SP, Brazil) was used to standardize brushing with a slight pressure.

Bonding Procedures

For each group, specimens were randomized and restored with DBS: Adper Scotchbond MultiPurpose (3M

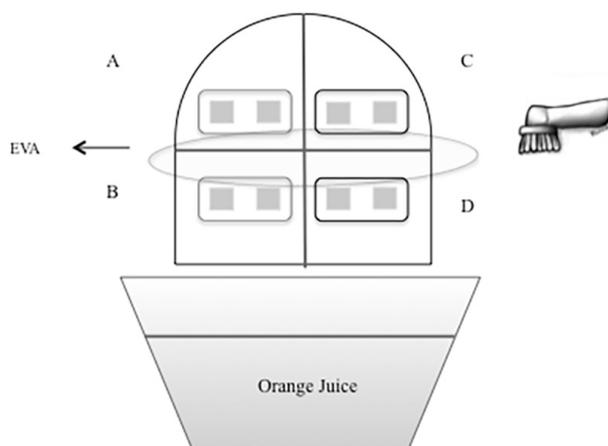


Figure 1. Representative schematic of palatal device and the tested challenge: A= CONT; B= ERO; C= ABR and D= ERO+ABR. Only B and D were immersed in orange juice. Each specimen was challenged 3x/day/5 min during 5 days. Only C and D were abraded after immersion in orange juice.

ESPE, St. Paul, MN, USA) (three-step etch-and-rinse), Adper Single Bond 2 (3M ESPE) (two-step etch-and-rinse) and Clearfil SE Bond (Kuraray CO., LTD, Osaka, Japan) (two-step self-etching). For all DBS, acid-etching on enamel was made with 37% phosphoric acid (Dentsply, Catanduva, SP, Brazil) for 30s to MP and SB and for 20 s to SE, as recommended by the manufacturers. Acid was removed by air-water spray for the same time of the etching step. All DBSs were applied according to the manufacturers, as described in Table 3, and light cured using a LED unit (Radii-cal- SDI, Bayswater, Victoria, Australia), with 1,000 mW/cm². Two increments of 2 mm-layer of the composite Filtek™ Z250 Universal Restorative® (3M ESPE, A2 shade) were inserted on enamel surfaces and light cured for 20 s each. The specimens were then immersed in deionized

water for 24 h at 37 °C.

Microtensile Bond Strength Test

Each block per group was longitudinally sectioned; perpendicularly to the bonding interface using an Isomet 1000 digital saw (Buehler, Lake Bluff, IL, USA). An average of 6 to 8 of 1mm²-beams per block were obtained and measured using a digital caliper (Mitutoyo digital caliper, Mitutoyo America, Aurora, IL, USA). Each beam was fixed to the Bencor Multi-T testing apparatus (Danville Engineering Co., Danville, CA, USA) with cyanoacrylate resin (Super Bonder Flex Gel- Loctite, Henckel Ltda, Itapevi, SP, Brazil) and submitted to μTBS in a universal testing machine (Emic, São José dos Pinhais, PR, Brazil) operating at a 0.5mm/min crosshead speed and 50N load cell. After testing, the

Table 1. Erosive/ abrasive challenges

Groups*	Letters	Treatments
Cont	A	Not challenged
Ero	B	Specimens daily challenged for 3x/day/5 min with orange juice, during 5 days
Abr	C	Specimens daily brushed with dentifrice (Oral B Pró Saúde, Oral B, São Paulo, SP, Brazil) solution (1:3) fluoride (1,450 ppm) and an electric toothbrush (Cross action Power / Oral B, São Paulo, SP, Brazil) for 3x/day/1 min, during 5 days
Ero+Abr	D	Specimens daily challenged for 3x/day/5 min with orange juice, followed by brushing with dentifrice (Oral B Pró Saúde, Oral B, São Paulo, SP, Brazil) solution (1:3) fluoride (1,450 ppm) and electric toothbrush (Cross action Power / Oral B, São Paulo, SP, Brazil) for 3x/day/1 min, during 5 days

