A collection of scientific results

Adper Easy Bond™
Self-Etch Adhesive

3M ESPE
Adper™ Easy Bond and Adper™ Easy One are the same adhesive with different product names that are sold in different regions of the world.

Adper™ Single Bond Plus, Adper™ Single Bond 2 and Scotchbond™ 1 XT are the same adhesive with different product names that are sold in different regions of the world.

Adper™ Scotchbond™ SE and Adper™ SE Plus are the same adhesive with different product names that are sold in different regions of the world.
Letter from the Director…

Dear Dental Professional,

Adhesives comprise one of broader 3M Company’s most sophisticated technology platforms, and 3M ESPE has successfully leveraged this platform to respond to the unique needs of the dental industry. Our aim is to bring you products that make a real difference in your dental practice. Over 25 years of dental science has led to the development of Adper™ Easy Bond Self-Etch Adhesive. Adper Easy Bond self-etch adhesive incorporates our core adhesive technology, nanofiller technology and Vitrebond™ Copolymer technology to bring you an adhesive that is strong, reliable, simple, convenient and reduces potential for patient sensitivity.

The unique chemistry of Adper Easy Bond self-etch adhesive is also based on our Adper™ Single Bond Plus Adhesive which has delivered over a dozen years of high level clinical success.

During the development of Adper Easy Bond self-etch adhesive and since its introduction, researchers worldwide have evaluated its performance in numerous studies. More than 30 studies involving clinical use, adhesion, bond stability, sealing, marginal integrity and technique variability have been collected and summarized in this booklet. Clinical studies continue to be carried out to investigate the long-term behavior.

Best Regards

Dr. Al Viehbeck
3M ESPE Global Technical Director
St. Paul, MN and Seefeld, Germany
January 2010
Introduction

3M ESPE has a strong reputation in adhesives dating back to the development of Concise™ Enamel bonding agent in the 1970s. The launch of Adper™ Scotchbond™ Multi-Purpose Adhesive provided phosphoric acid etching to dentin and dramatically improved dentin bond strengths. Adper™ Single Bond Adhesive combined the primer and adhesive of Adper Scotchbond Multi-Purpose adhesive into one bottle, simplifying the procedure and reducing application time. This product was followed by Adper™ Single Bond Plus Adhesive, which added a bonded nanofiller to provide enhanced bond strength. Adper™ Prompt™ Adhesive was 3M ESPE’s first self-etch bonding agent and featured the convenient L-Pop™ unit-dose delivery system.

Building upon this strong tradition in bonding agents, 3M ESPE has developed Adper™ Easy Bond Self-Etch Adhesive. Incorporating over 25 years of adhesive technology in a single bottle, Adper Easy Bond self-etch adhesive offers fast application time along with the reduced risk of post-operative sensitivity inherent to self-etch adhesives.

Adper Easy Bond self-etch adhesive shares much of the same chemistry as Adper Single Bond Plus adhesive. Both share the same unique components that give Adper adhesives strength and versatility to be used in clinical procedures with confidence.

Unique to 3M ESPE adhesives and resin-modified glass ionomer materials is the inclusion of the “Vitrebond™ Copolymer” component. The Vitrebond copolymer is a methacrylate-modified polyalkenoic acid that aids in film forming and resistance to moisture variables to allow more consistent bonding in moist environments.

<table>
<thead>
<tr>
<th>Shared Chemistry</th>
<th>Adper™ Easy Bond Self-Etch Adhesive</th>
<th>Adper™ Single Bond Plus Adhesive</th>
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<tbody>
<tr>
<td>Methacrylated phosphoric esters</td>
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<tr>
<td>Vitrebond™ Copolymer</td>
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<td>Vitrebond™ Copolymer</td>
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<td>Nanofiller</td>
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<td>Ethanol</td>
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<tr>
<td>Dimethacrylates</td>
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<td>Dimethacrylates</td>
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<tr>
<td>HEMA</td>
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<td>HEMA</td>
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<tr>
<td>Initiators</td>
<td></td>
<td>Initiators</td>
</tr>
</tbody>
</table>
Clinical Results

Clinical performance is the true test of a dental adhesive. In the laboratory setting, isolation is complete, visibility is perfect and the surface is flat. Contrast this with the clinical setting where isolation is variable, visibility is limited and the surface is three-dimensional.

After placement of a restoration, the clinical setting stresses the restoration via thermal loading, occlusal forces stress the fatigue resistance of the bond, and various staining solutions from wine to espresso serve as continual indicators of the marginal integrity.

The ability for an adhesive to be easy to use, resistant to the variables that arise in the clinical situation and adequately seal the tooth allow for a good patient experience from the perspective of post-operative sensitivity.
1. Clinical Results (In-Vivo)

Clinical Evaluation of Three Adhesive Systems in Class V Restorations

Authors: R. Sadid Zadeh, M. Anabtawi, D. Givan, B. Waldo and L. Ramp, University of Alabama, Birmingham, AL; J.O. Burgess, University of Alabama School of Dentistry, Birmingham, AL
Reference: AADR 2010, Washington DC, USA, Abstract # 28

Aim of the Study: The purpose of this clinical trial is to compare the clinical performance of two new self etching dental adhesives in the restoration of NCCL to Single Bond Plus a traditional one bottle total etch dental adhesive. Restoration of non-curious cervical lesion (NCCL) is used to evaluate adhesive effectiveness.

Method: 50 adult patients 19 years or older were recruited after obtaining informed consent. Each had at least 3 NCCLs with minimum depth of 1.5mm, no chronic periodontal disease, and normal salivary function. The teeth were restored randomly with Adper Single Bond Plus, Adper Easy Bond or Adper Scotchbond SE dental adhesives and Filtek Supreme Plus (3M ESPE) composite resin. All restorations were isolated with a rubber dam and cleaned with flour of pumice. A short enamel bevel was made with an OS 2 bur (Brassler, GA) and high speed hand piece (NSK, Japan). One of the adhesives was applied following manufacturer’s directions. Application time was measured with a stop watch. The proper composite shade was selected, placed in 2mm increments and cured using G Light (GC America, Chicago, IL). Output was measured daily (> 700mW/cm²). Finishing was completed using finishing burs (7901 and OS 2 Brassler). Polishing was completed with Sof-Lex and Enhance/PoGo polishing systems. Digital images were made before and after preparation, at baseline and at each recall. Patients were evaluated at base line (after 2 weeks) and 6 months for anatomic form, margin adaptation, staining, retention, surface roughness, color match, postoperative cold sensitivity and secondary caries.
Clinical Evaluation of Three Adhesive Systems in Class V Restorations (cont.)

1. Clinical Results (In-Vivo)

Results: The results were evaluated with McNemars test. Of all placed restorations evaluated at 6-month recall, one restoration failed in the Adper Single Bond Plus category.

<table>
<thead>
<tr>
<th></th>
<th>Adper Easy Bond</th>
<th>Adper Scotchbond SE</th>
<th>Adper Single Bond Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Alpha</td>
<td>% Alpha</td>
<td>% Alpha</td>
<td>% Alpha</td>
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<tr>
<td>Retention</td>
<td>100</td>
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<td>96</td>
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<tr>
<td>Anatomic Form</td>
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<td>96</td>
<td>92</td>
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<tr>
<td>Color Match</td>
<td>94</td>
<td>92</td>
<td>94</td>
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<tr>
<td>Margin Integrity</td>
<td>100</td>
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<tr>
<td>Margin Discoloration</td>
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<td>96</td>
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<tr>
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<td>96</td>
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<td>98</td>
</tr>
<tr>
<td>Secondary Caries</td>
<td>96</td>
<td>94</td>
<td>98</td>
</tr>
<tr>
<td>Staining</td>
<td>100</td>
<td>98</td>
<td>98</td>
</tr>
</tbody>
</table>

Conclusions: Within the limits of this short term evaluation, there is no significant clinical difference between adhesives (p <0.05).
Clinical Use of Adper Easy Bond

Authors: 3M ESPE Internal Data
Reference: Unpublished

Aim of the Study: Prior to the introduction of the Adper Easy Bond onto the market, a clinical field evaluation of the adhesive was conducted. The evaluation focused on a variety of clinical use questions including the occurrence of any initial patient sensitivity following the restorative procedure.

Method: The adhesive was supplied to 100 dentists who were instructed to use it on approximately 50 patients each over a period of one month in a variety of restorative procedures and record the results with respect to sensitivity for each patient following treatment.

Results: During the evaluation, 5,572 restorations were placed with the 100 dentists. Seven of the dentists had patients that experienced some level of sensitivity. Of the 5,572 restorations placed, only 26 restorations were noted to have any sensitivity. The percentage of restorations experiencing sensitivity was 0.47%.

Conclusion: The clinical use of Adper Easy Bond demonstrates virtually no incidence of post-operative sensitivity.

Restorations Experiencing Sensitivity = 0.47% (26)
Adhesion to Enamel and Dentin

The section presents results into the bonding capabilities of Adper™ Easy Bond Self-Etch Adhesive. Testing the ability of an adhesive to bond to enamel and dentin is perhaps the most popular in vitro test performed on a dental adhesive. Adhesion testing is used to design new adhesives, compare existing products, investigate variables such as the effects of moisture and contamination, and ultimately to try to predict clinical performance.

There are many different test procedures used to evaluate bond performance. They include varying types of shear and tensile methods. They can also vary in the type of surface treatment, sample preparation, storage and thermal stress and test geometry. Thus it is important to look at several results in order to draw conclusions pertaining to performance.

