A New Universal Simplified Adhesive: 6-Month Clinical Evaluation

ALEXANDRA MENA-SERRANO, DDS, MS*, **CARLOS KOSE,** DDS, MS*, **ELOISA ANDRADE DE PAULA,** DDS, MS*, **LIDIA YILENG TAY,** DDS, MS*, **ALESSANDRA REIS,** DDS, PhD†, **ALESSANDRO D. LOGUERCIO,** DDS, MS, PhD†, **JORGE PERDIGÃO,** DMD, MS, PhD‡

ABSTRACT

Statement of the Problem: Multimode adhesives, which can be used as etch-and-rinse or as self-etch adhesives, have been recently introduced without clinical data to back their use.

Purpose of the Study: To evaluate the 6-month clinical performance of Scotchbond Universal Adhesive (SU; 3M ESPE, St. Paul, MN, USA) in noncarious cervical lesions (NCCLs) using two evaluation criteria.

Methods/Materials: Thirty-nine patients participated in this study. Two hundred restorations were assigned to four groups: SU-TE*m*: etch-and-rinse + moist dentin; SU-TE*d*: etch-and-rinse + dry dentin; SU-SE*et*: selective enamel etching; and SU-SE: self-etch. The composite resin Filtek Supreme Ultra (3M ESPE) was placed incrementally. The restorations were evaluated at baseline and after 6 months using both the World Dental Federation (FDI) and the United States Public Health Service (USPHS) criteria. Statistical analyses were performed with Friedman repeated measures analysis of variance by rank and McNemar test for significance in each pair ($\alpha = 0.05$).

Results: Only four restorations (SU-SE: 3 and SU-TE*m*: 1) were lost after 6 months ($p > 0.05$ for either criteria). Marginal discoloration occurred in one restoration in the SU-SE group ($p > 0.05$ for either criteria). Only 2/200 restorations were scored as bravo for marginal adaptation using the USPHS criteria (one for SU-SE and one for SU-SE*et*, $p > 0.05$). However, when using the FDI criteria, the percentage of bravo scores for marginal adaptation at 6 months were 32%, 36%, 42%, and 46% for groups SU-TE*m*, SU-TE*d*, SU-SE*et*, and SU-SE, respectively ($p > 0.05$).

Conclusions: The clinical behavior of the multimode adhesive does not depend on the bonding strategy at 6 months. The FDI evaluation criteria are more sensitive than the USPHS criteria.

CLINICAL SIGNIFICANCE

At 6 months, the clinical behavior of the new multimode adhesive Scotchbond Universal was found to be reliable when used in noncarious cervical lesions and may not depend on the bonding strategy employed.

(J Esthet Restor Dent 25:55–69, 2013)

INTRODUCTION

One of the disadvantages of etch-and-rinse adhesives is their susceptibility to variations in the degree of dentin moisture.[1,2] The complete filling of the interfibrillar spaces by resin monomers is unfeasible, and an area of exposed demineralized dentin may remain within the bonded interface.[3–5] Consequently, interfacial degradation may occur as a result of the incomplete infiltration of resin monomers into the dentin collagen network.[6,7] In vivo morphological evidence of hydrolysis of collagen has been reported in human primary teeth with bonded restorations.[8] Elution of resin from the bonded

*PhD candidate, Universidade Estadual de Ponta Grossa, Restorative Dentistry, Ponta Grossa, Paraná, Brazil

†Professor, Universidade Estadual de Ponta Grossa, Restorative Dentistry, Ponta Grossa, Paraná, Brazil

‡Professor, Department of Restorative Sciences, University of Minnesota, Minneapolis, Minnesota, USA

 DOI 10.1111/jerd.12005

interface as a result of hydrolysis has also been reported in vitro.[9]

Self-etch adhesives dissolve the smear layer only partially and do not demineralize dentin as deep as etch-and-rinse adhesives.[7] The incorporation of smear layer, resin, collagen, and mineral[10] into the hybrid layer and the superficial portion of the resin tags may prevent postoperative sensitivity that occurs with etch-and-rinse adhesives because of incomplete infiltration of resin monomers into the collagen network.[11,12] On the other hand, self-etch adhesives do not etch enamel to the same depth that phosphoric acid does, resulting in lower enamel bond strengths and frequent occurrence of enamel marginal discrepancies in clinical studies.[11,13] To overcome this limitation, selective etching of enamel margins has been recommended prior to the application of self-etch adhesives.[14,15] For some self-etch adhesives, bond strengths may decrease when they are applied on acid-etched dentin compared with the same adhesive applied in the self-etch mode.[16–18]

Clinically, it is difficult to apply phosphoric acid on enamel without overflowing to dentin, especially if dentists use low-viscosity gels or liquid etchants. Some dentists even dry the enamel surface to check for a frosty aspect of the etched enamel, which would result in air-drying the dentin surface as well. Overdrying acid-etched dentin may prevent collagen fibers from being completely enveloped by resin monomers leading to degradation by hydrolysis and decreased durability of the bonding.[8,19]

In spite of compromised in vitro and clinical longevity associated with ultrasimplified adhesives compared with that of adhesives that rely on several steps,[7,20] several one-step self-etch adhesives have been recently developed to simplify and shorten the application time, making the clinical procedure more user-friendly.[21] Manufacturers have recently launched universal or multimode one-bottle adhesives that can be used as self-etch or as etch-and-rinse adhesives.[22,23] These materials, and the respective concept behind them, are novel; hence, only immediate ultramorphological and bond strength studies have been published.[22,23] Clinical studies are needed to back the use of these new adhesives as suggested by the respective manufacturers, i.e., evaluating the same adhesive under two adhesive strategies: self-etch and etch-and-rinse.

In 2007, several journals published new criteria for evaluation of dental restorations called the "World Dental Federation (FDI) criteria" as a result of the efforts of FDI to organize them.[24,25] Since then, results have so far been only partly published,[25] and only one study compared the FDI criteria with the United States Public Health Service (USPHS) criteria[26] for the evaluation of restorations in primary teeth.[27] This study[27] concluded that the FDI criteria were more sensitive for identifying differences in the restorations. However, this paper[27] is an abstract and has not been published in full article format.

Thus, the aim of this randomized, double-blind clinical trial was to study the influence of different application strategies of a new universal multimode adhesive (Scotchbond Universal Adhesive [SU], 3M ESPE, St. Paul, MN, USA) placed in noncarious cervical lesions (NCCLs) over the course of 6 months using two evaluation criteria (FDI and USPHS criteria). The null hypotheses tested were (1) that bonding to NCCLs using the self-etch strategy, associated or not to enamel etching (selective etching), or using the etch-and-rinse strategy applied on dry or moist dentin, would not result in similar clinical performance over 6 months of clinical service, and (2) that different evaluation criteria, FDI or USPHS criteria, would not result in different outcomes for the same data.

