

Critical Appraisal

BONDING TO FLUOROSED TOOTH STRUCTURE

Author and Associate Editor

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In many continuing education lectures, I frequently have been asked the question "When bonding to fluorosed teeth, should I do anything differently?" As the prevalence of fluorosis has increased, this question has become more and more clinically relevant. Unfortunately, there has not been extensive research in this area, but there has been some. Recent Ask the Expert pieces in the Journal have addressed the issue, and this Critical Appraisal covers the recent research on bonding of resin-based materials to fluorosed enamel and dentin in greater detail.

MICRO-SHEAR BOND STRENGTH AND MORPHOLOGICAL ANALYSIS OF A SELF-ETCHING PRIMER ADHESIVE SYSTEM TO FLUOROSED ENAMEL

D.S. Weerasinghe, T. Nikaido, K.A. Wettasinghe, J.B. Abayakoon, J. Tagami *Journal of Dentistry* 2005 (33:419–26)

ABSTRACT

Objective: This study evaluated the bond of a self-etching primer adhesive system to different degrees of fluorosed enamel, and the influence of prior etching with phosphoric acid.

Materials and Methods: Eighty extracted molars were obtained from adult subjects (age 20–40) living in endemic areas for fluorosis in Sri Lanka. The teeth were classified into four groups according to a standard fluorosis index (Thylstrup-Fejerskov index, or TFI); the groups were no, mild, moderate, or severe fluorosis. Roots were cut from the teeth, and crown segments approximately 2-mm thick were removed using an Isomet (Buehler, Ltd., Lake Bluff, IL, USA) diamond saw. Two coronal and two cervical enamel sites were selected as substrates for microshear bond strength testing. The cervical areas were located approximately 2 mm above the CEJ.

To standardize enamel reduction, depth orientation pits of 0.5 mm were placed. Superficial enamel was removed using a superfine diamond on high speed followed by grinding with 600-grit abrasive paper. In one group of teeth, the enamel was treated using the self-etching primer adhesive system Clearfil SE Bond (Kuraray Medical, Tokyo, Japan). In a second group, application of Clearfil was preceded by a 30-second etch using 37% phosphoric acid.

Small pieces of tubing (internal diameter = 0.8 mm) were fixed to the treated surfaces and filled with composite resin, which was lightactivated. Specimens were stored in water for 24 hours. Shear bond strength testing was performed using a Bencor Multi-T (Danville Engineering, San Ramon, CA, USA) test apparatus mounted in a

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universal testing machine (EZ-Test, Shimadzu, Kyoto, Japan).

Fractured specimens were examined using confocal laser scanning microscopy at magnifications of $20 \times$ and $100 \times$. Bond failures were classified as adhesive, cohesive in the resin or enamel, or mixed.

Additional specimens representing the various levels of fluorosis were treated in the same manner as those prepared for bonding. Bonded interfaces were examined using field emission scanning electron microscopy (FE-SEM).

Results: On normal enamel (i.e., no fluorosis), the mean microshear bond strength was approximately 29 MPa, regardless of whether the enamel was pre-etched with phosphoric acid or not. The statistical analysis revealed that the degree of fluorosis had no significant effect on bond strengths for either bonding approach. Pre-etching with phosphoric acid significantly improved adhesion of Clearfil SE Bond to enamel with moderate or severe fluorosis.

Failure modes were primarily adhesive except in the moderate to severe fluorosis groups that were etched. As would be expected, acid-etching produced deeper zones of etching than the self-etch primer did. The etch zones were similar in normal and fluorosed enamel.

Conclusions: Bonding of a selfetch adhesive system to moderately and severely fluorosed enamel was inferior to that achieved by etching with phosphoric acid.

COMMENTARY

The results of this study suggest that fluorosis does not adversely

affect the bond of a self-etch primer adhesive system to enamel. However, it should be noted that the superficial 0.5 mm of enamel was removed before bonding. The outermost enamel is typically hypermineralized and acidresistant, so the results might have been quite different if this layer had not been removed.

Pre-etching with phosphoric acid did not improve the bond of the self-etch system to normal, nonfluorosed enamel. However, etching did significantly improve its bond to moderately and severely fluorosed enamel. Clinicians who use Clearfil SE Bond or similar adhesives should be aware of this when bonding to fluorosed enamel.