It is also important to look at different surfaces of the enamel and dentin. For enamel, we must consider the cut or prepared surface as well as the intact or uncut surface. This is especially important when assessing the self-etch materials that typically have a higher pH than the phosphoric acid from the total-etch systems, which can impact the clinical performance and bond to the more highly mineralized intact enamel. For dentin, there is a difference in the tubule size and distribution from the superficial to the deep dentin as well as differences in root surface dentin.
The purpose of this study was to examine the bonding performance of all-in-one adhesive systems, Adper Easy Bond (AE, 3M ESPE), and Clearfil Tri-S Bond (TS, KURARAY), to enamel and dentin as compared with those of Single Bond (SB, 3M ESPE) and Clearfil SE Bond (SE, KURARAY).

The uncut labial enamel surface (UE) of 25 human extracted incisors was cleaned simply with a rotated polishing-brush. Standardized V-shaped cavity having an enamel bevel was prepared in the buccocervical region of 25 extracted premolars. UD and both the cut surfaces of beveled enamel (CE) and gingival dentin wall (CD) of the standardized cavities were pretreated with the five systems according to the manufacturer’s instructions. The immediate tensile bond strength (TBS) of the systems to UE/CE/CD in MPa were measured (n = 5) with a portable adhesion tester (JDR 75, 1996). The data were statistically analyzed using ANOVA and Tukey’s q-test.
Results: The TBS of the systems except SB were not influenced statistically by the difference in bonded surfaces. The TBS of TS to UE was statistically smaller than the values of AE and SB at p <0.05. There was no significant difference in the TBS to UE among the four systems. The TBS of AE, TS and SE to CD were statistically greater than that of SB at p <0.05.

Conclusion: The two all-in-one adhesive systems demonstrated excellent bonding performance that was not influenced by the difference in bonded surfaces. Dentin bonding performance of the two systems was superior to that of Single Bond Plus. Especially the TBS of Easy Bond was similar to or greater than the values of the other systems regardless of the bonded surface.
Immediate Shear Bond Strengths of Total and Self-Etch Adhesives

Authors: R. Ritter and C. Ramsey, Private Practice, Jupiter, FL; J.M. Powers, Dental Consultants, Inc, Ann Arbor, MI
Reference: AADR 2010, Washington DC, USA, Abstract # 779

Aim of the Study:
To determine if two different self-etching adhesives had different immediate shear bond strengths compared with a total-etch adhesive on dentin.

Method:
Thirty human molars were sectioned, mounted and ground to a flat dentin surface using 600-grit silicon carbide paper. The dentin specimens were divided into three separate groups (n = 10):

- **Group 1:** Total Etch MPa (Clinician’s Choice) (Control);
- **Group 2:** Self-etching primer Peak SE (Ultradent);
- **Group 3:** Self-etching primer Easy Bond (3M ESPE).

The specimens with the total-etch adhesive were etched with phosphoric acid for 10 seconds, rinsed and blotted before application of the adhesive. The self-etch adhesives were applied for 20 seconds each as per manufacturers’ instructions. The adhesives were air thinned and light cured for 10 seconds each. All of the specimens were immediately sheared in a testing machine (Instron) at a crosshead speed of 1.0mm/min. using the Ultradent shear bond test. Mean shear bond strengths were calculated and subjected to analysis of variance at the 0.05 level of significance.
Immediate Shear Bond Strengths of Total and Self-Etch Adhesives (cont.)

Results: The bond strength of Group 3 was statistically different ($p = 0.0001$) from those of Groups 1 and 2, which were statistically the same. The self-etch adhesives had bond strengths equal to or better than the traditional total-etch adhesive on dentin.

Conclusion: The use of self-etching adhesives on dentin produced the same or higher bond strength than a total-etch adhesive on dentin among the adhesives tested.
2. Adhesion to Enamel and Dentin

Immediate Microtensile Bond Strength of One-Bottle All-in-one Adhesive Systems to Enamel/Dentin

Authors: M. Hara, T. Yamada, T. Suzuki, T. Kimishima, T. Maseki and Y. Nara, Nippon Dental University, Tokyo, Japan; I.L. Dogon, Harvard University, Boston, MA, USA

Reference: IADR 2008, Toronto, Canada, Abstract #398

Aim of the Study:
The purpose of this study was to examine the bonding efficiency of one-bottle, one-step, all-in-one adhesive systems to cervical enamel and dentin.

Method:
Four one-bottle one-step all-in-one adhesive systems on the market; Tokuyama Bond Force (BF, Tokuyama), Adper Easy Bond (EB, 3M ESPE), G-Bond (GB, GC) and Clearfil Tri-s Bond (TS, Kuraray), and a popular two-bottle two-step self-etching primer system; Clearfil SE Bond (SE, Kuraray, for control), were used. Standardized V-shaped cavity with a bevel at occlusal enamel was prepared in the buccocervical region of 40 extracted human premolars. The cavities were pretreated clinically with the five systems according to the manufacturer’s instructions. The immediate tensile bond strength (ITBS) of the systems to the surface of beveled enamel (E, n = 8) and to gingival dentin wall (D, n = 8) were measured with a custom-made in vivo/vitro bi-use portable adhesion tester (JDR 75, 1996). The data were statistically analyzed using ANOVA, Tukey’s q-test and student’s t-test.
Results: Although the ITBS was significantly influenced by the difference in systems at p < 0.05, it was not influenced by the difference in tooth substance. The ITBS of four one-bottle all-in-one adhesive systems to E was significantly smaller than the value of SE at p < 0.05. The ITBS of BF, EB and TS to D were similar to that of SE, and the value of GB was significantly smaller than EB and SE at p < 0.05.

Conclusion: The bonding efficiency of one-bottle one-step all-in-one adhesive systems in this study to enamel was inferior to that of Clearfil SE represented as a typical two-step self-etching primer system. However the efficiency of the one-bottle all-in-one systems to dentin, except G-Bond, was similar to that of Clearfil SE.
Aim of the Study: The purpose of this study was to compare the bond strengths of four one-bottle self-etch adhesive systems to dentin and enamel.

Method: Four commercially available one-bottle bonding agents were evaluated;

- **Group 1**: Adper Easy Bond (3M ESPE),
- **Group 2**: Optibond All-in-One (Kerr),
- **Group 3**: Clearfil S3 Bond (Kuraray Dental),
- **Group 4**: Xeno IV (Dentsply/Caulk).

Recently extracted healthy human 3rd molar were imbedded in acrylic. Dentin or enamel was exposed and polished to 600-grit to be used as dentin or enamel substrate, respectively. Ultradent shear bonding technique was used. The adhesive was placed on the specimen surface following the manufacturers’ instructions. The specimen was then mounted onto the jig and light cured. About 0.5mm thick layer of Z100 (3M ESPE, A2 shade) was packed into the mold, and light cured for 40 seconds with a halogen curing unit (XL3000, 3M with light intensity 500–600mW/cm²). Then a 1.5mm layer of Z100 was added and light cured. The specimen was removed from the jig and stored in 37°C tap water for 24 hours before tested on an MTS universal material testing machine at a cross-head speed of 1mm/min. Ten specimens were made per group. Shear bond strength (SBS, MPa) were calculated by dividing the peak load by the bonding area. Data were analyzed by 2-way analysis of variance (ANOVA) and then by 1-way ANOVA for each substrate. Tukey-Kramer test were performed to compare the means of different dental adhesives at the level of 0.05.
Comparison of One-Step Dental Bonding Agents (cont.)

2. Adhesion to Enamel and Dentin

Results:
The four groups tested had similar bonding strength on enamel; Adper Easy Bond and Optibond All-in-one had higher bond strength on dentin than Clearfil S3 Bond and Xeno IV, while Xeno IV had the weakest bond on dentin.
The goal of this study was to compare the adhesion performance of Adper™ Easy Bond, a new self etch “one bottle” adhesive with other commercially available one bottle adhesives.

The adhesion specimens were prepared for evaluation employing the “Notched Edge” test method. Manufacturers’ instructions were followed in placing the adhesive. The commercial adhesives employed were Adper Easy Bond, Xeno IV, Clearfil tri-S-bond (S3), i-Bond and G-Bond. Filtek™ Z250 (3M ESPE) shade A2 was used as the composite for all adhesives. Adhesion performance was evaluated on enamel and dentin after 24 hour storage in water at 37°C.

Two sample t-test showed differences (p-value table will be presented). ANOVA (one-way) showed differences on dentin.
Thirty Operator Bond Strength Evaluation of Adper™ Easy Bond

Authors: B.A. Shukla, S. Aasen, B.D. Craig, R. Ferguson, V.A. Russell, C.A. Sigurdson, C. Thalacker, and R.R. Wertish, 3M ESPE Dental Products, St. Paul, MN, USA

Reference: IADR 2007, New Orleans, USA, Abstract #1495

Aim of the Study: This study compared the shear bond strengths (SBS) of self-etch adhesive systems. The adhesives included in the study were Adper™ Easy Bond (EB, 3M ESPE), Clearfil™ S3 Bond (CS3, Kuraray) and Xeno® IV (X4, Dentsply) on bovine cut enamel (E) and superficial dentin (D).

Method: A notched edge shear test method was used to measure the SBS to E and D at 24 hours after curing the composite (Filtek™ Z250 A2, 3M ESPE) buttons. A panel of 30 dentists applied the adhesives per manufacturers’ instructions, and a group of four experienced operators applied the composite buttons.

Results: Mean (standard deviation) SBS in MPa are listed in the graph below. Two-sample t-tests (p <0.05) were used to compare individual sample sets.