MATERIALS AND METHODS

Study Design

The experimental design followed the Consolidated Standards of Reporting Trials (CONSORT) statement.[28] This was a randomized, double-blind, clinical trial. The study took place in the clinic of the State University of Ponta Grossa School of Dentistry from January 2011 to November 2011. All participants were informed about the nature and objectives of the study; however, they were not aware of what lesion received the treatments under evaluation.

DOI 10.1111/jerd.12005

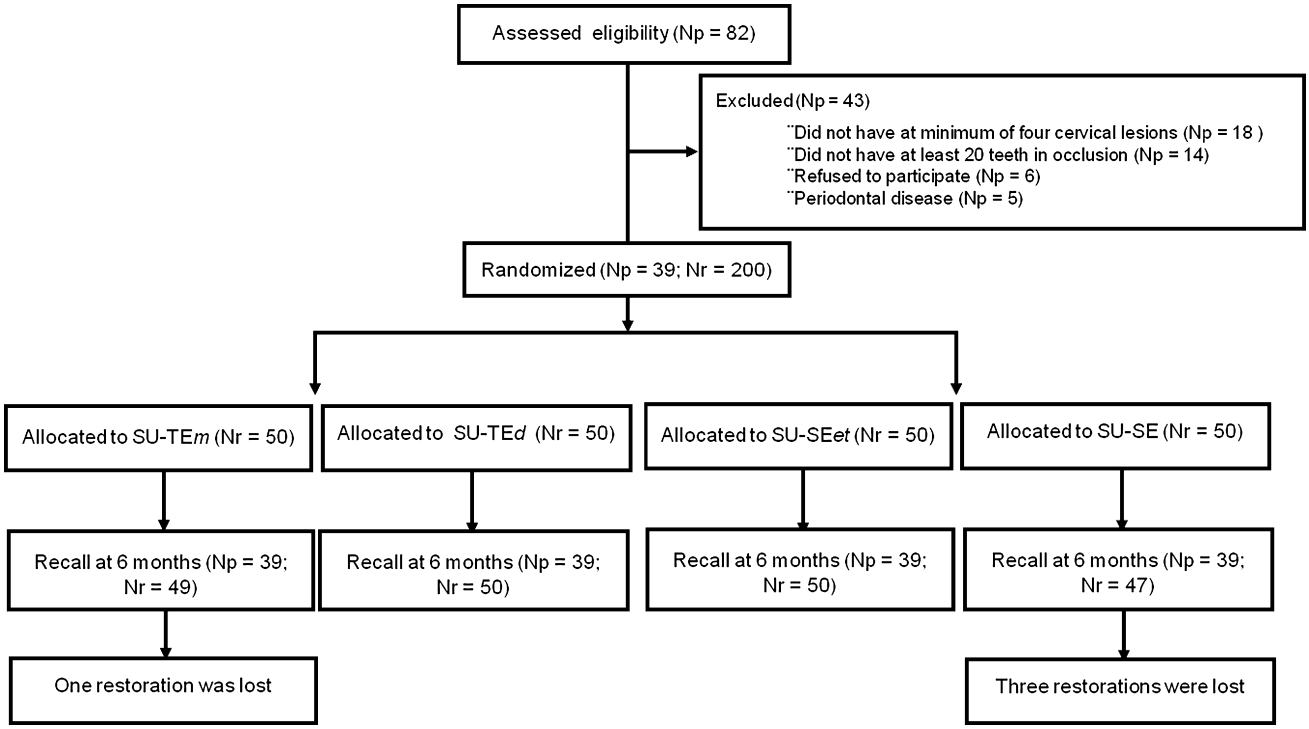

FIGURE 1. Flow diagram. Np = number of patients; Nr = number of restorations; SU-SE = self-etch; SU-SE*et* = selective enamel etching; SU-TE*d* = etch-and-rinse, dry dentin; SU-TE*m* = etch-and-rinse, moist dentin.

Participant Selection

The Local Ethics Committee on Investigations Involving Human Subjects reviewed and approved the protocol and consent form for this study (protocol 05909/11). Written informed consent was obtained from all participants before starting treatment. Based on preestablished criteria, 39 volunteers were selected for this study (Figure 1).

Inclusion and Exclusion Criteria

A total of 82 participants were examined to check if they met the inclusion and exclusion criteria (Figure 1) by two precalibrated operative dentistry residents. The qualified patients were recruited in the order in which they reported for the screening session, thus forming a convenience sample.

The evaluations were performed using a mouth mirror, an explorer, and a periodontal probe. Participants had to be in good general health and at least 18 years old. They needed to have an acceptable oral hygiene level and present at least 20 teeth under occlusion. They were required to have at least four NCCLs in four different teeth with a maximum of six lesions that needed to be restored. These lesions had to be noncarious, nonretentive, and deeper than 1 mm, and involve both the enamel and dentin of vital teeth without mobility. The cavosurface margin could not involve more that 50% of enamel.[29]

All patients were given oral hygiene instructions before operative treatment was performed. Patients with extremely poor oral hygiene, severe or chronic periodontitis, or heavy bruxism habits were excluded from the study.

Interventions: Restorative Procedure

All the volunteer participants received a dental prophylaxis with pumice and water in a rubber cup and signed an informed consent form 2 weeks before the restorative procedures.

 DOI 10.1111/jerd.12005

TABLE 1. Dentin sclerosis scale*

Category	Criteria
1	No sclerosis present; dentin is light yellowish or whitish, with little discoloration; dentin is opaque, with little translucency or transparency
2	More sclerosis than in category 1 but less than halfway between categories 1 and 4
3	Less sclerosis than in category 4 but more than halfway between categories 1 and 4
4	Significant sclerosis present; dentin is dark yellow or even discolored (brownish); glassy appearance, with significant translucency or transparency evident

*Adapted from Swift and colleagues.[30]

The features of the NCCLs were evaluated prior to the placement of the restorations. The degree of sclerotic dentin was measured according to the criteria described by Swift *et al*.[30] (Table 1). The cavity dimensions in millimeters (height, width, and depth) and the geometry of the cavity (evaluated by photograph profile and labeled at <45°, 45–90°, 90–135°, >135°) were also recorded. Other features such as the presence of antagonist and attrition facets were also observed and recorded. Preoperative sensitivity was evaluated by applying air for 10 seconds from a dental syringe placed 2 cm from the tooth surface. For the calibration procedure step, the study director placed one restoration of each group in order to identify all steps involved in the application technique. Then, all four operators, who were resident dentists with over 5 years of clinical experience in operative dentistry, placed four restorations of each group under the supervision of the study director in a clinical setting. The restoration deficiencies were shown to the operators prior to starting the study. At this point, the operators were considered calibrated to perform the restorative procedures.

The same calibrated operators restored all teeth under the supervision of the study director. All subjects received a minimum of four restorations, one of each experimental group, in different lesions previously selected according to the inclusion criteria.

