Acta Odontologica Scandinavica, 2005; 63: 173–178

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ORIGINAL ARTICLE

An 18-months' evaluation of self-etch and etch & rinse adhesive in non-carious cervical lesions

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Abstract

Objective. In this intra-individual comparison (an 18-months' randomized, controlled prospective study), we evaluated the clinical performance of one self-etch and one "etch & rinse" adhesive in non-carious cervical lesions. ***Methods.*** Twenty-five patients with at least two pairs of similar-sized non-carious cervical lesions participated. Seventy-eight restorations were placed; 39 with etch & rinse (Single-Bond) and 39 with self-etch (Adper Prompt). Both adhesives were combined with the microfilled resin composite Filtek-A110. The restorations were evaluated at baseline, 6, 12, and 18 months according to slightly modified USPHS criteria. Statistical differences between the adhesives was tested with McNemar's test and clinical degradation over time for each material with the Fisher exact test ($\alpha = 0.05$). ***Results.*** Thirty pairs were evaluated at 12 and 18 months. Two self-etch restorations were lost after 18 months. Nine Adper Prompt and four Single-Bond restorations scored bravo for marginal adaptation at 18 months ($p < 0.05$). Nine Adper Prompt and three Single-Bond restorations scored bravo for marginal discoloration ($p < 0.05$). ***Conclusions.*** Both adhesive systems showed acceptable clinical retention rates according to the ADA full acceptance criteria for enamel-bonding systems in class V non-carious lesions. The self-etch adhesive showed a faster progressive marginal degradation.

Key Words: *Adhesives systems, clinical evaluation, etch & rinse, non-carious cervical lesions, resin composite, self-etch*

Introduction

The increasing demand for minimally invasive dentistry has generated intensive research on adhesive materials. Successful adhesion to hard tissues is a fundamental requirement prior to the placement of resin composites [1]. While enamel bonding has been shown to be reliable in operative dentistry during the past 30 years [2,3], obtaining an acceptable dentin bonding is still a challenge due to factors such as the composition and intrinsic moisture of dentin, hydrostatic pressure from the pulp, and presence of the smear layer [4].

Resin-based adhesive systems can be classified as either "etch & rinse" or "self-etch". The first step with etch & rinse adhesive is use of an acid conditioner, which removes the smear layer and demineralizes the superficial enamel and dentin. After rinsing in water and careful drying, a hydrophilic primer is applied as the second step. The third step is application of a hydrophobic adhesive to obtain a bond with the resin composite restorative or luting agent [4]. In simplified two-step versions, the primer and adhesive are combined into one step [1]. Although the etch & rinse adhesive systems have been improved [1,5], randomized clinical trials have shown varying degrees of retention rates of commercial systems [6–9]. Technique sensitivity of the etch & rinse systems and possible discrepancy between the extent of demineralization by the acidic conditioner and infiltration of the primer monomers in demineralized tissue [10] may be the reason for early degradation in the oral environment [11,12].

With the self-etch adhesives, no separate etching or rinsing steps are needed. Conditioning and resin monomer infiltration in the enamel and dentin occur simultaneously, thus reducing the potential for degradation over time [1]. Although the literature on this

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(Received 29 November 2004; accepted 28 February 2005)

ISSN 0001-6357 print/ISSN 1502-3850 online
DOI: 10.1080/00016350510019874

matter is controversial [13], the self-etch adhesives reduce technique sensitivity during handling and application [1]. Only a few randomized clinical trials have evaluated the performance of this new adhesive strategy [9,14–16].

The hypothesis tested was that an aggressive acidic self-etch adhesive shows similar clinical retention as an etch & rinse adhesive. The aim of the present study was to evaluate the durability of two adhesive systems, a two-step etch & rinse and a one-step self-etch in non-carious cervical lesions according to the ADA guidelines for enamel-dentin bonding systems.

Material and methods

The adhesive materials studied were the two-step, etch & rinse adhesive Single-Bond (3M ESPE, St. Paul, Minn., USA; Scotchbond 1 in Europe) and the experimental EXM-618, a one-step self-etch adhesive system (now available commercially as Adper Prompt, 3M ESPE). Both adhesives were combined with the microfilled resin composite Filtek-A110 (3M ESPE) (Table I).