* For each palatal appliance

Table 2. Composition of orange juice and fluoride toothpaste

Product	Composition	pH
Fluoride Toothpaste (Oral B Pró Saúde, Oral B, São Paulo, SP, Brazil)	Sodium fluoride (1,450 ppm), aqua, sorbitol, silica, sodium lauryl sulfate, cellulose gum, stannous chloride, sodium gluconate, carrageenan, zinc citrate, titanium dioxide.	6.9
Orange Juice (Suco Del Valle do Brasil, Coca-Cola, Americana, SP, Brazil)	Water, sugar, orange juice concentrate, natural flavor, citric acid and antioxidant ascorbic acid.	3.1

Table 3. Protocol Application of each DBS

Dentin Bonding Agent	Protocol Application
Adper Scotchbond Multi Purpose (MP)	1. Acid etching for 30 s; 2. Wash for 30 s; 3. Dry with absorbent paper; 4. Apply primer and volatilization with air dry for 5 s; 5. Apply Bond; 6. Light-cure for 20 s
Adper Single Bond 2 (SB)	1. Acid etching for 30 s; 2. Wash for 30 s; 3. Dry with absorbent paper; 4. Apply two consecutive layers of bond and volatilization with air dry for 15 s; 5. Light-cure for 10 s
Clearfil SE Bond (SE)	1. Acid etching for 20 s; 2. Wash for 20 s; 3. Dry with absorbent paper; 4. Dry with absorbent paper; 5. Apply primer and wait for 20 s; 6. Volatilization with air dry; 7. Apply bond and create a uniform film using a gentle air stream; 8. Light cure for 10 s

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μ TBS was expressed in MPa as derived from dividing the maximum load (kgf) by the bond cross-sectional area (cm^2).

Failure Mode Analysis

After bonding tests, each fractured surface was analyzed with a handle digital microscope (DINO-LITE^{plus} digital microscope, AnMo Electronics Corporation, Hsinchu- China) at 40x magnification and was categorized according to failure as: adhesive, mixed, cohesive in enamel or cohesive in resin failures.

Statistical Analysis

Data was calculated and statistically analyzed with Statistica software (Statsoft®, Tulsa, OK, USA). The assumptions of normal distribution and of equality of variances were checked for all the variables using Kolmogorov-Smirnov and Levene test, respectively. As the assumptions were satisfied, data was analyzed by

two-way ANOVA and Tukey tests ($p < 0.05$). Scanning electronic microscopy (SEM) - Two additional specimens were prepared according to the same challenge protocols for SEM evaluation. These specimens were mounted in stubs, sputter coated with gold, and examined using a SEM (JSM T220A) at $\times 500$.

Results

Bond strength means and standard deviations are summarized in Table 4. Data revealed significance only for DBS ($p = 0.006$). There were no significant differences related nor to challenge neither to any interactions among these factors evaluated: challenge ($p = 0.514$), DBS \times challenge ($p = 0.284$). Also, when volunteer effect was evaluated, it was not significant either ($p = 0.990$) even when interacted with adhesive system ($p = 0.157$), challenge ($p = 0.244$) or with both the factors ($p = 0.473$).

Regarding the results in terms of DBS, SE was the DBS that even did not exhibit the greater values in all conditions overall, it did not differ to the other tested DBSs after any challenge. SB and MP statistically differed according to their performance in all situations.

Description of the distribution of failure modes is presented in Table 5. Adhesive and mixed failure modes were predominant, which also state for a reliable test.

Discussion

As this investigation was partially performed intraorally, it was necessary to sterilize the specimens before their application. Based on the literature (13), the main concern is associated when formaldehyde is used to sterilize dentin as it can promote the chemical fixation of the collagen fibrils and alter their mechanical and biological properties. However, as enamel compound is mostly based on inorganic matrix (hydroxyapatite), there is no evidence of alterations using formaldehyde, in terms of bonding effect.

The results demonstrated significant differences in the adhesion according to DBSs, thus the first null hypothesis was rejected, as the bond strength was material-dependent. In the control group, Adper Single Bond 2 presented the highest means of bond strength to enamel, which showed no statistical difference to Clearfil SE Bond. However, it differed statistically to Adper Scotchbond Multipurpose, which presented the lowest means. When these results are compared to the other three challenged conditions, it is highlighted that Clearfil SE Bond was the unique DBS that was not affected in any situation.