The randomization process within patients was performed by computer-generated tables by a staff member not involved in the research protocol. Details of the allocated group were recorded on cards contained in sequentially numbered, opaque, sealed envelopes. These were prepared by a person not involved in any of the phases of the clinical trial. The allocation assignment was revealed by opening the envelope on the day of the restorative procedure. The operator was not blinded to group assignment when administering interventions; however, participants were blinded to the group assignment.

Before placing the rubber dam, the operators anesthetized the teeth with 3% mepivacaine solution (Mepisv, Nova DFL, Rio de Janeiro, RJ, Brazil) and cleaned all lesions with pumice and water in a rubber cup, followed by rinsing and drying. Using a shade selection guide, the proper shade of the composite was determined. Following the American Dental Association (ADA) guidelines,[31] the operators did not prepare any additional retention or bevel.

Then, the NCCLs received the SU system applied in different modes: the etch-and-rinse approach, keeping the dentin moist (SU-TE*m*) or dry (SU-TE*d*), and in the self-etch approach with (SU-SE*et*) or without selective enamel etching (SU-SE). The compositions, application modes, and batch numbers are described in Table 2.

In the SU-TE*m* group, dentin was kept visibly moist, whereas in the SU-TE*d* group, dentin was air-dried for 5 seconds, but not overdried. In the SU-SE*et* group, the lesion was air-dried after rinsing the etchant from the enamel. Dentin was kept dry in both SE groups. The adhesive was vigorously agitated on the entire dentin surface in all groups for approximately 20 seconds, according to the manufacturer's recommendations (Table 2). The brush was scrubbed on the dentin surface under manual pressure (equivalent to approximately 45 g or more) followed by gentle air thinning for 5 seconds and finally light-curing (Radii Cal, SDI, Bayswater, Victoria, Australia) for 10 seconds (1,000 mW/cm^2).

 DOI 10.1111/jerd.12005

TABLE 2. Adhesive system: composition and application mode

Adhesive systems	Composition	Application mode*			
Scotchbond Universal Adhesive (3M ESPE, St. Paul, MN, USA)	1. Scotchbond Universal Etchant: 34% phosphoric acid 2. Adhesive: methacryloyloxydecyl dihydrogen phosphate, phosphate monomer, dimethacrylate resins, hydroxyethyl methacrylate, methacrylate-modified polyalkenoic acid copolymer, filler, ethanol, water, initiators, silane	Etch-and-rinse	Apply etchant for 15 seconds. Rinse for 10 seconds. Air dry to remove excess water.	Keep dentin moist.	Apply the adhesive for 20 seconds with vigorous agitation. Gently air thin for 5 seconds. Light-cure for 10 seconds.
				Keep dentin dry; do not overdry.	
		Selective etching	Apply etchant only on enamel for 15 seconds. Rinse for 10 seconds. Air dry to remove excess water.	Keep dentin dry; do not overdry.	
		Self-etch	Do not use etchant.	Keep dentin dry; do not overdry.	

*According to the manufacturer's instructions.

Filtek Supreme Ultra (3M ESPE) resin composite was used in three increments, each one being light-cured for 30 seconds. The restorations were finished immediately with fine-grain diamond burs (KG Sorensen, Barueri, SP, Brazil). Polishing was performed with rubber points (Astropol, Ivoclar Vivadent, Schaan, Liechtenstein) 1 week after placement of the restorations.

Sample Size Calculation

The retention rate of SU in the etch-and-rinse approach was considered based on the retention rate of Adper single bond (3M ESPE). It was considered 94% at 18- to 24-month follow-up.[32–37] Using an α of 0.05, a power of 80%, and a two-sided test, the minimal sample size was 50 restorations in each group in order to detect a difference of 20% among the tested groups.[38]

Clinical Evaluation

Two experienced and calibrated dentists, not involved with the placement of the restorations and therefore blinded to the group assignment, performed the evaluation. For training purposes, the examiners observed 10 photographs that were representative of each score for each criterion. They evaluated 10 to 15 subjects each on 2 consecutive days. These subjects had cervical restorations and they did not participate in this project. An intraexaminer and interexaminer agreement of at least 85% was necessary before the beginning of the evaluation.[26]

All parameters during evaluation were recorded using a standardized paper case report form. The evaluation paper had to be sent after each observation to the research auxiliary, so that evaluators were blinded to group assignment during follow-up recalls.

The restorations were evaluated by two criteria: the FDI criteria[24,25] and the classical USPHS criteria adapted by Dalton Bittencourt *et al*.[39] and Perdigão *et al*.[37] at baseline and after 6 months of clinical service.

For either of the two criteria, only the clinically relevant measures of performance of adhesives were evaluated. For example, wear and color match were not considered as relevant parameters (Tables 3 and 4). The primary clinical endpoint was restoration retention/fractures, but the following secondary endpoints were also evaluated: marginal staining, marginal adaptation, postoperative sensitivity, and recurrence of caries. The evaluation of the postoperative sensitivity was performed 1 week after the restorative procedure by applying air for 10 seconds from a dental syringe placed 2 cm from the tooth surface.

 DOI 10.1111/jerd.12005

TABLE 3. World Dental Federation (FDI) criteria used for clinical evaluation[24,25]

	Esthetic property	**Functional properties**		**Biological properties**	
	1. Marginal staining	**2. Fractures and retention**	**3. Marginal adaptation**	**4. Postoperative (hyper) sensitivity**	**5. Recurrence of caries**
1. Clinically very good	1.1 No marginal staining.	2.1 Restoration retained, no fractures/cracks.	3.1 Harmonious outline, no gaps, no discoloration.	4.1 No hypersensitivity.	5.1 No secondary or primary caries.
2. Clinically good (after correction very good)	1.2 Minor marginal staining, easily removable by polishing.	2.2 Small hairline crack.	3.2.1 Marginal gap (50 μm). 3.2.2 Small marginal fracture removable by polishing.	4.2 Low hypersensitivity for a limited period of time.	5.2 Very small and localized demineralization. No operative treatment required.
3. Clinically sufficient/satisfactory (minor shortcomings with no adverse effects, but not adjustable without damage to the tooth)	1.3 Moderate marginal staining, not esthetically unacceptable.	2.3 Two or more or larger hairline cracks and/or chipping (not affecting the marginal integrity).	3.3.1 Gap <150 μm not removable. 3.3.2 Several small enamel or dentin fractures.	4.3.1 Premature/slightly more intense. 4.3.2 Delayed/weak sensitivity, no subjective complaints, no treatment needed.	5.3 Larger areas of demineralization, but only preventive measures necessary (dentin not exposed).
4. Clinically unsatisfactory (repair for prophylactic reasons)	1.4 Pronounced marginal staining; major intervention necessary for improvement.	2.4 Chipping fractures that damage marginal quality; bulk fractures with or without partial loss (less than half of the restoration).	3.4.1 Gap >250 μm or dentin/base exposed. 3.4.2 Chip fracture damaging margins. 3.4.3 Notable enamel or dentin wall fracture.	4.4.1 Premature/very intense. 4.4.2 Extremely delayed/weak with subjective complaints. 4.4.3 Negative sensitivity intervention necessary but not replacement.	5.4 Caries with cavitation (localized and accessible and can be repaired).
5. Clinically poor (replacement necessary)	1.5 Deep marginal staining not accessible for intervention.	2.5 Partial or complete loss of restoration.	3.5 Filling is loose but in situ.	4.5 Very intense, acute pulpitis or nonvital. Endodontic treatment is necessary and restoration has to be replaced.	5.5 Deep secondary caries or exposed dentin that is not accessible for repair of restoration.
Acceptable or not acceptable (*N*, % and reasons)	Esthetic criteria.	Functional criteria.		Biological criteria.	