Conclusion: Xeno IV had a statistically lower SBS than Adper Easy Bond (p = 0.013) and Clearfil S3 (p = 0.005) on enamel. Adper Easy Bond had statistically higher SBS than both Clearfil S3 (p = 0.004) and Xeno IV (p = 0.001) on dentin.
Bonding Performance of Recent Self-etch Adhesive Systems under Combination Stress

Authors: Y. Nara, M. Hara, T. Yamada, T. Suzuki, T. Maseki and T. Kimishima, The Nippon Dental University, Tokyo, Japan; I.L. Dogon, Harvard University, Boston, MA, USA

Reference: IADR 2008, Toronto, Canada, Abstract #369

Aim of the Study:
The purpose of this study was to examine the bonding performance of three recent one-bottle self-etch adhesive systems, i.e., Tokuyama Bond Force (BF, TOKUYAMA), Adper Easy Bond (EB, 3M ESPE), and Clearfil Tri-S Bond (TS, KURARAY) as compared with that of a popular two-bottle self-etching primer system; Clearfil SE Bond (SE, control, KURARAY).

Method:
Standardized V-shaped cavity was prepared in the cervical region of 50 extracted human premolars. The cavities were pretreated with the five systems (n = 10 each) and then restored clinically according to the manufacturer’s instructions. The restored specimens were subjected to a combination stress load condition simulating oral environment; thermocycling (4°C/60°C x 1,250 sets) and simultaneous repeated-load (12kgf x 105 times). Each specimen was longitudinally serially sectioned into two slabs of 1.0mm thickness. The slabs were trimmed into a standardized dumbbell-form specimen. The measurement of micro-tensile bond strength (μ-TBS, n = 20 each) to the dentin wall of the specimens was attempted. The data of μ-TBS were examined using t-test and Weibull analysis.
2. Adhesion to Enamel and Dentin

Bonding Performance of Recent Self-etch Adhesive Systems under Combination Stress (cont.)

Results: The mean μ-TBS(s.d.) in MPa / Weibull modulus were BF;11.4 (4.2)/2.83, EB;26.7(10.9)/2.37, TS;13.7(3.1)/4.51, SE;15.4(7.4)/2.47. The μ-TBS of EB was significantly greater than those of the other systems and the value of BF was statistically smaller than that of SE. Weibull modulus of TS was greater than those of BF, SE and EB at p <0.01, and no difference in the modulus was recognized among SE, BF and EB.

Conclusion: The bonding durability of Adper Easy Bond was superior to Clearfil SE Bond Force and Tri-S Bond.
Aim of the Study: To measure and compare the shear bond strength of three adhesives to enamel and dentin at 24 hours and 11 months. There is a concern that the bond strength of the one-bottle bonding systems may degrade over time due to their increased hydrophilicity.

Method: One hundred twenty extracted human molars were divided into two groups (24 hr, 11 month) and wet ground with 600-grit SiC paper to obtain flat enamel (60) and dentin (60) surfaces. The adhesives used were Adper™ Single Bond Plus, a total-etch one bottle adhesive Adper™ Scotchbond™ SE, a two component etching adhesive and Adper™ Easy Bond, a single component self-etching adhesive (n = 10/group). Each material was applied to the bonding area according to manufacturer’s instructions. Two teeth/per adhesive were prepared until sample size for each group was reached. A plastic tube (diameter = 1.5mm) filled with composite-resin (Z100) was placed over the adhesive and cured for 40 seconds. Sixty samples were stored for 24 hours/37°C and 60 samples were stored for 11 months/37°C/ tap water. Specimens were placed on a universal testing machine (INSTRON-5565) and loaded to failure (1mm/min), and statistically analyzed (2-factor ANOVA, p = 0.05). Results, based on n = 10, in MPa (standard deviation).
2. Adhesion to Enamel and Dentin

Shear Bond Strength of Three Adhesives to Enamel and Dentin—Initial and Aged (cont.)

Results: Early in-vitro results showed no significant differences between the substrate or the bonding agent (p > .05). Single Bond Plus was significantly higher than Easy Bond on both substrates after 11 months and showed significantly higher result on enamel after storage (p < .05).

Conclusion: The bond strength values of self-etching adhesives did not deteriorate overtime and show promise as effective bonding agents.
2. Adhesion to Enamel and Dentin

Six and Twelve* Month Bond Strength Evolution of All-in-One Adhesives

Authors: O. Kappler, H. Loll, and C. Thalacker, 3M ESPE AG, Seefeld, Germany
Reference: IADR CED 2009, Munich, Germany, Abstract #85

Aim of the Study: Aim of this study was to investigate the effect of long-term storage on the shear bond strengths (SBS) of All-in-One (7th generation) adhesives to bovine enamel and dentin.

Method: Bovine incisors were embedded in cold-cure acrylic resin. The labial surface of each tooth was ground to expose enamel or dentin. A cylindrical button of Filtek™ Z250 (4.67mm diameter, 2mm height) was cured on the tooth surfaces treated with Adper Easy Bond (AEB, 3M ESPE), iBOND SE (IBSE, Heraeus Kulzer), Xeno V (XV, Dentsply), AdheSE One (AO, Ivoclar-Vivadent) according to the instructions for use (n = 5). After storage intervals of 24h (baseline t = 0), 6 and 12 months in water at 37°C, the specimens were tested in shear mode using a Zwick Z010 universal testing machine (crosshead speed 2mm/min).

*12 month data will be presented at IADR 2010, Barcelona, Spain
Six and Twelve* Month Bond Strength Evolution of All-in-One Adhesives (cont.)

Results: The graph shows the SBS in MPa with standard deviations. All data were analyzed by ANOVA and multiple comparisons using Fisher’s LSD procedure (p < 0.05).

Conclusion: Multiple statistically significant differences were found. Adper Easy Bond performed maintained high and consistent bond strengths over the 12 month period.
Dentin Bond Strength, Flexural Strength and Modulus of Bonding Agents

Authors: A. Carvalho, G. Ambrosano, R. Cantanhede de Sá, and M. Giannini, State University of Campinas, Piracicaba, Brazil; M. Carrilho, Piracicaba School of Dentistry, University of Campinas, University of Sao Paulo, Sao Paulo, Brazil; D. Mettenburg, F. Rueggeberg, Medical College of Georgia, Augusta, GA

Reference: AADR 2010, Washington DC, USA, Abstract #435

Aim of the Study: This study evaluated the tensile bond strength (TBS) to dentin, as well as the biaxial flexural strengths and flexural moduli of four commercial adhesive systems (AS) (3M ESPE): one-step self-etching (Easy Bond) (EB), two-step self-etching (Scotchbond SE) (SE), two-step etch-&-rinse (Single Bond Plus) (SBP), and three-step etch-&-rinse (Scotchbond Multi-Purpose) (SBMP).

Method: Occlusal surfaces of extracted, human third molars were flattened, exposing the middle portion of dentin. Dentin surfaces were polished with 600-grit SiC-paper for one minute and assigned to one of four groups (n = 8). AS were applied and polymerized according to manufacturers' instructions and 5mm-high composite blocks were incrementally added and cured to provide gripping (Supreme Plus, 3M ESPE). Specimens were stored in distilled water at 37°C for 24 hours and sectioned mesio-distally and buccal lingually to obtain bonded beams (cross-sectional area 1mm²). Micro-tensile bond strengths of beams were measured (EZ-Test – 0.5mm/min). For biaxial testing, resin discs (0.6mm thick, 6.2mm diameter) were prepared in molds (n = 10). Adhesives were applied incrementally to the molds and light-activated: halogen light-curing unit, Optilux 501. Discs were water-stored for one week before testing to flexural failure (1.27mm/min, Model 5844, Instron Corporation). Bond strength and flexural data were statistically analyzed by one-way ANOVA and Tukey’s post-hoc test at a pre-set alpha of 0.05. Results: Table provides test results (mean (sd).
2. Adhesion to Enamel and Dentin

Dentin Bond Strength, Flexural Strength and Modulus of Bonding Agents (cont.)

Results: No significant difference in bond strength was noted among adhesives (p = 0.2768). Flexural modulus of SBMP and SE were greater than SBP and EB. SBMP and EB showed highest flexural strengths while SBP and SE showed the lowest.

<table>
<thead>
<tr>
<th></th>
<th>TBS (MPa)</th>
<th>Flexural Modulus (MPa)</th>
<th>Flexural Strength (MPa)</th>
</tr>
</thead>
<tbody>
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<td>1375(325)b</td>
<td>73(7)ab</td>
</tr>
<tr>
<td>SE</td>
<td>40(6)a</td>
<td>1851(216)a</td>
<td>67(15)bc</td>
</tr>
<tr>
<td>SBP</td>
<td>48(8)a</td>
<td>1308(256)b</td>
<td>59(7)c</td>
</tr>
<tr>
<td>SBMP</td>
<td>45(7)a</td>
<td>2132(240)a</td>
<td>85(9)a</td>
</tr>
</tbody>
</table>

Within column, cells with same letter are not significantly different.
2. Adhesion to Enamel and Dentin

Bond Strength Testing of All-in-One Adhesives on Enamel and Dentin

Authors: G. Kugel, R.D. Perry, M. Finkelman, and R. Perry, Tufts University, Boston, MA

Reference: AADR 2010, Washington DC, USA, Abstract #19

Aim of the Study: To compare the shear bond strength (SBS) of 5 All-in-One (AIO) adhesive systems on enamel and dentin at 24 hours and 10,000 cycles.