For the etch-and-rinse DBSs (Adper Scotchbond

Table 4. Microtensile bond strength values in MPa

Adhesive Systems	Cont	Ero	Ero+Abr	Abr
MP	22.19 (6.19)B	36.71(26.72)A	26.42(5.61)AB	22.15(5.61)B
SB	36.84(19.61)A	23.00(4.94)B	33.77(19.03)A	29.77(4.71)AB
SE	29.10(7.22)AB	29.21(5.08)AB	31.04(11.88)A	32.46(8.44)A

MP= Adper Scotchbond Multi Purpose; SB= Adper Single Bond 2; SE= Clearfil SE Bond. N=8; $p > 0.05$. Different letters indicate differences in the comparison of the DBS in each column (challenges).

Table 5. Failure mode distribution (%) according to each challenge and dentin bonding system

Adhesive System	Failure Mode	Cont	Ero	Abr	Ero+Abr
MP	M	47.37%	47.00%	67.00%	57.14%
	A	21.05%	41.00%	14.00%	21.43%
	CE	31.58%	0.00%	19.00%	21.43%
	CR	0.00%	12.00%	0.00%	0.00%
SB	M	57.89%	42.00%	53.00%	37.50%
	A	26.32%	25.00%	41.00%	37.50%
	CE	10.53%	33.00%	6.00%	25.00%
	CR	5.26%	0.00%	0.00%	0.00%
SE	M	55.56%	60.00%	58.00%	38.89%
	A	27.78%	30.00%	21.00%	27.78%
	CE	16.67%	10.00%	21.00%	33.33%
	CR	0.00%	0.00%	0.00%	0.00%

A= adhesive, M=mixed, CE=cohesive in enamel, CR= cohesive in resin.

Multipurpose/ three-step and Adper Single Bond 2/ two-step), previous studies displayed that etching with phosphoric acid permitted to remove bulk enamel in a range between 0.2 to 11.7 μm , depending on its concentration, form and time of etching (15). Based on the role of acid conditioning on enamel surface, a standard pattern of conditioning is expected as shown in Figure 2B. For all conditions, SB and MP varied from values of minimal to maximum BS in the comparison of the DBSs. Maybe it could be partially related to two main reasons: the variation of deep range after acid mineral removal of the surface and the composition of the two materials that interacted with the surface. It is relevant to emphasize that the etch-and-rinse systems investigated in the present study, showed greater standard deviations compared to the self-etching system. Even these variations were observed, the data was homogeneous and also the volunteer effect was considered to discard any bias in the interpretation of them. Therefore it seems appropriate to suggest that the etch-and-rinse systems were more susceptible to interact to the altered surfaces. When the surfaces shown in the Figures 2A, 3A, 4A and 5A are compared, differences on the challenged enamel allowed suggesting that these differences could exert these differences. Also, it is important to emphasize that as the surface was prepared, the aprismatic layer was removed during the polishing procedure before acid conditioning. Therefore, the most homogeneous layer was removed before.

Regarding the self-etching systems, as the Clearfil SE Bond system, an average of 0.5 μm thickness of enamel is conditioned. Evidences revealed an unstable interface, which encouraged the previous use of phosphoric acid as etch-and-rinse systems (16). Through previous SEM observations, self-etching primer created a weaker etched

pattern on the enamel surface than phosphoric acid. For this reason, it has been recommended the employment of phosphoric acid before its application as well (16), as was performed in the present study.

Clearfil SE Bond system present 10-methacryloyloxydecyl-dihydrogen phosphate (MDP) as a relevant ingredient, a phosphate and bifunctional monomer that is able to bind chemically to dental substrate, which could explain the more stable μTBS . MDP monomer form a nanolayer with the deposition of Ca - MDP stable salt in the adhesive interface, thereby increasing the mechanical strength. On enamel surface, previous phosphoric acid is also recommended for Clearfil SE bond application and this DBS is able to bind to remainder Ca content.

Regarding the analysis of the bonding enamel surface, erosive and/or abrasive challenges showed no significant differences in adhesion, thus the second null hypothesis was accepted.