These variables were ranked according to the criteria in the following scores: FDI criteria (clinically very good, clinically good, clinically sufficient/satisfactory, clinically unsatisfactory, and clinically poor) and USPHS criteria (*alfa*, *bravo*, and *charlie*). In the case of marginal staining and marginal adaptation, the semiquantitative criteria (SQUACE) proposed by Hickel *et al*. was used.[24,25] Each evaluator outlines the extent of the observed event on the sketch of each restoration using a pen according to defined criteria (marginal staining and marginal adaptation); after that, each margin is assessed quantitatively as a proportion of the total length of the margin.

Both examiners evaluated all the restorations once and independently. When disagreements occurred during the evaluations, they had to reach a consensus before the participant was dismissed.

 DOI 10.1111/jerd.12005

TABLE 4. Modified United States Public Health Service (USPHS) criteria according to Dalton Bittencourt *et al*.[39] and Perdigão *et al*.[37]

	Marginal staining	Retention	Fracture	Marginal adaptation	Postoperative sensitivity	Recurrence of caries
Alfa	No discoloration along the margin	Retained	None	Restoration is continuous with existing anatomic form	No postoperative sensitivity directly after the restorative process and during the study period	No evidence of caries contiguous with the margin
Bravo	Slight and superficial staining (removable, usually localized)		Small chip, but clinically acceptable	Detectable V-shaped defect in enamel only. Catches explorer going both ways	–	–
Charlie	Deep staining cannot be polished away	Missing	Failure due to bulk restorative fracture	Detectable V-shaped defect to dentin-enamel junction	Sensitivity present at any time during the study period	Evidence of presence of caries

The restoration retention rates were calculated according to the ADA guidelines.[31] Cumulative failure percentage = $[(PF + NF)/(PF + RR)] \times 100\%$, where PF is the number of previous failures before the current recall, NF is the number of new failures during the current recall, and RR is the number of currently recalled restorations.[31]

Statistical Analysis

The statistical analyses followed the intention-to-treat protocol according to CONSORT suggestion.[28] This protocol includes all participants in their originally randomized groups, even those that were not able to keep their scheduled recall visits. This approach is more conservative and less open to bias.

Descriptive statistics were used to describe the distributions of the evaluated criteria. Statistical analysis for each individual item was performed, as well as for each property. The differences in the ratings of the four groups after 6 months were tested with the Friedman repeated measures analysis of variance by rank ($\alpha = 0.05$), and differences in the ratings of each group at baseline and after 6 months were evaluated using the McNemar test ($\alpha = 0.05$). SQUACE was evaluated for Kruskall–Wallis and Mann–Whitney tests ($\alpha = 0.05$). Cohen's kappa statistic was used to test interexaminer agreement.

RESULTS

The restorative procedures were implemented exactly as planned, and no modification was performed. The performed analyses had been prespecified in the protocol. No subgroup analysis was done. Forty-three out of 82 patients were not enrolled in the study because they did not fulfill the inclusion criteria. Thus, 39 subjects (28 patients with four restorations and 11 patients with eight restorations) were selected. All details regarding the research subjects and characteristics of the restored lesions are presented in Table 5. The overall Cohen's kappa statistics (0.94) showed good agreement between the examiners. All research subjects were evaluated at the baseline and at 6 months (Figure 1).

Nine restorations had postoperative sensitivity 1 week after the restorative procedures using both the FDI and USPHS criteria (1 for SU-TE*m*, 4 for SU-TE*d*, 3 for SU-SE*et*, and 1 for SU-SE), with no statistical difference when compared with different groups ($p > 0.05$) (Tables 6 and 7). None of the restorations showed postoperative sensitivity under both the FDI and USPHS criteria at the 6-month recall evaluation.

Four restorations were lost at 6 months (1 for SU-TE*m* and 3 for SU-SE) according to FDI and USPHS criteria. Six-month retention rates were 98%

 DOI 10.1111/jerd.12005

TABLE 5. Distribution of noncarious cervical lesions according to research subject (gender and age) and characteristics of Class V lesions (shape, cervicoincisal size of the lesion, degree of sclerotic dentin, presence of antagonistic, presence of attrition facets, presence of preoperative sensitivity, and tooth and arch distribution)

Characteristics of research subjects	**Number of lesions**			
Gender distribution				
Male	24			
Female	15			
Age distribution (years)				
20–29	05			
30–39	12			
39–49	12			
>49	10			
Characteristics of Class V lesions	**Number of lesions SU-TE*m***	**SU-TE*d***	**SU-SE*et***	**SU-SE**
Shape (degree of angle)				
<45				
45–90	14	14	12	12
90–135	34	34	38	38
>135	02	02		
Cervicoincisal height (mm)				
<1.5	06	03	05	07
1.5–2.5	29	36	29	30
2.5–4.0	12	10	14	12
>4.0	03	01	02	01
Degree of sclerotic dentin				
1	20	18	17	19
2	12	14	13	10
3	12	12	09	09
4	06	06	11	12
Presence of antagonist				
Yes	50	50	50	50
No	00	00	00	00
Attrition facet				
Yes	24	22	18	26
No	26	28	32	24
Preoperative sensitivity (spontaneous)				
Yes	0	0	0	0
No	50	50	50	50
Preoperative sensitivity (air dry)				
Yes	24	26	30	28
No	26	24	20	22
Tooth distribution				
Anterior				
Incisor	02	02	02	02
Canines	04	08	06	08
Posterior				
Premolar	32	26	34	28
Molar	12	14	08	12
Arc distribution				
Maxillary	25	26	30	28
Mandibular	25	24	20	22

SU-SE = self-etch; SU-SE*et* = selective enamel etching; SU-TE*d* = etch-and-rinse, dry dentin; SU-TE*m* = etch-and-rinse, moist dentin.