Method: Adhesives: iBOND Self-Etch (IBSE, Heraeus Kulzer), Clearfil S3 Bond (S3B, Kuraray), Adper Easy Bond (AEB, 3M ESPE), Optibond solo Plus (OSP, Kerr) and Xeno IV (XIV, Dentsply-Caulk). Adhesives were applied according to manufacturers’ instructions and light-activated. 160 human molars were randomly divided into 20 groups (n = 8). Flat enamel and dentin surfaces were prepared on SiC paper, grit 120 through 320. Venus Diamond composite, shade A2 (Heraeus Kulzer) was filled in cylindrical plastic molds (Ultradent equipment) and cured for 20 seconds. Light-activation of adhesives and composite was done with a LED curing unit (Translux Power Blue, Heraeus Kulzer). Shear bond strength (shear rate: 1mm/min) was determined after 24 hour water-storage of specimens at 37°C and after additional thermocycling (10k, 5/55°C). Statistical analysis was done by three-way ANOVA, with post-hoc analysis conducted via Tukey’s HSD.
2. Adhesion to Enamel and Dentin

Bond Strength Testing of All-in-One Adhesives on Enamel and Dentin (cont.)

### Results:

#### Results after 24h at 37°C (Enamel)

<table>
<thead>
<tr>
<th></th>
<th>IBSE</th>
<th>AEB</th>
<th>S3B</th>
<th>OAO</th>
<th>XIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Value [Mpa]</td>
<td>32.8</td>
<td>30.6</td>
<td>29.4</td>
<td>24.6</td>
<td>26.5</td>
</tr>
<tr>
<td>Standard Deviation [Mpa]</td>
<td>4</td>
<td>3.3</td>
<td>5</td>
<td>5.6</td>
<td>5</td>
</tr>
</tbody>
</table>

#### Results after 10,000 Thermocycles (Enamel)

<table>
<thead>
<tr>
<th></th>
<th>IBSE</th>
<th>AEB</th>
<th>S3B</th>
<th>OAO</th>
<th>XIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Value [Mpa]</td>
<td>31.3</td>
<td>25.3</td>
<td>25.5</td>
<td>32.4</td>
<td>13.1</td>
</tr>
<tr>
<td>Standard Deviation [Mpa]</td>
<td>2.6</td>
<td>3.9</td>
<td>3.6</td>
<td>6</td>
<td>4.4</td>
</tr>
</tbody>
</table>

#### Results after 24h at 37°C (Dentin)

<table>
<thead>
<tr>
<th></th>
<th>IBSE</th>
<th>AEB</th>
<th>S3B</th>
<th>OAO</th>
<th>XIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Value [Mpa]</td>
<td>39.3</td>
<td>42.9</td>
<td>38.3</td>
<td>40.2</td>
<td>33.3</td>
</tr>
<tr>
<td>Standard Deviation [Mpa]</td>
<td>2.8</td>
<td>3.8</td>
<td>7.6</td>
<td>8.3</td>
<td>7.9</td>
</tr>
</tbody>
</table>

#### Results after 10,000 Thermocycles (Dentin)

<table>
<thead>
<tr>
<th></th>
<th>IBSE</th>
<th>AEB</th>
<th>S3B</th>
<th>OAO</th>
<th>XIV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Value [Mpa]</td>
<td>33.7</td>
<td>39.5</td>
<td>39.5</td>
<td>35.6</td>
<td>28.9</td>
</tr>
<tr>
<td>Standard Deviation [Mpa]</td>
<td>5.7</td>
<td>3.1</td>
<td>5.1</td>
<td>6.9</td>
<td>13.4</td>
</tr>
</tbody>
</table>

### Conclusion:

The All-in-One adhesives had significantly higher SBS when applied to dentin than when applied to enamel (p <0.001). Bond values were significantly higher after 24 hours at 37°C than after additional thermocycling (p = 0.001). The adhesive system was also a statistically significant factor (p <0.001); the post-hoc analysis revealed that XenoIV exhibited lower SBS than all other systems.
Bonding Durability of All-in-one Adhesive Systems under Thermo-mechanical Repeated Stress

Authors: Y. Nara, M. Hara, T. Yamada, S. Ogawa, T. Maseki, and T. Kimishima, Nippon Dental University, Tokyo, Japan; I.L. Dogon, Harvard University, Boston, MA

Reference: AADR 2010, Washington DC, USA, Abstract #213

**Aim of the Study:**
The purpose of this study was to examine the bonding durability of recent three all-in-one adhesive systems; Tokuyama Bond Force (BF, TOKUYAMA), Adper Easy Bond (EB, 3M ESPE) and Clearfil Tri-S Bond (TS, KURARAY), as compared with that of a popular self-etching primer adhesive system; Clearfil SE Bond (SE, control, KURARAY).

**Method:**
Standardized V-shaped cavity was prepared in the cervical region of 80 extracted human premolars. The cavities were pretreated with the four systems (20 each) and then restored clinically according to the manufacturer’s instructions. A half of the restored specimens (10 each system) were subjected to thermo-mechanical repeated stress condition simulating oral environment; thermocycling (4°C/60°C x 1,250 sets) and simultaneous repeated-load (12kgf x 105 times). Another half of specimens were supplied as non-stress control group. Micro-tensile bond strengths (μ-TBS) to the gingival dentin wall of the specimens with and without the stress load were measured. The data of μ-TBS were examined using two-way ANOVA and Tukey’s q-test.
2. Adhesion to Enamel and Dentin

Bonding Durability of All-in-one Adhesive Systems under Thermo-mechanical Repeated Stress (cont.)

Results: The difference in system and the mode of stress influenced significantly the μ-TBS. The μ-TBS of BF and SE under the stress condition were statistically smaller than the values under non-stress condition at p <0.01. However the μ-TBS of EB and TS did not vary with the mode of stress. There was no significant difference in the μ-TBS under non-stress condition among the four systems. Under the stress condition, the value of EB was significantly greater than those of the other systems at p <0.01.

Conclusion: The bonding durability, based on the μ-TBS, of the three all-in-one adhesive systems was similar to or superior to that of Clearfil SE. The thermo-mechanical repeated stress decreased significantly the μ-TBS of Bond Force and Clearfil SE. However Adper Easy Bond demonstrated excellent bonding durability that could maintain the μ-TBS over 25 MPa under the stress condition.
Microtensile Bond Strengths of Current Adhesive Systems to Root Dentin

Authors: F. Ozer, M. Sher, O. Ekmekcioglu, J.A. Ruch, M.B. Blatz, University of Pennsylvania, USA
Reference: Academy of Dental Materials 2009, Portland, USA, Abstract #42

Aim of the Study: To evaluate the microtensile bond strength of some current adhesive systems on root surface dentin after 24 hours of storage in distilled water.

Method: Long flat dentin surfaces below the CEJ on 54 human extracted teeth were prepared with a series of sandpaper discs, and then treated with one of the adhesive systems according to the manufacturer’s instructions. Each adhesive group comprised six teeth. The adhesives were two-step etch & rinse (Optibond Solo Plus (OSP), Kerr Corp.; XP Bond (XP), Dentsply; Prime&Bond NT (PB), Dentsply; I-Bond (IB), Heraeus Kulzer), two-bottle self-etch (Clearfil SE Bond (CSE), Kuraray; FL Bond (FLB), Shofu; Scotch Bond SE (SSE), 3M ESPE), and one-bottle self-etch (Clearfil Tri S Bond (CS3), Kuraray; Adper Easy Bond (AEB), 3M ESPE). 3mm high composite resin build-ups were formed on the bonding surfaces with composite resin. After storage in distilled water for 24 hours, the specimens were sectioned into 1mm thick slabs at 90° angles to the long axis of the teeth and hour-glass shaped specimens with an area of about 1mm² at the bonded interface were prepared. The slabs were then subjected to microtensile testing. Statistic analysis was carried out with SPSS 13.0. Data of groups were analyzed using Mann-Whitney U test.
2. Adhesion to Enamel and Dentin

Microtensile Bond Strengths of Current Adhesive Systems to Root Dentin (cont.)

Results: The bond strengths of CSE, AEB, PB, FLB, and IB were not significantly different (p >0.05). The lowest bond strength values of all bonding agents were found with CS3.

Conclusion: The results of this study suggest that there are similar root surface bond strengths between two-bottle self-etch and etch & rinse dentin adhesives.
Bond Strength of SE Adhesive in Different Cuts of Dentine

Authors: D. Lafuente, Universidad de Costa Rica, San Jose, Costa Rica

Reference: IADR 2009, Miami, USA, Abstract #2963

Aim of the Study: To evaluate the difference in bond strength of self-etch adhesives when the dentine tubules have different orientation and size.

Method: 30 recently extracted human molars were cut in three different areas (n = 10): just below the ED junction, at the CEJ and longitudinally MD at the central groove. Groups received adhesives either Easy Bond or Scotchbond SE (3M ESPE) following manufacturer’s instruction before having composite applied over it using “Ultradent jig”. Specimens were stored at 37°C in 100% relative humidity for 7 days before being tested in shear with an universal testing machine (Tinius Olsen H10KS) until break, at a crosshead speed of 0.1 cm/min. Data stored in MPa, and analyzed using 2-way ANOVA at 0.05. Tukey HSD intervals for comparison of means also at 0.05 significance level were 3.5 between adhesives and 2.6 among surfaces.

Results: Easy Bond had statistically higher BS than Scotchbond SE. Only with Adper Easy Bond the area of dentine exposed and the orientation of the dentinal tubules the BS was affected. The vertical cut at the root provided a dentine surface with more and wider dentinal tubules, which produced a higher BS than the superficial dentine that has less and narrower tubules. At the root, the tubules run toward the pulp chamber, thus the exposed dentine when cut vertically or horizontally provides a different substrate for the DBA. Easy One showed that this difference affected how it bonded to dentine.