It is important to state that the used challenge protocols were based on the simulation of erosion used mainly in *in vitro* investigations, which showed its impact on the surface based on profilometric and hardness assessments (4,17). However, its effect on bonding property and under *in situ* simulations was not discussed yet.

Based on the previous studies that evidenced structural compromising of enamel when subjected to erosive/abrasive challenges (18), it was necessary to check if these alterations would damage on the establishment of a homogeneous resin-enamel interface somehow (7,19). In this study, industrialized orange juice (pH 3.1) was used to promote erosion. Barac et al. (20) demonstrated that erosion of the enamel surfaces exposed to orange juice was directly proportional to the exposure time. In the present study, we artificially reproduced erosive attack by 5-min

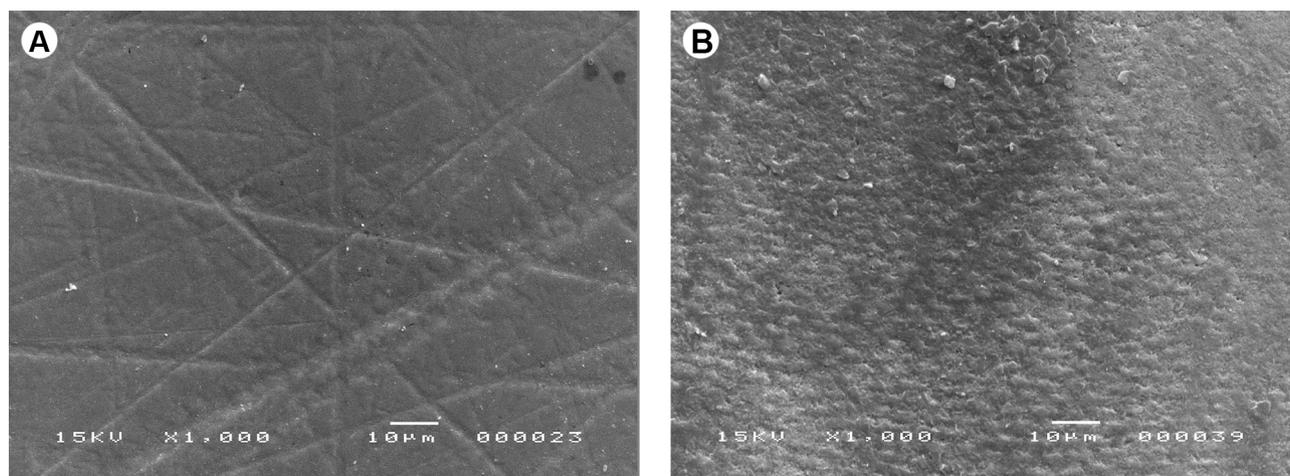


Figure 2. A: Surface of control polished bovine enamel. Some scratches resulted from the polishing procedure are observed. B: Surface of control group after etching with phosphoric acid gel. The standard pattern of prisms exposures is observed, presenting surface irregularities.