DOI 10.1111/jerd.12005

TABLE 6. Number of evaluated restorations for each experimental group according to the adhesive (SU-TE*m*, SU-TE*d*, SU-SE*et*, and SU-SE classified according to the World Dental Federation (FDI) criteria[24,25]

Time		**Baseline**				**6 Months**			
FDI criteria		**SU-TE*m***	**SU-TE*d***	**SU-SE*et***	**SU-SE**	**SU-TE*m***	**SU-TE*d***	**SU-SE*et***	**SU-SE**
Marginal staining	VG	50	50	50	50	50	50	50	49
	GO	–	–	–	–	–	–	–	01
	SS	–	–	–	–	–	–	–	–
	UN	–	–	–	–	–	–	–	–
	PO	–	–	–	–	–	–	–	–
Fractures and retention	VG	50	50	50	50	49	50	50	47
	GO	–	–	–	–	–	–	–	–
	SS	–	–	–	–	–	–	–	–
	UN	–	–	–	–	–	–	–	–
	PO	–	–	–	–	01	–	–	03
Marginal adaptation	VG	50	50	50	50	34	32	29	27
	GO	–	–	–	–	16	18	21	23
	SS	–	–	–	–	–	–	–	–
	UN	–	–	–	–	–	–	–	–
	PO	–	–	–	–	–	–	–	–
Postoperative (hyper) sensitivity	VG	49	46	47	49	50	50	50	50
	GO	–	–	–	–	–	–	–	–
	SS	01	04	03	01	–	–	–	–
	UN	–	–	–	–	–	–	–	–
	PO	–	–	–	–	–	–	–	–
Recurrence of caries	VG	50	50	50	50	50	50	50	50
	GO	–	–	–	–	–	–	–	–
	SS	–	–	–	–	–	–	–	–
	UN	–	–	–	–	–	–	–	–
	PO	–	–	–	–	–	–	–	–

SU-SE = self-etch; SU-SE*et* = selective enamel etching; SU-TE*d* = etch-and-rinse, dry dentin; SU-TE*m* = etch-and-rinse, moist dentin; GO = clinically good; PO = clinically poor; SS = clinically sufficient/satisfactory; UN = clinically unsatisfactory; VG = clinically very good.

for SU-Te*m*, 100% for SU-Te*d*, 100% for SU-SE*et*, and 94% for SU-SE, with no statistical difference between any pair of groups at each recall ($p > 0.05$) (Tables 6 and 7).

For the FDI criteria, 78 restorations were considered to have minor discrepancies with marginal adaptation (16 for SU-TE*m*, 18 for SU-TE*d*, 21 for SU-SE*et*, and 23 for SU-SE, $p = 0.001$) (Table 6). These discrepancies were

 DOI 10.1111/jerd.12005

TABLE 7. Number of evaluated restorations for each experimental group according to the adhesive (SU-TE*m*, SU-TE*d*, SU-SE*et*, and SU-SE) classified according to the adapted United States Public Health Service (USPHS) criteria[37,39]

Time		**Baseline**				**6 Months**			
USPHS modified criteria		**SU-TE*m***	**SU-TE*d***	**SU-SE*et***	**SU-SE**	**SU-TE*m***	**SU-TE*d***	**SU-SE*et***	**SU-SE**
Marginal staining	*Alfa*	50	50	50	50	50	50	50	49
	Bravo	–	–	–	–	–	–	–	01
	Charlie	–	–	–	–	–	–	–	–
Retention	*Alfa*	50	50	50	50	49	50	50	47
		–	–	–	–	–	–	–	–
	Charlie	–	–	–	–	01	–	–	03
Fracture	*Alfa*	50	50	50	50	50	50	50	50
	Bravo	–	–	–	–	–	–	–	–
	Charlie	–	–	–	–	–	–	–	–
Marginal adaptation	*Alfa*	50	50	50	50	50	50	50	48
	Bravo	–	–	–	–	–	–	–	02
	Charlie	–	–	–	–	–	–	–	–
Postoperative sensitivity	*Alfa*	49	46	47	49	50	50	50	50
		–	–	–	–	–	–	–	–
	Charlie	01	04	03	01	–	–	–	–
Recurrence of caries	*Alfa*	50	50	50	50	50	50	50	50
		–	–	–	–	–	–	–	–
	Charlie	–	–	–	–	–	–	–	–

SU-SE = self-etch; SU-SE*et* = selective enamel etching; SU-TE*d* = etch-and-rinse, dry dentin; SU-TE*m* = etch-and-rinse, moist dentin.

easily removed. No significant difference was detected among groups at the 6-month recall ($p > 0.05$). Also, there was no statistical difference among groups when SQUACE[24,25] was compared ($p > 0.05$; Table 8). In this specific item, only overcontour in the enamel margins was observed. For the USPHS modified criteria, only two restorations in the SU-SE group were classified as *bravo* for marginal adaptation, and no significant difference was found among groups at the 6-month recall ($p > 0.05$) (Table 7).

Marginal staining was only observed in one restoration for the SU-SE group according to FDI criteria, and no significant difference was found between groups and at 6 months ($p > 0.05$). No restoration had clinical problems related to fracture, postoperative sensitivity, and recurrence of caries at 6 months for either the FDI or the USPHS criteria. Thus, no statistical differences were noted for any of the other parameters.

When the FDI criteria for "acceptable" versus "not acceptable" restorations were applied, only the four lost restorations were ranked as "not acceptable" (Table 9).

DISCUSSION

We failed to reject both null hypotheses, as there were no statistical differences in the clinical parameters for the different bonding strategies tested in this study and

 DOI 10.1111/jerd.12005

TABLE 8. Number of evaluated restorations for each experimental group according to the adhesive classified for semiquantitative score (SQUACE)[24,25]

FDI criteria*		SU-TE*m*	SU-TE*d*	SU-SE*et*	SU-SE
SQUACE	Less than 10%	10	09	13	08
	Between 10% and 20%	03	05	05	05
	Between 21% and 30%	03	04	03	08

SU-SE = self-etch; SU-SE*et* = selective enamel etching; SU-TE*d* = etch-and-rinse, dry dentin; SU-TE*m* = etch-and-rinse, moist dentin.
*No significant difference was found between groups (Kruskall–Wallis, $p = 0.45$).