BONDING TO GROUND AND UNGROUND ENAMEL IN FLUOROSED TEETH

R.B. Ermis, J. De Munck, M.V. Cardoso, E. Coutinho, K.L. Van Landuyt, A. Poitevin, P. Lambrechts, B. Van Meerbeek *Dental Materials* 2007 (23:1250–5)

ABSTRACT

Objective: The purpose of this study was to evaluate the bonding effectiveness of a three-step etch-&-rinse adhesive and a two-step self-etch adhesive to fluorosed enamel using microtensile bond strength (MTBS) and microscopy. Materials and Methods: Fluorosed teeth were collected from an area in Turkey known to have endemic fluorosis. Nonfluorosed teeth were obtained in Belgium and were used as a control. According to the standard, TFI scale and scoring by two examiners, the fluorosis in the other teeth was considered moderate. The adhesives used in the study were the three-step OptiBond FL (Kerr Corporation, Orange, CA, USA) and the self-etch primer system Clearfil Protect Bond (Kuraray Medical).

The teeth were mounted in gypsum blocks. Using a depth-gauge

diamond and an automated cutting device, 0.3 mm of the mid-buccal and mid-lingual enamel was removed. Areas adjacent to the grooves prepared by this diamond were left unprepared. The adhesives were applied according to manufacturers' instructions and composite was applied and lightactivated in increments. Composite was bonded to both ground and unground enamel.

Following 24 hours storage in water, the bonded specimens were sectioned into small "sticks" with a cross-sectional area of 0.45 mm². These were loaded in tension using an LRX testing machine (Lloyd, Hampshire, UK). The exact dimension of each stick was measured using digital calipers and the MTBS was calculated in MPa units.

Failure modes were determined using optical microscopy at 50× magnification. Representative specimens from each group were further examined using FE-SEM.

Results: For Clearfil Protect Bond, the mean MTBS to unground fluorosed enamel was 15.8 MPa. The mean MTBS to unground normal enamel was significantly higher, at 27.1 MPa. The bond strength to ground enamel was much higher (40–45 MPa) and was not related to the degree of fluorosis.

For OptiBond FL, the mean MTBS to unground normal enamel was 35.5 MPa and was slightly (not significantly) less to unground fluorosed enamel (27.2 MPa). The mean MTBS for ground normal enamel was 50.5 MPa, and the mean for ground fluorosed enamel was 42.2 MPa, but these values were not significantly different.

Most failures were mixed, regardless of the adhesive type or experimental condition. However, fluorosed teeth tended to fail more cohesively in enamel than did normal teeth.

Conclusions: Using a self-etch adhesive, bonding to fluorosed enamel was not as effective as bonding to normal enamel. Preparation of the enamel surface improved the bond of both the self-etch and etch-&-rinse adhesive to fluorosed enamel.

COMMENTARY

This study showed that bonding of excellent adhesives representing the etch-&-rinse and self-etch categories was compromised when the enamel was moderately fluorosed. This was particularly true for the self-etch material.

Removal of the superficial enamel—in this case, 0.3 mm—greatly improved the bond of both adhesives to fluorosed enamel. When superficial enamel is prepared to this depth, the outermost hypermineralized layer and an underlying porous layer related to fluorosis are removed.

Highly fluorosed enamel is weaker than normal enamel, which makes bond strength testing somewhat problematic. As shown in this study, some of the bond failures actually were cohesive failures in the enamel itself, rather than a failure of the resin bond itself.

BONDING OF ACID-ETCH AND SELF-ETCH ADHESIVES TO HUMAN FLUOROSED DENTINE

P.G. Waidyasekera, T. Nikaido, D.S. Weerasinghe, J. Tagami *Journal of Dentistry* 2007 (35:915–22)

ABSTRACT

Objective: The purpose of this study was to compare the adhesion of etch-&-rinse, two-step selfetching primer, and "all-in-one" resin-based adhesives to normal dentin and to mild and moderately fluorosed dentin.

Materials and Methods: The adhesives used in this study were Single Bond (St. Paul, MN, USA; etch-&-rinse), Clearfil SE Bond (Kuraray Medical; two-step, selfetching primer), and Clearfil Tri-S Bond (Kuraray Medical; all-in-one).

Forty-eight extracted molars from subjects aged 30 to 40 years and living in endemic areas for fluorosis in Sri Lanka were used in the study. The teeth were caries-free and were extracted for periodontal reasons. Two independent examiners evaluated each tooth according to the standard fluorosis index and assigned scores representing normal, mildly fluorosed, or moderately fluorosed enamel (on the assumption that the enamel and underlying dentin would fall into similar categories). None of the teeth had severe fluorosis. The teeth were divided into

groups based on their fluorosis scores.