All participants were healthy and had at least 20 teeth. According to the treatment rules at the School of Dentistry, Department of Dental Materials and Operative Dentistry, University of Oeste de Santa Catarina, all patients were given oral hygiene instructions before operative treatment was performed. Patients with extremely poor oral hygiene or heavy bruxing habits were excluded. Each participant had at least two pairs of equal-sized non-carious cervical lesions without undercuts, fulfilling criteria 2 and 3 on Duke's dentin sclerosis scale [17]. All teeth had occlusal contact. No more than 50% of the cavosurface margin involved enamel [18]. Hypersensitivity lesions were not included [7]. All patients were informed about the study and written informed consent was obtained. The study was approved by the Ethics Committee of the University of São Paulo.

Out of 50 patients, 25 participants were selected (12 M, 13 F) with a mean age of 35 years (range 22–54 years; median 37). Seventy-eight restorations were placed, 39 with each adhesive system; 41 in the maxilla and 37 in the mandibula; 58 were placed in premolars, 14 in incisors and 6 in canines.

Operative procedure

All lesions were restored by two calibrated operators familiar with adhesive dentistry (DDB, IGE) under the supervision of an experienced clinician (A.D.L.). The order of placement and selection of the material to be placed were randomly allocated for each patient. Before placement of the rubberdam and clamps, the teeth were anesthetized (Citanest, Dentsply, Petrópolis, RJ, Brasil) and all lesions were cleaned with pumice and water. According to the ADA guidelines, no additional retention or bevel was prepared. The adhesives were used in accordance with the manufacturer's instructions (Table I). The resin composite was applied in 1–3 increments and light cured for 30 s/increment (VIP light unit; Bisco, Schaumburg, Ill., USA; 600 mW/cm^2). The restorations were finished directly with fine-grain diamond burs (# 1190F and 2135F, KG Sorensen) and, finally, polished with Soft-Lex Pop-On discs (3M ESPE) after 1 week.

Clinical evaluation

Slightly modified USPHS criteria according to Barnes et al. [19] were used to evaluate the restorations at baseline and after 6, 12, and 18 months (Table II). The variables evaluated were: retention, color match, anatomic form, marginal adaptation, marginal discoloration, postoperative sensitivity, and recurrent caries. Restoration retention rates were calculated

Table I. Adhesive systems and resin composite: composition and mode of application

	Composition	Mode of application
Single Bond* (3M ESPE)	1. Scotchbond—37% phosphoric acid. 2. Primer/Adhesive—Bis-GMA, HEMA, dimethacrylates, polyalkenoic acid copolymer, initiators, water and ethanol.	a—Acid-etch (15 s); b—rinse (15 s); c—air-dry (30 s); d—dentin re-wetted with water (moist technique); e—two coats of primer/adhesive, brushed for 10 s each; f—air-dry for 10 s at 20 cm; g—light-cure (10 s—600 mW/cm^2)
Experimental EXM-618 Self-etching (3M ESPE)**	Liquid 1: Methacrylated phosphoric esters, Bis-GMA, initiators based on camphoroquinone, stabilizers. Liquid 2: Water, HEMA, polyalkenoic acid, co-polymer, stabilizers.	a—Mixed one coat of liquid A and one coat of liquid B (5 s); b—one coat of mixture was brushed (10 s); c—air-dry for 10 s at 20 cm; d—light-cure (10 s—600 mW/cm^2); e—one coat of mixture was brush (10 s); f—air-dry for 10 s at 20 cm; g—light-cure (10 s—600 mW/cm^2)
Filtek A110 (3M ESPE)	Microfilled resin composite. Silica filler, average particle size of 0.04 (particle size distribution: 0.01–0.09) and approximately 56% wt or 40% vol filler load. Matrix consists Bis-GMA and TEGDMA. Additional contents: stabilizers, catalysts and pigments.	a—Incremental placement (< 1.5 mm); b—Light-curing (30 s—600 mW/cm^2)

*3M ESPE, St. Paul, Minn., USA; Scotchbond 1 in Europe.
**Now available commercially as Adper Prompt (3M ESPE).

Table II. Modified USPHS criteria according to Barnes et al. [19]

Category	Rating scale
Retention	A: Full retention B: Partial retention C: Lost
Anatomic form	A: The restoration is continuous with existing anatomic form B: Generalized wear but clinically acceptable C: Wear beyond the dentin-enamel junction
Marginal adaptation	A: Restoration is continuous with existing anatomic form B: Crevice at margin, enamel exposed C: Obvious crevice at margin, dentin or base exposed
Marginal discoloration	A: No discoloration along the margin B: Slight staining (removable, usually localized) C: Gross staining cannot be polished away
Recurrent caries	A: No evidence of caries contiguous with the margin B: Evidence of caries
Postoperative sensitivity	A: No postoperative sensitivity directly after the restorative process and during the study period B: Sensitivity at any time during the study period
Color match	A: No color mismatch between restoration and tooth B: Slight mismatch C: Obvious or gross mismatch

according to the ADA Guidelines [20]: Cumulative failure $\% = [(PF + NF)/(PF + RR)] \times 100\%$. PF is the number of previous failures before the current recall; NF the number of new failures during the current recall; and RR the number of restorations recalled for the actual recall.