TABLE 9. Restorations acceptable or not acceptable according to the World Dental Federation (FDI) criteria after 6 months[24,25]

Properties	Esthetic				Functional								Biological							
	Staining margin				Fractures and retention				Marginal adaptation				Postoperative (hyper) sensitivity				Recurrence of caries			
	SU-TE*m*	SU-TE*d*	SU-SE*et*	SU-SE	SU-TE*m*	SU-TE*d*	SU-SE*et*	SU-SE	SU-TE*m*	SU-TE*d*	SU-SE*et*	SU-SE	SU-TE*m*	SU-TE*d*	SU-SE*et*	SU-SE	SU-TE*m*	SU-TE*d*	SU-SE*et*	SU-SE
Acceptable	50	50	50	50	49	50	50	47	50	50	50	50	50	50	50	50	50	50	50	50
Not acceptable	00	00	00	00	01	00	00	03	00	00	00	00	00	00	00	00	00	00	00	00
Reasons					Total loss of the restorations															

SU-SE = self-etch; SU-SE*et* = selective enamel etching; SU-TE*d* = etch-and-rinse, dry dentin; SU-TE*m* = etch-and-rinse, moist dentin.

there was no difference among the four bonding strategies when evaluated with the FDI and the USPHS criteria. In the present study, the behavior of SU in self-etch mode (SU-SE) suggests that SU may possess an intrinsic ability to bond chemically to dentin and enamel. SU differs from Adper Single Bond Plus adhesive primarily in the partial replacement of the dimethacrylate monomers with the 10-methacryloyloxydecyl dihydrogen phosphate (MDP) monomer to provide acidity for its self-etching capability. Chemical bonding between 10-MDP and enamel and dentin may play an important role in providing stable and durable interfaces.[15,40] The chemical bonding provided by the 10-MDP molecule in the primer, combined with the excellent mechanical properties and high conversion rate of its filled hydrophobic resin,[41,42] resulted in very good clinical behavior of Clearfil SE Bond (CSE; Kuraray, Osaka, Japan) at 8 years.[11] CSE, a 10-MDP-based two-step self-etch adhesive, is considered the reference for all other self-etch adhesives.[11,43,44]

Although SU contains less 10-MDP than CSE,[40] SU also contains a polyalkenoic acid copolymer. This copolymer was first used in the composition of Vitrebond (3M ESPE), also known as Vitrebond copolymer or VCP. This copolymer bonds chemically to the calcium in hydroxyapatite.[45] Clinical studies have shown a good performance of VCP-containing etch-and-rinse adhesives,[39,46] which may be attributed, at least partially, to chemical bonding. For self-etch adhesives, chemical bonding between polycarboxylic monomers (such as VCP) and hydroxyapatite plays a crucial role in their bonding mechanism.[47,48] Over 50% of the carboxyl groups in the polyalkenoic acid copolymer are capable of bonding to hydroxyapatite.[47] Carboxylic groups replace phosphate ions on the substrate and make ionic bonds with calcium.[47] With these two chemical bonding mechanisms in mind, the clinical behavior of SU-SE in our study may have been a result of: (1) the chemical bonding ability of both the 10-MDP monomer[49–51] and VCP[43] to hydroxyapatite; (2) the protective effect of the calcium-MDP (Ca-MDP) salt,[11] as the Ca-MDP salt is

 DOI 10.1111/jerd.12005

one of the most hydrolytically stable salts[49]; and (3) the formation of a submicron micromechanical interlocking at the dentin surface by SU.[40] The monomer 10-MDP is adsorbed onto hydroxyapatite in a regularly layered structure at the hydroxyapatite surface (nano-interaction)[40,51] and at the same time decalcifies hydroxyapatite.[49] However, SU does not form nanolayered structures with the same frequency as CSE on the dentin surface. This difference may be related to the presence of the VCP and 2-hydroxyethyl methacrylate (HEMA) in SU, which may compete with 10-MDP.[40]

When SU was applied on dentin in the self-etch mode, with (SU-SE*et*) or without (SU-SE) selective enamel etching, the clinical behavior of SU was similar to that of the etch-and-rinse groups, SU-TE*m*, and SU-TE*d*. Besides the chemical bonding between enamel and both 10-MDP and VCP, etching may have provided micromechanical enamel retention. Enamel microtensile bond strengths are higher when two multimode one-bottle adhesives, SU and G-Bond Plus (GC Corporation, Tokyo, Japan), are applied on etched enamel.[20,52] The benefits of enamel selective etching may be only apparent after a few years. Enamel marginal defects were more prevalent in clinical studies up to 8 years when a 10-MDP-based adhesive was applied as a self-etch adhesive.[11,13,53]

The amount of resin impregnation within the hybrid layer for water-free adhesives with dry bonding is significantly lower than when dentin is left moist.[54] In our study, when dentin and enamel were etched with phosphoric acid, the amount of surface moisture (moist versus dry dentin) did not influence the clinical behavior of SU. This adhesive is ethanol- and water-based (10–15% by Wt of each).[55] In spite of the dryness of the dentin surface, the water contained in SU may be able to plasticize the collapsed collagen network, allowing for reexpansion and reopening of the interfibrillar spaces for the infiltration of resin monomers.[56] This phenomenon was deemed responsible for the hybrid layer formed with SU-TE*d* in a recent in vitro investigation.[23] Additionally, a dynamic application of the adhesive on dry dentin may have contributed to the indistinguishable behavior between moist and dry dentin, as in vitro and clinical research has shown that rubbing the adhesive continuously on dry dentin results in similar performance.[57,58]

Despite 92 teeth that showed preoperative sensitivity to air, only 9 teeth had postoperative sensitivity after the restorations were inserted, which disappeared at the 6-month recall. Clinical studies have shown no difference in postoperative sensitivity between self-etch and etch-and-rinse adhesives.[37] For self-etch adhesives, they use part of the smear layer as the bonding substrate; therefore, the monomer-impregnated smear plugs serve as barrier to prevent the fluid shift inside the tubules. For SU used as etch-and-rinse adhesive on moist or on dry dentin, resin tags were found to be profusely branched out into dentin tubules and able to seal the tooth-resin interface,[23] which may explain that no tooth showed postoperative sensitivity.

Recent studies have shown water sorption of adhesive resin as proportional to its hydrophilic characteristics.[59,60] The self-etching ability of one-bottle adhesives is commonly achieved by incorporation of water in resin monomers that enables ionization of acidic monomers. In addition to the water in the compounds, the ionizable moieties of acidic monomers are also hydrophilic. The presence of such a more hydrophilic layer may thus induce water sorption and water uptake, in turn jeopardizing the stability of the polymer network. Accordingly, other studies should focus on the use of SU as a two-step self-etch adhesive by adding a hydrophobic resin layer as a second step in the bonding sequence. In fact, a systematic review[61] of clinical studies published between 1998 and 2009 found that two-step self-etch adhesives and glass-ionomer cement-based materials resulted in the lowest failure rate when used to restore NCCL. Besides the proven chemical affinity between 10-MDP and hydroxyapatite, the laboratory and clinical success of mild two-step self-etch adhesives might also be a result of the presence of a hydrophobic bonding layer.[62,63] The addition of a hydrophobic resin layer to the new multipurpose adhesive systems is a clinically relevant topic of future research. Besides further recall evaluations already planned for this same project, bond strengths of aged dentin-resin interfaces with the same

 DOI 10.1111/jerd.12005

experimental groups are needed as they may shed some light into the clinical behavior of SU over 5 years. Although laboratory studies cannot always predict the clinical durability of bonded restorations, the dentin bond strengths of aged specimens seem to correlate with 5-year clinical data.[61] Another research group found evidence that dentin microtensile bond strength, especially after water storage for 6 months, showed a good correlation with marginal discoloration in short-term clinical Class V restorations.[64]

This clinical study has limitations, as 6 months may sound like a very short period to evaluate the long-term clinical behavior of dental adhesives. However, the fact that SU belongs to a novel family of simplified multimode dental adhesives, which lack clinical data and are indicated for use under different application strategies, warranted this short-term evaluation. Another limitation is that more than four restorations were placed in several patients (11). In spite of being a common situation in the dental literature,[11,29,35,39,46,53] this may have caused a clustering effect. The impact of this clustering effect on the final results was not considered, and it should be considered in the future studies.