<table>
<thead>
<tr>
<th>MPa</th>
<th>Superficial Dentin</th>
<th>Root Vertical</th>
<th>Root Horizontal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adper Easy Bond</td>
<td>20.0 (2.5)</td>
<td>25.2 (4.4)</td>
<td>16.4 (5.3)</td>
</tr>
<tr>
<td>Adper Scotchbond SE</td>
<td>16.9 (3.6)</td>
<td>15.7 (3.2)</td>
<td>16.0 (5.9)</td>
</tr>
</tbody>
</table>
Selective Enamel Etching — Etched Dentin Performance — Dentin Sealing
For total-etch systems (4th and 5th generation), a phosphoric acid conditioning step is utilized to modify the dentin and enamel surfaces to allow penetration of the adhesives into the tooth surfaces. Phosphoric acid is considered a strong acid with an approximate pH of 0.5. It is very effective in dissolving the smear layer and the smear layer and mineral within the collagen matrix of the dentin and the mineral of the enamel to expose the prismatic crystal structure.

On enamel, the phosphoric acid treatment allows for very effective and consistent bonding to both the uncut and cut (prepared) surfaces. Dentists have relied on this high enamel bond integrity to prevent microleakage, marginal degradation and staining.

On dentin, the phosphoric acid treatment completely removes the smear layer leaving the dentin tubules open and exposed. The collagen matrix is also demineralized. In this situation it is imperative to completely seal the tubules to prevent sensitivity and for some systems, the demineralized collagen must be kept moist to prevent the collapse of the collagen fibers and subsequent reduction in bond strength.

For self-etch systems (6th and 7th generation), the acidity varies significantly and can be significantly less than that of phosphoric acid. On dentin, this has clear advantages: the danger of over-etching, over drying of the etched dentin and occurrence of post-operative sensitivities is greatly reduced compared to total-etch adhesives. However, on the enamel surfaces, this reduced acidity leads to a less pronounced etch pattern compared to phosphoric acid, especially on unprepared or uncut surfaces. Therefore, most self-etch adhesive systems (including Adper™ Easy Bond Self-Etch Adhesive) recommend to incorporate a separate phosphoric acid etch of these uncut enamel surfaces prior to applying the self-etch
adhesives. While the bond strength of Adper Easy Bond self-etch adhesive to cut enamel is more than adequate, it can be desirable for certain indications to maximize enamel bond strength, e.g. when there is only little tooth surface to bond to, or in Class I cavities with a high ratio of bonded to unbonded surfaces (C factor) where the margins are situated mostly in enamel. As the following data show, this increase in enamel bond strength can be achieved by etching the uncut and cut enamel surfaces while leaving the dentin surface protected with the smear layer. This technique is commonly referred to as the “Selective Enamel Etch” technique with self-etch adhesives.

When incorporating this Selective Enamel Etch with a self-etch adhesive, the etchant is isolated to the enamel leaving the dentin intact. Therefore the clinician can maximize the enamel bond strength and take advantage of the low post-op sensitivity feature that the self-etch adhesive provides for on the dentin. One concern that a clinician may have with the Selective Enamel Etch is whether they can isolate the etchant and not inadvertently etch the dentin in the process. If this occurs, then the adhesive must properly infiltrate and wet the etched dentin for thorough sealing and to ensure high bonding and sensitivity prevention.

The data in this section will show how Adper Easy Bond self-etch adhesive has increased enamel bond performance to etched enamel. It also shows the high level of bond and sealing performance to etched dentin in both moist and dry conditions in the event that the dentin is accidentally or purposely etched. The ability to effectively seal the dentin surface allows for the adhesive to be used to treat hypersensitive roots as well.
3. Selective Enamel Etching — Etched Dentin Performance — Dentin Sealing

Bond Strengths of All-in-one Adhesives with and without Acid Etch

Authors: C. Thalacker, I. Richter, O. Kappler, and A. Rumphorst, 3M ESPE AG, Seefeld, Germany

Reference: IADR-CED 2009, Munich Germany

Aim of the Study: This study compares the shear bond strengths (SBS) of all-in-one adhesives on cut enamel and dentin with (E) and without (SE) a 15 second phosphoric acid etch, and of etch-and-rinse adhesives.

Method: Materials and methods: Bovine incisors were embedded in cold-cure acrylic resin. The labial surface of each tooth was ground to expose enamel or dentin. Cylindrical buttons of Filtek™ Z250 (4.67mm diameter, 2mm height) were cured on the tooth surfaces treated with Adper Easy Bond (AEB, 3M ESPE), iBOND SE (IBSE, Heraeus Kulzer), Xeno V (XV, Dentsply), AdheSE One (AO, Ivoclar-Vivadent), Syntac Classic (SC, Ivoclar-Vivadent), Prime&Bond NT (PBNT, Dentsply), XP-Bond (XPB, Dentsply), ExciTE (EX, Ivoclar-Vivadent), Scotchbond 1XT/SingleBond Plus (SB1XT, 3M ESPE) according to the instructions for use by 6 dentists (n = 12). For the all-in-one adhesives, an additional set of specimens was prepared after a 15 second phosphoric acid etch. After storage of 24 hours in water at 37°C, the specimens were tested in shear mode using a Zwick Z010 universal testing machine (crosshead speed 2mm/min).
3. Selective Enamel Etching —
Etched Dentin Performance — Dentin Sealing

Bond Strengths of All-in-one Adhesives with and without Acid Etch (cont.)

**Results:**
The table shows the SBS in MPa. The standard deviations (SD) are given in parentheses. All data were analyzed by ANOVA and multiple comparisons using Fisher’s LSD procedure (p <0.05). Same letters indicate statistically the same means.

<table>
<thead>
<tr>
<th>Material</th>
<th>E_Emamel</th>
<th>SE_Emamel</th>
<th>E_Dentin</th>
<th>SE_Dentin</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEB</td>
<td>28.2 (4.0) ab</td>
<td>19.4 (3.3) fghij</td>
<td>23.8 (6.5) cdef</td>
<td>22.2 (4.0) efgh</td>
</tr>
<tr>
<td>IBSE</td>
<td>26.9 (3.2) bcd</td>
<td>21.0 (5.6) efghi</td>
<td>15.4 (8.5) jklmn</td>
<td>18.1 (2.9) hijk</td>
</tr>
<tr>
<td>XV</td>
<td>26.8 (6.9) bcd</td>
<td>18.5 (3.3) ghijkl</td>
<td>16.7 (4.6) iklj</td>
<td>16.3 (4.5) jkln</td>
</tr>
<tr>
<td>A0</td>
<td>22.8 (6.6) defg</td>
<td>16.3 (3.6) jklm</td>
<td>17.6 (5.6) hijk</td>
<td>5.4 (4.5) o</td>
</tr>
<tr>
<td>PBNT</td>
<td>32.0 (7.6) a</td>
<td>—</td>
<td>11.7 (4.2) n</td>
<td>—</td>
</tr>
<tr>
<td>XPB</td>
<td>27.9 (6.3) abc</td>
<td>—</td>
<td>13.4 (7.5) lmn</td>
<td>—</td>
</tr>
<tr>
<td>EX</td>
<td>24.9 (5.6) bcde</td>
<td>—</td>
<td>11.9 (5.0) mn</td>
<td>—</td>
</tr>
<tr>
<td>SB1XT</td>
<td>28.9 (4.6) ab</td>
<td>—</td>
<td>14.8 (9.3) klmn</td>
<td>—</td>
</tr>
</tbody>
</table>

**Conclusion:**
Multiple statistically significant differences were found. Overall Adper Easy Bond provided the most consistent bond strengths and performed equal or superior to the total-etch systems.
3. Selective Enamel Etching —
Etched Dentin Performance — Dentin Sealing

Application of Wet Bonding for One-Step Bonding Systems
Authors: K. Yasumoto, S. Hoshika, T. Tanaka, and H. Sano, Hokkaido University, Japan; F. Nagano, Health Sciences University of Hokkaido, Japan; D. Selimovic, Strasbourg University, France; Y. Miyamoto, Tokyo University, Japan
Reference: Academy of Dental Materials 2009, Portland, USA, Abstract #48

Aim of the Study: The purpose of this study was to investigate the effect of wet bonding and Colloidal Platinum Nanoparticles (CPN, Apt, LTD) on the dentin bond strength of one-step bonding systems under four different bonding strategy groups: control, wet, etch-wet, etch-CPN-wet.

Method: Three one-step bonding systems used in this study were: Easy One/Easy Bond (EO; 3M, US), Bond Force (BF; Tokuyama, Japan), Beauti Bond (BB; Shofu, Japan). Twenty-four human molars were used in this study. The flat ground surfaces of dentin were polished with 600-grit silicon carbide paper under running water.

**Group 1 (control):** The dentin surfaces were bonded according to the manufacturers’ instructions of each one-step bonding system.

**Group 2 (wet):** The dentin surfaces were bonded under visible wet condition.

**Group 3 (etch-wet):** The dentin surfaces were treated with 35% phosphoric acid for 15 seconds, followed by rinsing with water for 5 seconds and bonded under visible wet condition.

**Group 4 (etch-CPN-wet):** The dentin surfaces were treated with 35% phosphoric acid for 15 seconds, followed by rinsing with water for 5 seconds. After air drying, they were treated with 10% CPN for 30 seconds which followed by rinsing with water for 20 seconds. Resin
3. Selective Enamel Etching — Etched Dentin Performance — Dentin Sealing

Application of Wet Bonding for One-Step Bonding Systems (cont.)

Method (cont.): composite was built up to approximately 5mm height on flat surfaces of dentin. They were sectioned into beam specimens (cross-sectional area 1mm²) after storage in 37°C water for 24 hours. The specimens were subjected to MTBS test and the resin dentin interfaces were observed by SEM (Hitachi S-4000). The Games-Howell test was used for the statistical analysis of the MTBS (p <0.05; n = 15).

Results: The result of the MTBS is showed in the Table below.