The occlusal enamel of 27 teeth was removed using a diamond saw, exposing superficial dentin. The dentin was ground to 600-grit to obtain a standardized smear layer. Composite was built up in increments after application of one of the three adhesives. After 24 hours of storage in water, the specimens were sectioned into 0.7 to 1.0 µm slabs for microtensile bond strength testing, which was accomplished using a universal testing machine (EZ-Test, Shimadzu). The remaining specimens were treated with the adhesives and examined using FE-SEM.

Results: On normal dentin, mean microtensile bond strengths were 45.8 MPa for Clearfil SE Bond, 30.3 MPa for Single Bond, and 26.7 MPa for Clearfil Tri-S Bond. On mildly fluorosed dentin, the respective values were 40.8, 28.5, and 20.2 MPa. On moderately fluorosed dentin, the means declined to 27.2, 24.0, and 16.6 MPa.

The most noteworthy finding of the FE-SEM examination was that the degree of smear layer removal by Clearfil SE Bond primer declined with increasing fluorosis.

Conclusions: Clearfil SE Bond, which uses a mild self-etching primer to condition the dentin, provided better adhesion than an etch-&-rinse or all-in-one adhesive to fluorosed dentin.

COMMENTARY

The bond strengths of all three adhesives tested were lower to fluorosed dentin than to normal dentin. For the two self-etch materials, the average bond strength was approximately 40% lower to moderately fluorosed than to normal dentin, whereas that of the etch-&-rinse material was 20% lower.

The most effective adhesive for bonding to fluorosed dentin was the two-step, self-etching Clearfil SE Bond. Because the primer is only mildly acidic, the adhesive monomer in Clearfil SE Bond (10-MDP) can chemically bond with residual hydroxyapatite crystals in the hybrid layer. The altered mineralization characteristics of fluorosed dentin probably affect this bond to some degree.

EFFECTS OF FLUOROSIS ON DENTIN SHEAR BOND STRENGTH OF A SELF-ETCHING BONDING SYSTEM

R.B. Ermis, N. Gokay Journal of Oral Rehabilitation 2003 (30:1090–4)

ABSTRACT

Objective: The purpose of this study was to evaluate the effect of fluorosis on the shear bond strength of a composite to dentin, using a self-etch primer adhesive system.

Materials and Methods: The materials used in this study were the adhesive Clearfil SE Bond (Kuraray Medical) and the microhybrid composite Clearfil AP-X (Kuraray Medical).

Teeth with varying degrees of fluorosis were obtained from a region in Turkey where many inhabitants have had excessive fluoride intake from naturally occurring fluoride in the water. Two examiners classified the severity of fluorosis as 0, 3, 4, or 5 on the TFI scale. (A score of 3 is in the mild range; 4 and 5 are in the moderate range.)

Buccal surfaces of the teeth were ground flat to expose dentin using

600-grit abrasive paper. The Clearfil SE Bond system was applied, and composite was applied and cured in molds. Shear bond strengths were determined using a universal testing machine. Failures were examined using a light microscope at 20× magnification.

Results: The mean shear bond strength for the control group (zero fluorosis) was 24.4 MPa. Means for the fluorosis groups were in the range of 22.7 to 27.0 MPa. No differences were statistically significant.

Conclusions: Fluorosis did not adversely affect adhesion of Clearfil SE Bond to dentin.

COMMENTARY

This study used teeth with a relatively low degree of fluorosis, so the results might have changed with more severe levels of fluorosis. With mild to moderate fluorosis, the two-step self-etch primer performed just as well as it did on normal dentin. The study by Waidyasekera et al. reviewed in this *Critical Appraisal* confirms these findings but also suggests that the adhesive does not work as well with more severe fluorosis.

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THE BOTTOM LINE

- Fluorosis, particularly if it is severe, can adversely affect resin bonding to enamel and dentin.
- For enamel, removal of the superficial enamel of fluorosed teeth greatly improves resin adhesion.
- Pre-etching with phosphoric acid improves the bond of self-etch adhesives to the enamel.
- Two-step self-etch adhesives that include a mildly acidic primer seem particularly well suited for bonding to fluorosed dentin.

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