CONCLUSIONS

Within the limitations of this study, the 6-month clinical behavior of SU does not depend on the bonding strategy used. The FDI evaluation criteria are more sensitive to small variations in the clinical outcomes than the USPHS criteria when evaluating restorations of NCCLs.

DISCLOSURE AND ACKNOWLEDGEMENTS

The authors do not have any financial interest in the companies whose materials are included in this article. This study was not funded by any sponsoring company.

However, special thanks are extended to 3M ESPE for providing the materials.

REFERENCES

1. Reis A, Pellizzaro A, Dal-Bianco K, et al. Impact of adhesive application to wet and dry dentin on long-term resin-dentin bond strengths. Oper Dent 2007;32:380–7.
2. Dal-Bianco K, Pellizzaro A, Patzlaft R, et al. Effects of moisture degree and rubbing action on the immediate resin-dentin bond strength. Dent Mater 2006;22:1150–6.
3. Spencer P, Swafford JR. Unprotected protein at the dentin adhesive interface. Quintessence Int 1999;30:501–7.
4. Wang Y, Spencer P. Quantifying adhesive penetration in adhesive/dentin interface using confocal Raman microspectroscopy. J Biomed Mater Res 2002;59:46–55.
5. Pioch T, Staehle HJ, Wurst M, et al. The nanoleakage phenomenon: influence of moist vs dry bonding. J Adhes Dent 2002;4:23–30.
6. Sano H. Microtensile testing, nanoleakage, and biodegradation of resin-dentin bonds. J Dent Res 2006;85:11–4.
7. Breschi L, Mazzoni A, Ruggeri A, et al. Dental adhesion review: aging and stability of the bonded interface. Dent Mater 2008;24:90–101.
8. Hashimoto M, Ohno H, Kaga M, et al. In vivo degradation of resin-dentin bonds in humans over 1 to 3 years. J Dent Res 2000;79:1385–91.
9. Carrilho MR, Carvalho RM, Tay FR, Pashley DH. Effects of storage media on mechanical properties of adhesive systems. Am J Dent 2004;17:104–8.
10. Hashimoto M. A review—micromorphological evidence of degradation in resin-dentin bonds and potential preventional solutions. J Biomed Mater Res B Appl Biomater 2010;92:268–80.
11. Peumans M, De Munck J, Van Landuyt KL, et al. Eight-year clinical evaluation of a 2-step self-etch adhesive with and without selective enamel etching. Dent Mater 2010;26:1176–84.
12. Carvalho RM, Chersoni S, Frankenberger R, et al. A challenge to the conventional wisdom that simultaneous etching and resin infiltration always occurs in self-etch adhesives. Biomaterials 2005;26:1035–42.
13. Perdigão J, Carmo AR, Anauate-Netto C, et al. Clinical performance of a self-etching adhesive at 18 months. Am J Dent 2005;18:135–40.
14. Frankenberger R, Lohbauer U, Roggendorf MJ, et al. Selective enamel etching reconsidered: better than etch-and-rinse and self-etch? J Adhes Dent 2008;10:339–44.
15. Erickson RL, Barkmeier WW, Latta MA. The role of etching in bonding to enamel: a comparison of self-etching and etch-and-rinse adhesive systems. Dent Mater 2009;25:1459–67.
16. Torii Y, Itou K, Nishitani Y, et al. Effect of phosphoric acid etching prior to self-etching primer application on

 DOI 10.1111/jerd.12005

adhesion of resin composite to enamel and dentin. Am J Dent 2002;15:305–8.
17. Van Landuyt KL, Peumans M, De Munck J, et al. Extension of a one-step self-etch adhesive into a multi-step adhesive. Dent Mater 2006;22:533–44.
18. Proença JP, Polido M, Osorio E, et al. Dentin regional bond strength of self-etch and total-etch adhesive systems. Dent Mater 2007;23:1542–8.
19. Hashimoto M, Ohno H, Sano H, et al. Micromorphological changes in resin-dentin bonds after 1 year of water storage. J Biomed Mater Res 2002;63: 306–11.
20. Peumans M, Kanumilli P, De Munck J, et al. Clinical effectiveness of contemporary adhesives: a systematic review of current clinical trials. Dent Mater 2005;21:864–81.
21. Perdigão J. New developments in dental adhesion. Dent Clin North Am 2007;51:333–57.
22. Hanabusa M, Mine A, Kuboki T, et al. Bonding effectiveness of a new "multi-mode" adhesive to enamel and dentine. J Dent 2012;40:475–84.
23. Perdigão J, Sezinando A, Monteiro PC. Laboratory bonding ability of a multi-purpose dentin adhesive. Am J Dent 2012;25:153–8.
24. Hickel R, Roulet JF, Bayne S, et al. Recommendations for conducting controlled studies of dental restoratives materials. Science committee project 2/98—FDI World Dental Federation study design (Part I) and criteria for evaluation (Part II) of direct and indirect restoration including onlays and partial crowns. J Adhes Dent 2007;9:121–47.
25. Hickel R, Peschke A, Tyas M, et al. FDI World Dental Federation—clinical criteria for the evaluation of direct and indirect restorations. Update and clinical examples. J Adhes Dent 2010;12:259–72.
26. Cvar JF, Ryge G, Schmalz G. Reprint of criteria for the clinical evaluation of dental restorative materials. Clin Oral Investig 2005;9:7–24.
27. Piva F, Coelho-Souza FH. A deciduous teeth composite restoration clinical trial using two methods. J Dent Res 2009;88(Special issue A): abstract 3241. Available at: http://www.dentalresearch.org; http://iadr.confex.com/iadr/2009miami/webprogram/Paper120866.html (accessed August 6, 2012).
28. Schulz KF, Altman DG, Moher D, CONSORT Group. CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. Int J Surg 2011;9:672–7.
29. Loguercio AD, Reis A, Barbosa AN, Roulet JF. Five-year double-blind randomized clinical evaluation of a resin-modified glass ionomer and a polyacid-modified resin in noncarious cervical lesions. J Adhes Dent 2003;5:323–32.
30. Swift JEJ, Perdigão J, Heymann HO, et al. Eighteen-month clinical evaluation of a filled and unfilled dentin adhesive. J Dent 2001;29:1–6.
31. American Dental Association Council on Scientific Affairs. Acceptance program guidelines: dentin and enamel adhesive materials. Chicago, IL: American Dental Association; 2001, p. 12.
32. Perdigão J, Carmo AR, Geraldeli S. Eighteen-month clinical evaluation of two dentin adhesives applied on dry vs moist dentin. J Adhes Dent 2005;7:253–8.
33. Aw TC, Lepe X, Johnson GH, Mancl LA. A three-year clinical evaluation of two-bottle versus one-bottle dentin adhesives. J Am Dent Assoc 2005;136: 311–22.
34. Gallo JR, Burgess JO, Ripps AH, et al. Three-year clinical evaluation of a compomer and a resin composite as class V filling materials. Oper Dent 2005;30:275–81.
35. Loguercio AD, Bittencourt DD, Baratieri LN, Reis A. A 36-month evaluation of self-etch and etch-and-rinse adhesives in noncarious cervical lesions. J Am Dent Assoc 2007;138:507–14.
36. Reis A, Loguercio AD. A 36-month clinical evaluation of ethanol/water and acetone-based etch-and-rinse adhesives in non-carious cervical lesions. Oper Dent 2009;34:384–91.
37. Perdigão J, Dutra-Corrêa M, Saraceni CH, et al. Randomized clinical trial of four adhesion strategies: 18-month results. Oper Dent 2012;37:3–11.
38. Pocock SJ. The size of a clinical trial. In: Pocock SJ, editor. Clinical trials: a practical approach. Chichester: John Wiley & Sons; 1983, pp. 123–41.
39. Dalton Bittencourt D, Ezecelevski IG, Reis A, et al. An 18-months' evaluation of self-etch and etch & rinse adhesive in non-carious cervical lesions. Acta Odontol Scand 2005;63:173–8.
40. Yoshida Y, Yoshihara K, Nagaoka N, et al. Self-assembled nano-layering at the adhesive interface. J Dent Res 2012;91:376–81.
41. Ikeda T, De Munck J, Shirai K, et al. Effect of fracture strength of primer-adhesive mixture on bonding effectiveness. Dent Mater 2005;21:413–20.
42. Sadek FT, Calheiros FC, Cardoso PE, et al. Early and 24-hour bond strength and degree of conversion of etch-and-rinse and self-etch adhesives. Am J Dent 2008;21:30–4.
43. De Munck J, Van Landuyt K, Peumans M, et al. A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res 2005;84:118–32.
44. Burrow MF, Kitasako Y, Thomas CD, Tagami J. Comparison of enamel and dentin microshear bond strengths of a two-step self-etching priming system with five all-in-one systems. Oper Dent 2008;33:456–60.