<table>
<thead>
<tr>
<th></th>
<th>EO/EB</th>
<th>BF</th>
<th>BB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>62.46 ± 22.14</td>
<td>45.73 ± 14.42</td>
<td>47.07 ± 13.72</td>
</tr>
<tr>
<td>Wet</td>
<td>57.4 ± 16.47</td>
<td>54.3 ± 17.60</td>
<td>33.2 ± 9.82</td>
</tr>
<tr>
<td>Etched (Wet)</td>
<td>58.97 ± 9.41</td>
<td>68.42 ± 18.20</td>
<td>22.1 ± 10.04</td>
</tr>
<tr>
<td>Etched (CPN)</td>
<td>62.34 ± 22.23</td>
<td>55.66 ± 16.90</td>
<td>31.16 ± 11.72</td>
</tr>
</tbody>
</table>

Conclusion: The result of this study revealed that the MTBS of Adper Easy One/Easy Bond showed no significant difference between four groups but there were significant difference between BF-control and BF-etch-wet, BB-control and BB-etch-CPN-wet. Adper Easy One/Easy Bond showed consistent bonds to etched dentin and moisture tolerance.
Adper Easy Bond Shear Bond Strength in Total-Etch Mode on Dentin

Authors: N. Karim, V.A. Russell, B.A. Shukla, and S.S. Velamakanni, 3M ESPE, St. Paul, MN, USA; C. Thalacker, 3M ESPE, Seefeld, Germany
Reference: Academy of Dental Materials 2009, Portland, USA, Abstract #44

Aim of the Study:
This study investigated the bonding efficacy of Adper™ Easy Bond (EB, 3M ESPE), a 7th generation adhesive, when used in total-etch (5th generation) mode on either moist (EB-TE-moist) or dry (EB-TE-dry) superficial bovine dentin. The moist or dry condition of the tooth is after etching. The dry condition represents a product misuse scenario.

Method:
A notched-edge shear method was used to measure the shear bond strengths (SBS) to dentin (composite: Filtek™ Z250 A2, 3M ESPE). EB in standard self-etch mode and the 5th generation adhesive Adper™ Single Bond Plus (SB+, 3M ESPE) were tested as controls. Bonded specimens were stored in water at 37°C for 24 hours. Half of the specimens were then randomly selected and tested for baseline data, and the remaining half were thermocycled between 5°C and 55°C (30 seconds each per cycle) and then tested after 7,000 cycles.
3. Selective Enamel Etching — Etched Dentin Performance — Dentin Sealing

Adper Easy Bond Shear Bond Strength in Total-Etch Mode on Dentin (cont.)

Results: Mean (standard deviation) Shear Bond Strength in MPa are listed in the table (n = 8).

<table>
<thead>
<tr>
<th></th>
<th>0 Cycles (Baseline)</th>
<th>7,000 Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adper™ Easy Bond Moist</td>
<td>45.0 ± 3.0</td>
<td>40.0 ± 2.5</td>
</tr>
<tr>
<td>Adper™ Easy Bond Dry</td>
<td>40.0 ± 2.5</td>
<td>35.0 ± 3.0</td>
</tr>
<tr>
<td>Adper™ Single Bond Plus</td>
<td>35.0 ± 2.5</td>
<td>30.0 ± 3.0</td>
</tr>
</tbody>
</table>

Conclusion: None of the sample sets showed a decline in adhesion performance after thermocycling. EB-TE-dry was not statistically different from either EB, EBTE-moist, or SB+ at either 0 cycles or 7,000 cycles. Adper Easy Bond performed equivalent to Adper Single Bond Plus to etched dentin even when the etched dentin surface was dried.
Microtensile Dentin Adhesion of Adper Easy Bond in Total-Etch Mode

Authors: N. Karim, B.A. Shukla, and S. Velamakanni, 3M ESPE, St. Paul, MN, USA; C. Thalacker, 3M ESPE, Seefeld, Germany

Reference: AADR 2010, Washington DC, USA, Abstract #144

Aim of the Study:
This study investigated the bonding efficacy of Adper™ Easy Bond (EB, 3M ESPE), a 7th generation adhesive, when used in total-etch (5th generation) mode on either moist (EB-TE-moist) or dry (EB-TE-dry) superficial bovine dentin. The moist or dry condition of the tooth is after etching. The dry condition represents a product misuse scenario.

Method:
A microtensile method was used to measure the tensile bond strengths (TBS) to dentin (composite: Filtek™ Z250 A2, 3M ESPE). EB in standard self-etch mode and the 5th generation adhesive Adper™ Single Bond Plus (SB+, 3M ESPE) were tested as controls. Bonded specimens were stored in water at 37°C for 24 hours and then tested.
3. Selective Enamel Etching — Etched Dentin Performance — Dentin Sealing

Microtensile Dentin Adhesion of Adper Easy Bond in Total-Etch Mode (cont.)

**Results:**
Mean (std dev) Microtensile Bond Strength (TBS) in MPa and p-values are listed in the table. Sample size for each set was EB (28), EB-TE-Moist (28), EB-TE-Dry (27) and SB+ (28).

**Conclusion:** EB-TE-moist was statistically equivalent to both Single Bond Plus and to Easy Bond in standard self-etch mode. EB-TE-dry (product misuse scenario) yielded statistically lower results but maintained greater than 85% of the performance level of the controls.
Microtensile Dentin Adhesion of All-in-One Systems to Etched Dentin

Authors: M. Taschner, University of Erlangen; L. Breschi, University of Trieste, Italy
Reference: IADR 2010, Barcelona, Spain

Aim of the Study:

Preliminary etching of the dentin substrate before the application of self-etching adhesives is controversial. In this in-vitro study the effect of additional etching with phosphoric acid on dentin before application of Adper Easy Bond (3M ESPE, Seefeld, Germany) and iBOND (Heraeus Kulzer, Hanau, Germany) was analyzed.

Method:

Recently extracted human sound molars were flattened using a slow speed diamond saw and adhesives were applied either with an etch-and-rinse (phosphoric acid etching for 15 seconds followed by extensive water rinsing) or with a self-etch approach (i.e. in accordance with manufactures’ instructions). Treatment groups were;

- **Group 1**: Adper Easy Bond (on etched dentin),
- **Group 2**: Adper Easy Bond (control),
- **Group 3**: iBOND (on etched dentin) and
- **Group 4**: iBOND (control).

Resin-dentin bonded specimens were sectioned after 14 hours in accordance with the non-trimming technique for microtensile bond strength analysis. Half of the beams were immediately pulled to failure (time 0) while the remaining half was stored for 6 months in artificial saliva at 37° C prior to testing.
3. Selective Enamel Etching —
Etched Dentin Performance — Dentin Sealing

Microtensile Dentin Adhesion of All-in-One Systems to Etched Dentin (cont.)

Results: At time 0, Adper Easy Bond used on etched dentin (Group 1) showed higher microtensile bond strength compared to all other groups (Mann-Whitney U-test, p < 0.05). Storage for 6 months in artificial saliva decreased bond strength of Groups 2, 3 and 4 (Mann-Whitney U-test, p < 0.05) compared to time 0 specimens, while Adper Easy Bond used in the etch-and-rinse approach (Group 1) showed no bond strength reduction over time (Mann-Whitney U-test, p < 0.05).

<table>
<thead>
<tr>
<th>Microtensile Bond Strength Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
</tr>
<tr>
<td>24 hr.</td>
</tr>
<tr>
<td>6 mo.</td>
</tr>
</tbody>
</table>

Values are mean bond strengths ± standard deviation in MPa. Groups with different superscripts are statistically significant different (p < 0.05). Premature failures due to preparation procedures were not included in the statistical evaluation.

Conclusion: These preliminary results support the use of Adper Easy Bond on etched dentin since increased immediate bond strength and superior stability over time was found if compared to its application on smear-layer covered dentin (i.e. self-etch approach in accordance with manufacturers’ instructions.)
Effect of Adhesive System Application Modes on Dentin Permeability

Authors: A. Carvalho, State University of Campinas, Piracicaba, SP, Brazil; M.T. Oliveira and M. Giannini, State University of Campinas, Piracicaba, Brazil; G.M.B. Ambrosano, Dental School of Piracicaba - UNICAMP, Piracicaba, SP, Brazil; T. Nikaido, Tokyo Medical & Dental University, Tokyo, Japan; J. Tagami, Cariology and Operative Dentistry, Tokyo Medical & Dental University; GCOE Program at TMDU, Tokyo Medical & Dental University, Tokyo, Japan

Reference: IADR 2009, Miami, USA, Abstract #2315

Aim of the Study: To evaluate the dentin hydraulic conductance (HC) with adhesive system applied following different conditions.

Method: One hundred twenty bovine incisors teeth were subjected to laminate cavity preparations. After removing the roots and the coronal pulp, the buccal dentin was treated with EDTA solution (0.5 M) for 5 minutes, rinsed, ultrasonicated for 12 minutes and connected to a permeability device. HC of the specimens was measured at 10 psi. Permeability was measured before and after the bonding procedures using the adhesives: G-Bond/GB (GC Corp.), Clearfil Tri-S-Bond/CTS (Kuraray Med.), Hybrid Coat/HY (Sun Medical), Bond Force/BF (Tokuyama), Adper Easy Bond/AEB (3M ESPE), Silorane/SI (3M ESPE), Clearfil SE Bond/CSE (Kuraray Med.) and Scotchbond Multi-Purpose/SMP (3M ESPE). All adhesive systems were applied in the following modes: 1) according to manufacturers’ instructions; 2) two coats of all-in-one self-etching adhesives (GB, CTS, HY, BF, AEB) or priming step plus two coats of bond resin for the other systems (SI, CSE and SMP); and 3) one coat of all-in-one self-etching adhesives plus a thin layer of a flowable composite (Filtek-Flow, 3M ESPE) or priming step (SI, CSE and SMP) plus a thin layer of the same flowable composite.
3. Selective Enamel Etching — Etched Dentin Performance — Dentin Sealing

Effect of Adhesive System Application Modes on Dentin Permeability (cont.)