Two independent and calibrated examiners performed the evaluations blindly (A.D.L. and A.R.). A pre-evaluation agreement of at least 85% was obtained between evaluators [21]. If disagreement occurred during evaluation, consensus was obtained between the evaluators before the patient was dismissed.

Descriptive statistics were used to describe the frequency distributions of the evaluated criteria. The differences in the ratings of the two materials after 6, 12, and 18 months were tested with the Fisher exact test ($\alpha = 0.05$) and performance of the materials at baseline and after each recall (6, 12, and 18 months) was evaluated using the McNemar test ($\alpha = 0.05$). Cohen's kappa statistic was used to test inter-examiner agreement.

Results

Cohen's kappa statistics showed excellent agreement between the examiners (0.92). Five patients with 18 lesions could not be evaluated at the 12- and 18-month recalls because of non-attendance. No postoperative symptoms were reported. At baseline and at 6 months, all restorations scored alfa for all evaluated variables.

Two restorations from the self-etch group were lost at 18 months, resulting in a retention rate for Adper Prompt of 93% and 100% for Single-Bond ($p = 0.78$). None of the restorations showed secondary caries or loss of anatomic form.

At 12 months, 6 Adper Prompt restorations and 4 Single-Bond restorations scored Bravo for marginal adaptation ($p = 0.92$). The numbers at 18 months were 9 and 4, respectively ($p = 0.82$). At 12 months, 2 Adper Prompt restorations and 3 Single-Bond restorations scored Bravo for marginal discoloration. The numbers at 18 months were 9 and 3, respectively ($p = 0.72$). The marginal discoloration was observed at the enamel margin for all restorations. The difference in the materials between baseline and 18 months for marginal adaptation and marginal discoloration was statistically different ($p = 0.001$). The color match of all restorations was scored as alfa score at the 18-month recall.

Discussion

Adhesive techniques have been developed to the extent that they are now used in most clinical procedures. Bonding to dentin has become more reliable since the introduction of amphiphilic monomers, which can infiltrate moist demineralized dentin surfaces and produce a hybrid layer after polymerization. The adhesive systems employed in the clinic now have a preponderant effect on the longevity of restorations [1,5]. Progress in adhesive technology has also resulted in a high frequency of new materials commercialized. In order to predict the clinical performance of these adhesive systems, laboratory tests (tensile, shear bond strength, and microleakage tests) are commonly performed. Dentin bond strength values similar to enamel have been reported [1,3]. Generally, it is difficult to compare the results from different studies, since testing procedures vary greatly [1,22]. Unfortunately, the *in vitro* screening tests do not always reflect the behavior of the material in the clinic and clinical

testing remains the ultimate proof of effectiveness [1,23].

Clinical testing of adhesive systems is recommended in non-prepared cervical lesions located mainly in dentin and which do not have undercuts. These surfaces are ideal for testing adhesives, but the restorations have no good long-term prognosis because of the high stress build-up in the cervical area. The American Dental Association guidelines [20] for submission of dentine and enamel adhesive materials require, for provisional acceptance, that no more than 5% of the restorations are lost and that not more than 5% show microleakage at the 6-month recall. To obtain full acceptance after 18 months, the cumulative incidence of clinical failures in each of two independent clinical studies has to be lower than 10% lost restorations and 10% microleakage [20]. Because of the rapid development of dental materials, the time necessary for clinical testing, and to publish results, clinical trials are limited in number. Many new materials are therefore released on to the market without proof of clinical performance.