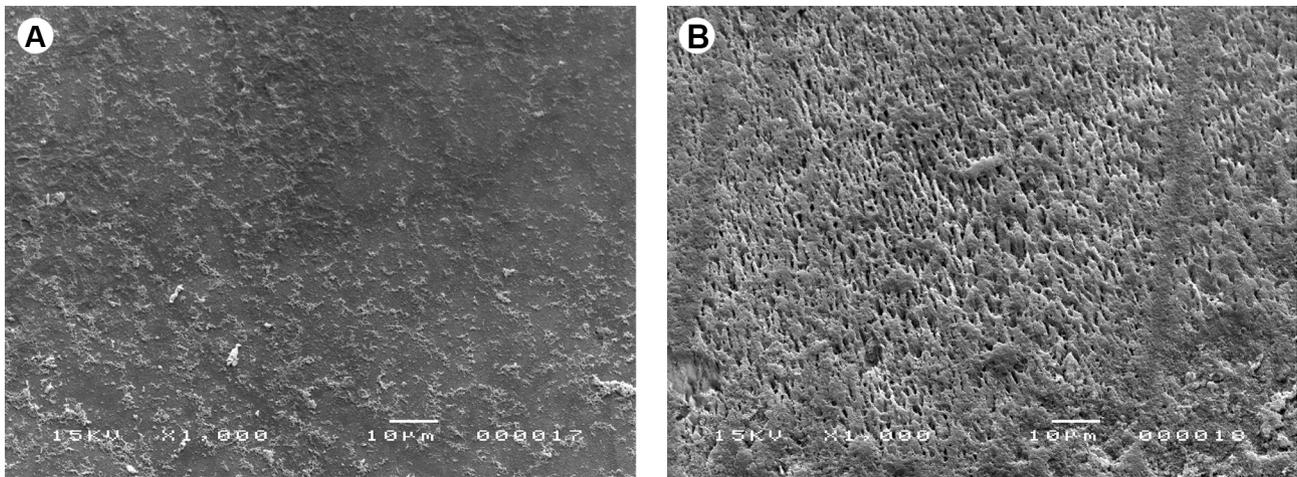


Figure 3. A: Surface of eroded bovine enamel. Evidence of demineralization of the surface, with presence of irregularities promoted by the erosive challenge. B: Surface of eroded bovine enamel after etching with phosphoric acid gel. The standard pattern of prisms exposures is observed more intensive compared to not challenged condition.

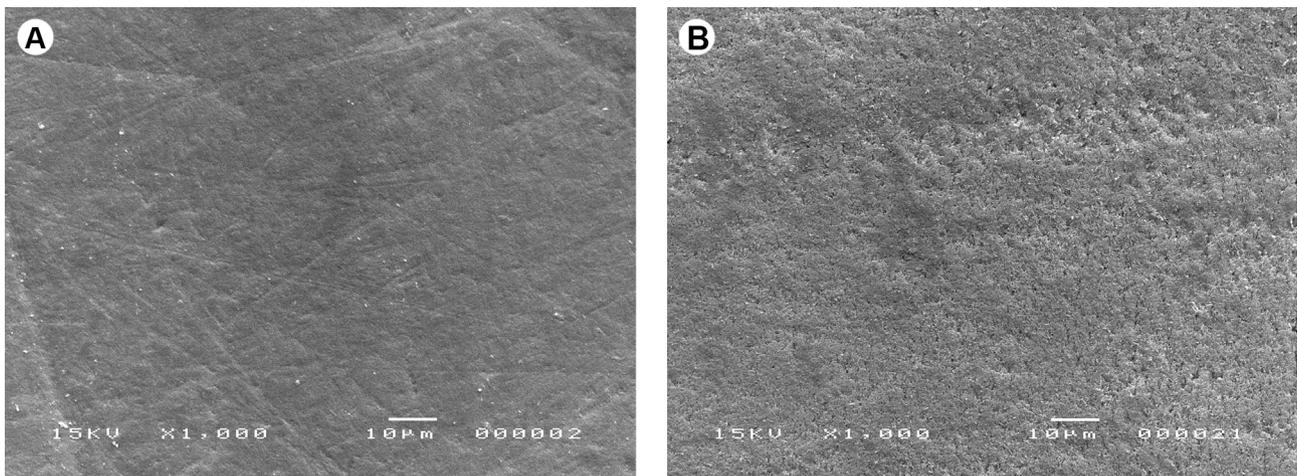


Figure 4. A: Surface of abraded bovine enamel. Discrete scratches are observed on the surface, specially compared to control group. B: Surface of abraded bovine enamel group after etching with phosphoric acid gel. The surface irregularities were more discrete.