 DOI 10.1111/jerd.12005

45. Mitra SB, Lee CY, Bui HT, et al. Long-term adhesion and mechanism of bonding of a paste-liquid resin-modified glass-ionomer. Dent Mater 2009;25:459–66.
46. Kubo S, Kawasaki K, Yokota H, Hayashi Y. Five-year clinical evaluation of two adhesive systems in non-carious cervical lesions. J Dent 2006;34:97–105.
47. Lin A, McIntyre NS, Davidson RD. Studies on the adhesion of glass-ionomer cements to dentin. J Dent Res 1992;71:1836–41.
48. Yoshida Y, Van Meerbeek B, Nakayama Y, et al. Evidence of chemical bonding at biomaterial-hard tissues interface. J Dent Res 2000;79:709–14.
49. Fukegawa D, Hayakawa S, Yoshida Y, et al. Chemical interaction of phosphoric acid ester with hydroxyl-apatite. J Dent Res 2006;85:941–4.
50. Van Landuyt KL, Yoshida Y, Hirata I, et al. Influence of the chemical structure of functional monomers on their adhesive performance. J Dent Res 2008;87:757–61.
51. Yoshihara K, Yoshida Y, Nagaoka N, et al. Nano-controlled molecular interaction at adhesive interfaces for hard tissue reconstruction. Acta Biomater 2010;6:3573–82.
52. Perdigão J, Sezinando A, Monteiro P. Evaluation of a new universal adhesive using different bonding strategies. J Dent Res 2012;91(Special issue A): abstract 18. Available at http://www.dentalresearch.org; http://iadr.confex.com/iadr/2012tampa/webprogram/Paper156756.html (accessed August 6, 2012).
53. Peumans M, De Munck J, Van Landuyt K, et al. Five-year clinical effectiveness of a two-step self-etching adhesive. J Adhes Dent 2007;9:7–10.
54. Hashimoto M, Ohno H, Kaga M, et al. The extent to which resin can infiltrate dentin by acetone-based adhesives. J Dent Res 2002;81:74–8.
55. Material Safety Data Sheet, 3M ESPE, Scotchbond Universal. Available at http://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSuUn_zu8l00xMY_eN8mGov70k17zHvu9lxtD7SSSSSS (accessed June 15, 2012).
56. Maciel KT, Carvalho RM, Ringle RD, et al. The effects of acetone, ethanol, HEMA, and air on the stiffness of human decalcified dentin matrix. J Dent Res 1996;75:1851–8.
57. Zander-Grande C, Ferreira SQ, Da Costa TR, et al. Application of etch-and-rinse adhesives on dry and rewet dentin under rubbing action: a 24-month clinical evaluation. J Am Dent Assoc 2011;142:828–35.
58. Loguercio AD, Raffo J, Bassani F, et al. 24-month clinical evaluation in non-carious cervical lesions of a two-step etch-and-rinse adhesive applied using a rubbing motion. Clin Oral Investig 2011;15:589–96.
59. Ito S, Hashimoto M, Wadgaonkar B, et al. Effects of resin hydrophilicity on water sorption and changes in modulus of elasticity. Biomaterials 2005;26:6449–59.
60. Malacarne J, Carvalho RM, de Goes MF, et al. Water sorption/solubility of dental adhesive resins. Dent Mater 2006;22:973–80.
61. Van Meerbeek B, Peumans M, Poitevin A, et al. Relationship between bond strength tests and clinical outcomes. Dent Mater 2010;26:e100–121.
62. Reis A, Albuquerque M, Pegoraro M, et al. Can the durability of one-step self-etch adhesives be improved by double application or by an extra layer of hydrophobic resin? J Dent 2008;36:309–15.
63. Reis A, Leite TM, Matte K, et al. Improving clinical retention of one-step self-etching adhesive systems with an additional hydrophobic adhesive layer. J Am Dent Assoc 2009;140:877–85.
64. Heintze SD, Thunpithayakul C, Armstrong SR, Rousson V. Correlation between microtensile bond strength data and clinical outcome of class V restorations. Dent Mater 2011;27:114–25.

Reprint requests: Jorge Perdigão, DMD, MS, PhD, University of Minnesota, Department of Restorative Sciences, 515 SE Delaware St., 8-450 Moos Tower, Minneapolis, MN 55455, USA; Tel.: 612-625-8486; email: perdi001@umn.edu

This article is accompanied by commentary, A New Universal Simplified Adhesive: 6-Month Clinical Evaluation, John M. Powers, PhD

DOI 10.1111/jerd.12006

 DOI 10.1111/jerd.12005