The present study was randomized and the examiners were blinded to the materials used. A high degree of agreement was obtained between the evaluators (kappa 0.92). Clinical effectiveness was evaluated pair-wise. Both adhesive systems fulfilled the ADA retention criteria. No restorations were lost at 6 months. After 18 months the cumulative loss rate for Adper Prompt increased to 7%, while Single Bond showed no lost restorations. Clinical investigations of the predecessor of Adper Prompt, Prompt-L-Pop, in non-carious cervical lesions showed high loss of retention [14,16,24]. Brackett et al. [13] placed 60 Class V Prompt-L-Pop restorations in caries-free cervical lesions and reported a 24% loss of retention after 6 months and 35% after 1 year. Friedl et al. [24] compared Prompt-L-Pop and a 3-step system and reported retention loss rates after 2 years of 16% and 8%, respectively. van Dijken [16] reported loss of retention in 3.9%, 13.5%, 15.4%, and 21.2% for Prompt-L-Pop restorations, applied according to the manufacturer's instructions in a one-layer application, after, 6, 12, 18, and 24 months, respectively. Another somewhat milder self-etch system, Clearfil Liner Bond 2, where the self-etch primer was covered with an adhesive, showed clearly lower loss rates of 4.3% at 18 months and 8.7% at 24 months.

Pashley et al. [25] showed that the bond strength values of a one-step self-etch system after application of a second adhesive layer increased two times compared to only one adhesive layer. Frankenberger et al. [26] showed that the predecessor of Adper Prompt, Prompt-L-Pop, applied according to the manufacturer's directions, resulted in a very thin barely visible non-uniform hybrid layer. Using an argon etching technique for 3-step systems, Miyazaki et al. [27] observed a well-developed hybrid layer, while the layer of "all-in-one" systems was thin.

Frankenberger et al. [26] also showed that, after careful application and air-thinning of the adhesive, the tooth surface showed areas dull in appearance. These represented dry spots where the material was probably too thin to be successfully light-cured. Re-application of the primer in multilayers resulted in a more uniform thicker hybrid layer and higher bond strength [26]. However, the thickness of the adhesive layer in the dentine surface may not be enough to prevent formation of defects in the bonding layer. This may partly be due to the presence of the oxygen inhibited monomers as a result of the thin primer application recommended by the manufacturer [25,26,28,29].

Adper Prompt, was therefore applied in the present study in two layers, and due regard was paid to the solvent removal before adhesive curing. The thicker hybrid layer may partly explain the improved retention of the adhesive compared to its predecessor. The clinical precautions in the present investigation may have precluded the high retention failure rates achieved in other randomized clinical trials [14,16,24].

Of several studies evaluating the enamel-etching ability of the self-etching adhesives [30–33], one has indicated that bonding to enamel with a self-etching adhesive is as effective as enamel bonding after conventional phosphoric acid treatment [33]. However, other studies have demonstrated that self-etch adhesives are effective only on ground enamel, and less effective on intact enamel [31], due to their inferior etching pattern [30].

The first marketed self-etch adhesives in the late 1990s showed relatively low enamel bond strength. *In vivo* evaluations of Class III restorations placed with only the self-etch conditioning, reported enamel marginal discoloration due to bond loss over time [34]. Phosphoric acid etching was therefore recommended for these systems. Recent self-etch systems have a lower acidity. Adper Prompt is a more viscous modification of Prompt-L-Pop. However, it has a slightly higher pH of 0.8 compared to 0.4 for Prompt-L-Pop. All-in-one self-etch systems like Adper Prompt or its predecessor, Prompt L-Pop, have demonstrated lower bond strength to both enamel and dentine then two-step etch & rinse systems (Single-Bond) [1,35–37].

The scores for marginal adaptation for both materials were: at 6 months 0%, at 12 months 7% for Adper Prompt and 10% for Single Bond, which increased at 18 months to 30% and 10%, respectively ($p < 0.05$). For all restorations, marginal discoloration occurred at the enamel margin, which is a common finding in clinical studies of Prompt L-Pop [14,38].

Recent *in vitro* and *in vivo* studies have shown improved enamel bond strength, increased retention rates, and less marginal discoloration if phosphoric acid etching performed before application of a mild two-step self-etch adhesive [39–41]. The higher marginal discoloration found with the one-step self-etch system in the present study indicates a faster deterioration of the enamel bond for the self-etch adhesive

then the phosphoric acid conditioned etch & rinse adhesive [30–32].

This may be caused by water sorption and dissolution of incompletely polymerized resin containing amphiphilic monomers, resulting in deterioration of the hybrid layer *in vivo*. The higher acidity and hydrophilicity of the acidic monomers increase the risk of hydrolytic degeneration [42].

We excluded from the study severe bruxing patients and lesions with score 1 or score 4 according to the sclerotic dentin scale of Duke [17]. The inclusion especially of lesions in bruxing patients may have resulted in higher retention losses.