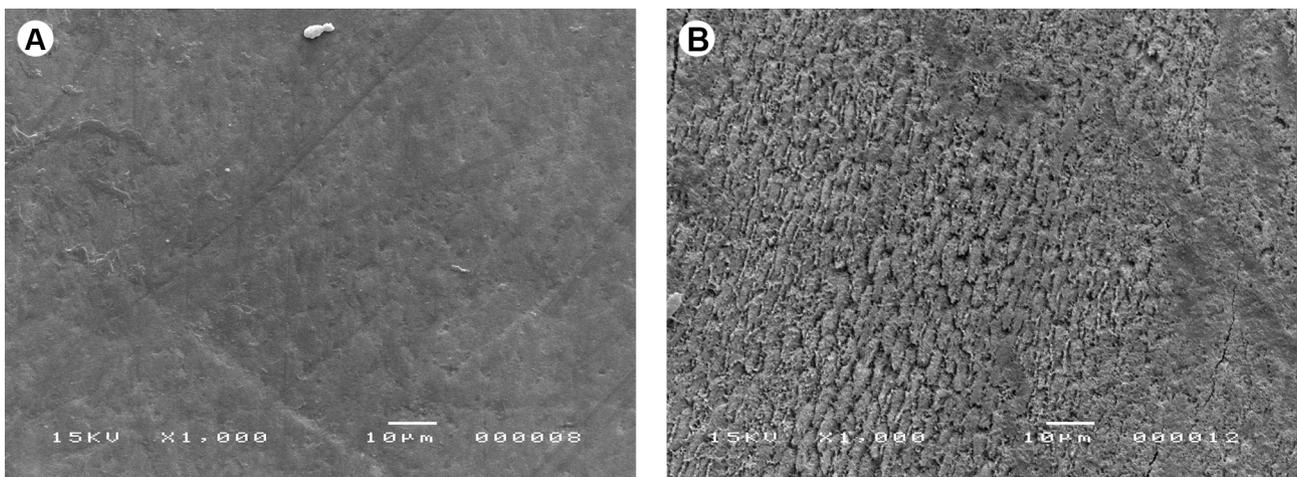


Figure 5. A: Surface of eroded/abraded bovine enamel. Discrete demineralization on the surface is observed. B: Surface of eroded/abraded bovine enamel after etching with phosphoric acid gel. More intense irregularities were shown.

immersion in orange juice. Based on the comprehension of the mechanism of erosion in two distinct phases, softening and wear (2), it seems reasonable to expect that phosphoric acid gel, with pH around 0.5, creates microporosities deeper than that provoked by orange juice, and thus, it is able to standardize the surface and be enough to favor for the penetration of the dentin bonding systems.

Usually it is expected for a simple and safe bonding to enamel, in which the adhesive resins penetrate into acid-etched enamel prisms and envelop apatite crystallites (16). Figure 2A, shows a representative aspect of sound enamel. After etching with phosphoric acid gel (Fig. 2B) prisms exposures are observed. These figures represent the expected standard situation. When enamel is somehow altered, changes in this substrate might affect the bond strength, failure mode, and the tag formation (16). Enamel solubility, in part, depends on the individual biologic variation in their structural arrangement and composition (4,13). However, some other factors also may be considered, as the enamel response to the frequent oral challenges and fluoride exposition for instance (21). As erosion attacks mineral content of enamel by removing them, this variation may determine varied alterations (17). The superficial softened layer can vary on a range of 20 μm , which is considered a fragile surface and should represent a poorly mineralized layer with no loss of substance (17). Eroded surface (Fig. 3A), has a different pattern compared to the sound enamel, with signs of demineralization and presence of irregularities on surface. However, when eroded enamel was etching with phosphoric acid gel (Fig. 3B) a more intense pattern of prisms exposures compared to not challenged condition (control or abraded) is observed. Abraded enamel (Fig. 4A) shows a slight increase of scratches, even so close to the sound enamel, as expect for this situation. When eroded/ abraded surfaces was analyzed (Fig. 5A) a discrete demineralization on the surface is observed and after etching (Fig. 5B), more intense irregularities were shown. The surface after challenge and after acid etching is closer to the noticed for eroded specimens in both conditions, respectively, suggesting that the erosion protocol may exert a potential alteration in this substrate, even it is not evidenced under bonding tests.

With increasing erosion episodes, substance loss by far exceeds subsurface mineral loss. However, clinically it is not possible to assure if the substrate is actually softened by the mineral loss only or if wear already occurred. Therefore, the bonding procedure can be performed on an altered substrate. In this study, dental erosion was simulated with orange juice, seeing that this beverage is considered one of the most aggressive in the erosive potential. The intention was to provoke a situation consistent with what occurs clinically (22).