Results: No significant difference was observed among the application modes concerning their ability to reduce dentin permeability ($p < 0.05$). None of the adhesives showed a complete sealing of the bovine tooth dentin. SI showed lower permeability compared to SMP, but it was not different from other systems. These systems were also similar to SMP. Results suggested that all systems tested were able to promote reduction in the HC.

<table>
<thead>
<tr>
<th>Adhesive System</th>
<th>Mode 1</th>
<th>Mode 2</th>
<th>Mode 3</th>
<th>Mean Values of 3 Modes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adper Easy Bond</td>
<td>94.6 ± 3.1</td>
<td>95.6 ± 2.6</td>
<td>96.9 ± 1.2</td>
<td>95.7 ± 2.3</td>
</tr>
<tr>
<td>Adper Scotchbond Multi-Purpose</td>
<td>88.7 ± 5.1</td>
<td>93.9 ± 5.5</td>
<td>94.7 ± 2.7</td>
<td>92.4 ± 4.4</td>
</tr>
<tr>
<td>G-Bond</td>
<td>94.9 ± 1.9</td>
<td>94.5 ± 4.2</td>
<td>96.4 ± 2.4</td>
<td>95.3 ± 2.8</td>
</tr>
<tr>
<td>Clearfil Tri-S-Bond</td>
<td>94.5 ± 3.8</td>
<td>94.6 ± 3.5</td>
<td>96.3 ± 2.6</td>
<td>95.1 ± 3.3</td>
</tr>
<tr>
<td>Hybrid Bond</td>
<td>93.9 ± 3.1</td>
<td>95.9 ± 2.5</td>
<td>94.9 ± 2.7</td>
<td>94.9 ± 2.7</td>
</tr>
<tr>
<td>Bond Force</td>
<td>94.9 ± 3.1</td>
<td>93.5 ± 3.8</td>
<td>94.7 ± 4.7</td>
<td>94.4 ± 2.3</td>
</tr>
<tr>
<td>Silorane</td>
<td>96.4 ± 2.4</td>
<td>97.6 ± 1.8</td>
<td>95.8 ± 3.6</td>
<td>96.6 ± 2.6</td>
</tr>
<tr>
<td>Clearfil SE Bond</td>
<td>95.1 ± 3.5</td>
<td>96.6 ± 2.2</td>
<td>95.4 ± 2.9</td>
<td>95.7 ± 2.9</td>
</tr>
</tbody>
</table>

Conclusion: The all-in-one self-etching adhesive systems tested were similarly able to reduce dentin HC, when compared to the three-step etch-and-rinse and the two-step self-etching adhesive systems. Adper Easy Bond performed similarly if not better than Adper Scotchbond Multi-Purpose.
Dentin Permeability of a 7th Generation Adhesive with Total Etch

Authors: R. Rusin, B. Shukla, S. Velamakanni, and C. Summers, 3M ESPE Dental, St. Paul, MN; C. Thalacker, 3M Company, Seefeld, Germany

Reference: AADR 2010, Washington DC, USA, Abstract #656

Aim of the Study: Since many dentists use both self-etch and total etch adhesives, it would be beneficial to be able to use one adhesive in either mode. The objective was to compare fluid movement across dentin for a new 7th-generation adhesive (3M ESPE Adper Easy Bond Dental Adhesive, EB) used in its self-etch mode on desiccated dentin (EBSED) with two experimental modes: total-etch on desiccated dentin (EBTED), and total-etch on moist dentin (EBTEM). These were additionally compared to clinically established 6th-generation (3M ESPE Adper Prompt L-Pop Dental Adhesive, PLP) and 5th-generation (3M ESPE Adper Single Bond Plus Dental Adhesive, SBP) adhesives.

Method: Crown segments from extracted maxillary third molars were cemented onto polycarbonate plates with a stainless steel tube for filling the pulp chamber with aqueous 1\% chloramine-T under 140cm (H_2O) pressure. The dentin surface was etched with 35\% H_3PO_4 for 15 seconds to permit measurement of the maximum permeability with a Flodec™ apparatus (DeMarco Engineering). For the self-etch groups EBSED and PLP, a smear layer was created with 320 grit SiC abrasive paper. Each adhesive was applied per manufacturer’s instructions; permeability was measured again after 7 days storage at RT. Data were analyzed via one-way ANOVA and Tukey’s T-test (p <0.05).
Dentin Permeability of a 7th Generation Adhesive with Total Etch (cont.)

Results: Percent reduction in permeability between the etched and adhesive-treated stages is shown below as mean (SD). Groups with the same superscript letter are not significantly different (p >0.05).

<table>
<thead>
<tr>
<th>Material</th>
<th>n</th>
<th>% Reduction in Permeability, mean (sd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EB-SED</td>
<td>10</td>
<td>99.1 (1.0)a</td>
</tr>
<tr>
<td>EB-TEM</td>
<td>10</td>
<td>92.2 (18.8)a</td>
</tr>
<tr>
<td>EB-TED</td>
<td>10</td>
<td>98.2 (2.1)a</td>
</tr>
<tr>
<td>PLP</td>
<td>8</td>
<td>99.0 (1.3)a</td>
</tr>
<tr>
<td>SBP</td>
<td>10</td>
<td>97.5 (2.4)a</td>
</tr>
</tbody>
</table>

Conclusion: The permeability reduction after adhesive application was statistically not different among all five groups. The new 7th-generation adhesive EB used in total-etch mode on either desiccated or moist dentin sealed as well as its self-etch mode, and also as well as clinically established adhesives PLP and SBP. Thus, EB has the potential to be used successfully in a total etch mode as well as its original self-etch mode.
Clinical Technique Variables: Moisture and Contamination

In both clinical and laboratory settings, application technique variables can affect the bonding performance of an adhesive system. Much research has been published on the effect of surface moisture on adhesion; particularly in bonding to dentin. With the “total-etch” systems and removal of the smear layer, the hydration state of dentin after the etchant has been rinsed can drastically affect the ability of the adhesive to saturate the exposed collagen layer effectively, resulting in reduced bonding performance. Most of these total-etch, two-step systems are either ethanol or acetone-based with little if any water present in the formulation. Self-etch systems are typically aqueous-based and are less sensitive to varying levels of moisture on the tooth to provide more consistent adhesion. The previous two sections on adhesion results showed the consistent performance of Adper™ Easy Bond Self-Etch Adhesive to moist and dry tooth surfaces, particularly unetched and etched dentin.

Another common clinical concern is the ability to adequately isolate the prepared tooth surface from saliva contamination. It is very important to try and maintain a clean and isolated bonding surface, however if the adhesive system could be tolerant to a slight amount of saliva contamination prior to the adhesive placement, that would be very beneficial clinically. Due to the acidic and aqueous nature of the self-etch adhesives, they may be able to maintain their bond strengths if the surface has been slightly contaminated.

The following two papers show that Adper Easy Bond self-etch adhesive can perform well under various conditions where the tooth has been contaminated with saliva.
Bonding of Self-Etch Adhesives to Saliva-Contaminated Dentin: Effect of Cleansing Solutions

Authors: H. Sheikh, H. Heymann, E.J. Swift, Jr., T.L. Ziemiecke, and A.V. Ritter, University of North Carolina, Chapel Hill, NC

Reference: IADR 2009, Miami, USA, Abstract #2839

Aim of the Study: To determine the effect of cleansing solutions on the microtensile bond strengths of self-etch adhesives to saliva-contaminated dentin.

Method: Fifty human molars were mounted in epoxy, ground flat to expose middle dentin, polished to 600-grit, and randomly assigned to five groups (n = 10), with different contamination and cleansing protocols (see Results graph). The specimens (n = 5) were bonded with Adper™ Easy Bond (all-in-one self etch adhesive). Specimens were restored with composite, and processed for microtensile bond strength testing (5–6 rods/tooth). Data was analyzed using two-way ANOVA and Tukey post-hoc test (alpha = 0.05).

Results: The microtensile bond strengths (MTBS) in Mpa (with s.d bars) are shown in the graph. There was no significant interaction between adhesive and saliva contamination/cleansing protocol (p = 0.168).
Bonding of Self-Etch Adhesives to Saliva-Contaminated Dentin: Effect of Cleansing Solutions (cont.)

Results (cont.):

<table>
<thead>
<tr>
<th>Cleansing Protocol</th>
<th>Microtensile Bond Strength [MPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>40.0</td>
</tr>
<tr>
<td>Water</td>
<td>55.0</td>
</tr>
<tr>
<td>2% Chlorhexidine</td>
<td>60.0</td>
</tr>
<tr>
<td>5% Sodium Hypochlorite</td>
<td>65.0</td>
</tr>
</tbody>
</table>

Saliva Contamination:
- None: [Bar chart showing bond strength for each cleansing protocol without saliva contamination]
- Yes: [Bar chart showing bond strength for each cleansing protocol with saliva contamination]

Conclusion: There was no negative impact on the bond strength with the saliva-contaminated surface. Water, 2% chlorhexidine, and 5% sodium hypochlorite were able to cleanse saliva-contaminated dentin without adversely affecting the bond strength of Adper Easy Bond.
Saliva Effect on Dentin Bond Strength for Three Adhesives

Authors: V.A. Russell, T.D. Dunbar, and B.A. Shukla, 3M ESPE Dental Products, St. Paul, MN, USA
Reference: Academy of Dental Materials 2009, Portland, USA, Abstract #41

This study investigated the effects of various human saliva contamination and decontamination protocols on the shear bond strengths (SBS) of three adhesives on bovine superficial dentin.