Self-etching adhesives are easy to apply and less technique-sensitive than the "etch & rinse" approach. However, clinicians have to consider the trade-offs of these materials before using them in routine practice. They should be applied in more than just one layer, and care should be taken during removal of solvents. Another approach, to double the application time of such systems has been suggested [32]. Successful retention rates have been reported when self-etch systems are applied on phosphoric acid treated enamel [39,40]. This approach, however, practically eliminates the advantages possessed by the self-etch approach, such as its lower technique sensitivity and the lack of discrepancy between demineralization and resin infiltration.

It is concluded that both adhesives systems meet the ADA full acceptance criteria for enamel-dentin bonded restorative materials. A faster progressive marginal deterioration but still within the acceptable range was observed for the self-etch adhesive.

Acknowledgments

This investigation was supported in part by UNOESC/ Joaçaba/SC. The materials were donated by the manufacturers (3M ESPE, Campinas, Brasil). We thank Janice Mengarda for cooperation at the beginning of this study.

References

[1] Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, et al. Adhesion to enamel and dentin: current status and future challenges. Oper Dent 2003;28:215–35.

[2] Swift EJ Jr, Perdigão J, Heymann HO. Bonding to enamel and dentin. A brief history and state of the art. Quintessence Int 1995;26:95–110.

[3] Lopes GC, Baratieri LN, Andrada MAC, Vieira LCC. Dental adhesion: present state of the art and future perspectives. Quintessence Int 2002;33:213–24.

[4] Pashley DH, Carvalho RM. Dentin permeability and dentin adhesion. J Dent 1997;25:355–72.

[5] Van Meerbeek B, Peumans M, Verschueren M, Gladys S, Braem M, Lambrechts P, et al. Clinical status of ten dentin adhesive systems. J Dent Res 1994;73:1690–702.

[6] van Dijken JWV. Clinical evaluation of three adhesive systems in class V non-carious lesions. Dent Mater 2000;16:285–291.

[7] Swift EJ Jr, Perdigão J, Heymann HO, Wilder AD Jr, Bayne SC, May KN Jr, et al. Eighteen-month clinical evaluation of a filled and unfilled dentin adhesive. J Dent 2001;29:1–6.

[8] Tyas MJ, Burrow MF. Three-year clinical evaluation of One-Step in non-carious cervical lesions. Am J Dent 2002;15: 309–11.

[9] Türkün S. Clinical evaluation of a self-etching and a one-bottle adhesive system at two years. J Dent 2003;31:527–34.

[10] Wang Y, Spencer P. Hybridization efficiency of the adhesive/dentin interface with wet bonding. J Dent Res 2003;82:141–5.

[11] Hashimoto M, Ohno H, Kaga M, Sano H, Endo K, Oguchi H. In vivo degradation of resin-dentin bonds in humans over 1 to 3 years. J Dent Res 2000;79:1385–91.

[12] De Munck J, Van Meerbeek B, Yoshida Y, Inoue S, Vargas M, Suzuki K, et al. Four-year water degradation of total-etch adhesives bonded to dentin. J Dent Res 2003; 82:136–40.

[13] Carvalho RM, Chersoni S, Frankenberger R, Pashley DH, Prati C, Tay FR. A challenge to the conventional wisdom that simultaneous etching and resin infiltration always occurs in self-etch adhesives. Biomaterials 2005;26:1035–42.

[14] Brackett WW, Covey DA, St Germain HA Jr. One-year clinical performance of a self-etching adhesive in Class V resin composites cured by two methods. Oper Dent 2002;27: 218–22.

[15] Burrow MF, Tyas MJ. Clinical evaluation of an 'all-in-one' bonding system to non-carious cervical lesions—results at one year. Aust Dent J 2003;48:180–2.

[16] van Dijken JWV. Durability of three simplified adhesive systems in Class V non-carious cervical dentin lesions. Am J Dent 2004;17:27–32.

[17] Duke ES, Lindemuth J. Variability of clinical dentin substrates. Am J Dent 1991;4:241–6.

[18] 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.

[19] Barnes DM, Blank LW, Gingell JC, Gilner PP. A clinical evaluation of a resin-modified glass ionomer restorative material. J Am Dent Assoc 1995;126:1245–53.

[20] American Dental Association—Council on Scientific Affairs American Dental Association Program Guidelines: products for dentin and enamel adhesive materials, June, 2001. Available at www.ada.org.

[21] Alhadainy HA, Abdalla AI. 2-year clinical evaluation of dentin bonding systems. Am J Dent 1996;9:77–9.