Thus, all the tested systems probably reached similar pattern of etching as all of them were previously treated with phosphoric acid before adhesive application. Etched enamel surface provides increasing of available area for adhesion, through providing microporosities which facilitates penetration of adhesive, promoting a mechanically adhesion of resin polymerized to enamel (23). Cruz et al. (24) found that there is no difference in bonding effectiveness in eroded bovine enamel among adhesive systems Adper Single Bond 2 and Clearfil SE Bond, when phosphoric acid was used, which is in accordance to the results from the present study.

Taking it into account, it was expected that eroded or abraded enamel result in a more irregular substrate, which in turn could be advantageous to bonding as these substrates increase the area for wettability and penetration of these systems (19). Probably, this may not exert any impact, probably due to the *in situ* protocol. Saliva seems to play an important role in minimizing enamel wear in erosive/abrasive attack. The buffering capacity, calcium and phosphate contents of saliva and the acquired pellicle may counteract the erosive attacks, by reducing enamel loss and softening, enhancing its rehardening and minimizing the surface wear by subsequent tooth-brushing procedures (11).

Additionally, when investigations are carried out using *in situ* models, a closer situation to actual oral environment is allowed, with the presence of saliva and formation of an acquired pellicle (5,22). Saliva may minimize the impact of these challenges as well due to its properties of buffering capacity and ability do neutralize acidic products (3,12-14). Even previous studies evidenced actual changes on enamel surface; the preconditioning with phosphoric acid would be enough to promote a reactive surface for bonding process, without the indication of roughening and allowing a more conservative approach (22).

The results of this experiment contribute to support that no additional treatment may be required before bonding to eroded/abraded enamel surfaces. Even previous studies evidenced actual changes on enamel surface; the preconditioning with phosphoric acid would be enough to promote a reactive surface for bonding process, without the indication of roughening and allowing a more conservative approach.

Resumo

Este estudo avaliou o impacto de suco de laranja na resistência de união (RU) de sistemas adesivos dentinários (SAD) à superfície do esmalte após a simulação com uma ciclagem erosiva *in situ* *ex vivo*. Cento e noventa e dois fragmentos de esmalte bovino (4x4x2mm) foram obtidos e randomizados considerando a microdureza superficial, e distribuídos em dispositivos palatinos para 8 voluntários, em três fases (uma para cada SAD), contendo 8 blocos, os quais foram alocados em 4 pares. Diariamente, esses pares eram submetidos às seguintes condições extraoralmente: CONT- sem desafio erosivo ou abrasivo; ERO- desafio erosivo somente;

ABR- desafio abrasivo somente; e ERO+ABR- com desafio erosivo e abrasivo. A ciclagem erosiva (imersão em suco de laranja, 3 vezes/dia/5 min/5 dias) e/ou ciclagem abrasiva (escova dentária elétrica, 3 vezes/dia/1 min/5 dias) foram feitas. Após estas ciclagens, todos os espécimes foram restaurados com os sistemas adesivos Adper Scotchbond Multi Purpose (MP), Adper Single Bond 2 (SB) ou Clearfil SE Bond (SE), e com a resina composta Filtek Z250. Após 7 dias, palitos (área ≈1 mm) eram obtidos e submetidos ao teste de resistência de união por microtração (μTBS) a 0,5 mm/min. Os dados foram estatisticamente analisados por ANOVA e teste de Tukey ($\alpha=0,05$). Os modos de fratura foram determinados utilizando um microscópio digital (40×). SAD foi o único fator estatisticamente significativo. SE foi o único SAD não afetado por qualquer desafio, enquanto o MP e o SB apresentaram um desempenho de acordo com o cenário. As fraturas do tipo mista e adesiva foram predominantes em todos os grupos. O desempenho geral sugeriu que RU ao esmalte após desafio erosivo/abrasivo por suco de laranja não foi afetada e foi material-dependente.

Acknowledgements

This study was supported by Foundation for Research Support of the State of São Paulo (FAPESP) (grant 2010/01442). Authors are also grateful for Oral B for material donation.

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Received June 28, 2016
Accepted August 4, 2016