[22] van Dijken JWV. Multi-step versus simplified enamel-dentin bonding systems. Réalités Cliniques 1999;10:199–222.

[23] Friedl K-H, Hiller K-A, Jung H, Schlittenbauer T, Lichtblau J, Schmalz G. Clinical evaluation of composite restorations using different adhesive systems. J Dent Res 2002;80 Spec Iss Abstract #535. Available at www.dentalresearch.org

[24] Wilder AD Jr, Perdigão J, Heymann HO. Six-month clinical study of an all-in-one dentin adhesive. J Dent Res 2001;80 Spec Iss Abstract #234. Available at www.dentalresearch.org

[25] Pashley EL, Agee KA, Pashley DH, Tay FR. Effects of one versus two applications of an unfilled, all-in-one adhesive on dentine bonding. J Dent 2002;30:83–90.

[26] Frankenberger R, Perdigão J, Rosa BT, Lopes M. "No-bottle" vs "multi-bottle" dentin adhesives: a microtensile bond strength and morphological study. Dent Mater 2001;17: 373–80.

[27] Miyasaki M, Iwasaki K, Onose H. Adhesion of single application bonding systems to bovine enamel and dentin. Oper Dent 2002;27:88–94.

[28] Rueggeberg FA, Margeson DH. The effect of oxygen inhibition on an unfilled/filled composite system. J Dent Res 1990; 69:1652–8.

[29] King NM, Tay FR, Pashley DH, Hashimoto M, Ito S, Brackett WW, et al. Conversion of one-step to two-step self-etch adhesives for improved efficacy and extended application. Am J Dent 2004. In press.

[30] Perdigão J, Geraldelli S. Bonding characteristics of self-etching adhesives to intact versus prepared enamel. J Esthet Restor Dent 2003;15:32–41.

[31] Kanemura N, Sano H, Tagami J. Tensile bond strength to and SEM evaluation of ground and intact enamel surfaces. J Dent 1999;27:523–30.

[32] Ferrari M, Mannocci F, Vich A, Davidson CL. Effect of two etching times on the sealing ability of Clearfil Liner Bond 2 in Class V restorations. Am J Dent 1997;10:66–70.

[33] Perdigão J, Lopes L, Lambrecths P, Leitão J, Van Meerbeek B, Vanherle G. Effects of self-etching primer on enamel shear bond strengths and SEM morphology. Am J Dent 1997; 10:141–6.

[34] van Dijken JWV. 3-year clinical evaluation of a compomer, a resin-modified glass ionômero and a resin composite in Class III cavities. Am J Dent 1996;9:195–8.

[35] Inoue S, Vargas MA, Abe Y, Yoshida Y, Lambrechts P, Vanherle G, et al. Microtensile bond strength of eleven contemporary adhesives to enamel. Am J Dent 2003;16:329–34.

[36] Armstrong SR, Vargas MA, Fang Q, Laffoon JE. Microtensile bond strength of a total-etch 3-step, total-etch 2-step, self-etch 2-step, and a self-etch 1-step dentin bonding system through 15-month water storage. J Adhes Dent 2003;5:47–56.

[37] Kenshima S, Reis A, Uceda-Gomez N, Tancredo LLF, Rodrigues Filho LE, Nogueira FN, et al. Effect of smear layer thickness and pH of self-etch adhesive systems on the bond strength and gap formation to dentin. J Adhes Dent 2005. In press.

[38] Munoz C, Dunn J, Fundingsland J, Richter R. Three-year clinical performance of Prompt L-Pop. J Dent Res 2004;82 Spec Iss A. Abstract #541. Available at www.dentalresearch.org.

[39] Torii Y, Itou K, Nishitani Y, Ishikawa K, Suzuki K. Effect of phosphoric acid etching prior to self-etching primer application on adhesion of resin composite to enamel and dentin. Am J Dent 2002;15:305–8.

[40] Miguez PA, Castro PS, Nunes MF, Walter R, Pereira PN. Effect of acid-etching on the enamel bond of two self-etching systems. J Adhes Dent 2003;5:107–12.

[41] Van Meerbeek B, Kanumilli P, DeMunck J, Van Landuyt K, Lambrechts P, Peumans M. A randomized controlled study evaluating the effectiveness of a two-step adhesive with and without selective phosphoric-acid etching of enamel. Dent Mater 2005. In press.

[42] Tay FR, Pashley DH. Aggressiveness of contemporary self-etching systems. Part I: Depth of penetration beyond dentin smear layers. Dent Mater 2001;17:296–308.