Method:

Adhesives tested were Adper Single Bond Plus Adhesive (SB+), Adper Scotchbond SE Self-Etch Adhesive (SBSE) and Adper Easy Bond Self-Etch Adhesive (EB) (all from 3M ESPE). A notched-edge shear method (Ultradent) was used to measure the SBS (composite: Filtek Z250 Universal Composite A2, 3M ESPE) with n=10 except as noted in results table. Bonded specimens were tested after 24 hr storage in water at 37°C. Various application protocols were used (see table), with the following abbreviations:

A = adhesive application per manufacturer’s instructions for use (IFU)
C = light cure per IFU
S = fresh human saliva application, 15 sec
D = air dry, 10 sec
R = rinse with water, 10 sec
A/Smix = mixture of 10% saliva/90% adhesive applied per IFU
4. Clinical Technique Variables: Moisture and Contamination

Saliva Effect on Dentin Bond Strength for Three Adhesives (cont.)

Results:
Mean (std dev) Shear bond strength (SBS) in MPa are listed in the table.

<table>
<thead>
<tr>
<th>Set ID</th>
<th>Application Protocol</th>
<th>SB+</th>
<th>EB</th>
<th>SBSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>A-C (control)</td>
<td>36.1 (8.1)</td>
<td>39.6 (5.8)</td>
<td>39.2 (10.5)</td>
</tr>
<tr>
<td>1</td>
<td>S-A-C</td>
<td>28.2 (6.0)</td>
<td>27.5 (10.6)</td>
<td>37.7 (12.1)</td>
</tr>
<tr>
<td>2</td>
<td>A-C-S</td>
<td>23.1 (10.5)</td>
<td>24.1 (6.0)</td>
<td>31.9 (7.7)</td>
</tr>
<tr>
<td>2A</td>
<td>A-C-S-R-D-A</td>
<td>30.6 (6.7)</td>
<td>37.3 (7.9)</td>
<td>40.1 (9.7)</td>
</tr>
<tr>
<td>3</td>
<td>A-S-C</td>
<td>0.0</td>
<td>0.0</td>
<td>2.9 (6.7)</td>
</tr>
<tr>
<td>3A1</td>
<td>A-S-R-D-A-C</td>
<td>16.9 (7.4)</td>
<td>34.0 (9.2)</td>
<td>26.1 (9.5)</td>
</tr>
<tr>
<td>42</td>
<td>A/S mix-C</td>
<td>24.1 (8.9)</td>
<td>36.0 (8.1)</td>
<td>16.6 (6.6)</td>
</tr>
</tbody>
</table>

1 For SB+, phosphoric acid etching was not repeated for reapply step
2 For SBSE, 10% saliva was mixed with both Liquid A and Liquid B

Conclusion:
The three adhesives were tolerant to saliva contamination and provided high adhesion values for a variety of contamination scenarios except for Set 3 where saliva was applied to uncured adhesive. However, if the saliva was rinsed off and the adhesive was reapplied (Set 3A), the SBS was increased for all groups, especially for Adper Easy Bond where the SBS was not statistically different from the control.
Marginal Integrity and Leakage

An important aspect of bonding is the ability of an adhesive to resist the polymerization forces of the dental composite and maintain a sealed, continuous interface between tooth structure and composite. In the oral environment the ability to maintain marginal integrity will resist staining and degradation and ultimately, resist secondary decay.

As with adhesion tests, there are a variety of ways to measure marginal integrity. One common method is to conduct a microleakage test. Variables in this type of study include the staining regimen, sample geometry, and thermal history. Often the seal of enamel and dentinal margins can be measured on the same sample. An alternative to a microleakage study is to use a microscopic technique such as SEM to measure continuous bonded interfaces.

In addition to being able to seal the external margins of the restoration, the adhesive must also be able to adequately seal or penetrate the dentin collagen network. If the etched or demineralized collagen network is not thoroughly infiltrated, open pathways can exist. These open pathways can allow for “Nanoleakage” under the restoration. If there is a significant amount of nanoleakage, the dentin bond can degrade over time. Dye infiltration studies can be conducted with microscopic examination to determine the degree of porosity in the infiltrated collagen layer to determine the degree of nanoleakage potential for an adhesive.

In the next few pages are studies that challenged the ability of Adper™ Easy Bond Self-Etch Adhesive to maintain marginal integrity and to provide for low nanoleakage.
Evaluation of Marginal Integrity of Adper Easy Bond in Class V Restorations

Authors: B. Haller, University of Ulm, Germany
Reference: Unpublished

Aim of the Study:
This study investigated the ability of Adper Easy Bond to produce gap and leakage free marginal adaptation to enamel and dentin in Class V composite restorations compared to other self-etch adhesive systems.

Method:
25 caries-free extracted human molars received two cylindrical Class V preparations (3mm x 1.5 mm) with a 0.5mm enamel bevel. The margin of the coronal half is located in enamel and that of the apical half in root cementum/dentin. The adhesives; Adper Easy Bond, Clearfil S3 Bond and Clearfil SE Bond were placed according to manufacturer’s instructions. Restoration were completed with Filtek Z250, shade A3. The surface was polished with Sof-Lex. The teeth were stored for 24 hours and then thermocycled for 1,500 cycles from 5°C and 55°C. Impressions of the tooth surfaces were taken and epoxy replicas made and coated for SEM evaluation % of continuous margin and margin gap. The restorations were then subjected to a fuchsin dye penetration process, sectioned and evaluated for depth of dye penetration. Data was analyzed using Kruskal-Wallis test and Mann-Whitney test for pair-wise comparison.
5. Marginal Integrity and Leakage

Evaluation of Marginal Integrity of Adper Easy Bond in Class V Restorations (cont.)

Results: The percentage with standard deviation (s.d) after thermocycling of continuous margins to dentin and enamel and marginal gap to dentin and enamel are listed in the table. The depth of dye penetration along the interface is also listed with standard deviation (s.d) after thermocycling.

<table>
<thead>
<tr>
<th></th>
<th>Continuous Margin on Dentin (%)</th>
<th>Continuous Margin on Enamel (%)</th>
<th>Marginal Gap on Dentin (%)</th>
<th>Marginal Gap on Enamel (%)</th>
<th>Dye Penetration along Interface (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adper Easy Bond</td>
<td>97.7 (2.9)</td>
<td>99.9 (0.5)</td>
<td>2.2 (3.0)</td>
<td>0.2 (0.5)</td>
<td>0.08 (0.09)</td>
</tr>
<tr>
<td>Clearfil S3 Bond</td>
<td>95.1 (9.3)</td>
<td>97.6 (7.7)</td>
<td>4.6 (8.3)</td>
<td>2.5 (7.7)</td>
<td>0.19 (0.25)</td>
</tr>
<tr>
<td>Clearfil SE Bond</td>
<td>98.0 (5.2)</td>
<td>99.9 (0.4)</td>
<td>2.1 (5.3)</td>
<td>0.1 (0.4)</td>
<td>0.31 (0.51)</td>
</tr>
</tbody>
</table>

Conclusion: Adper Easy Bond performed well to produce gap and leakage free margins compared to the other self-etch systems.
Effect of Different Preliminary Etching Protocols on Marginal Quality of Resin Composite Restorations Bonded with Adper Easy Bond

Authors: R. Frankenberger, Philippus University Marburg and University Medical Center Giessen and Marburg

Reference: Abstract submitted IADR 2010, Barcelona, Spain

Aim of the Study:
This study evaluated marginal integrity of bonded posterior resin composite fillings to enamel and dentin, before and after thermo-mechanical loading (TML).

Method:
Sixty four MOD cavities with one proximal box beneath the CEJ were prepared in extracted human third molars. Direct resin composite restorations (Filtek Supreme XT) were bonded with Adper Easy Bond according to eight different protocols (apmi: as per manufacturer’s instructions; 30 seconds SEE: selective enamel etching with phosphoric acid; 15 seconds SEE; 15 seconds SEE ROD: rinsed over dentin; 15 seconds SEE with dentin etched for 5 seconds; 15 seconds SEE with dentin etched for 10 seconds; 15 seconds E+R: etch&rinse with phosphoric acid; 30 seconds E+R). Before and after thermo-mechanical loading (TML: 100,000 x 50N, 2,500 thermocycles between 5°C and 55°C), marginal gaps were analyzed using SEM of epoxy resin replicas (200x). Results were analyzed with Kruskal-Wallis and Mann-Whitney U-tests (p <0.05).
5. Marginal Integrity and Leakage

Effect of Different Preliminary Etching Protocols on Marginal Quality of Resin Composite Restorations Bonded with Adper Easy Bond (cont.)

Results: Marginal quality is displayed in the following table:

<table>
<thead>
<tr>
<th>Group</th>
<th>% gap-free margins (SD)</th>
<th>enamel</th>
<th>after TML</th>
<th>dentin</th>
<th>after TML</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>initial</td>
<td>after TML</td>
<td>initial</td>
<td>after TML</td>
</tr>
<tr>
<td>apmi</td>
<td>84.5 (9.8) B</td>
<td>39.2 (11.8) B</td>
<td>100</td>
<td>48.8 (7.4) B</td>
<td></td>
</tr>
<tr>
<td>30s SEE</td>
<td>100 A</td>
<td>88.3 (8.9) A</td>
<td>100</td>
<td>45.3 (5.5) B</td>
<td></td>
</tr>
<tr>
<td>15s SEE</td>
<td>100 A</td>
<td>87.5 (10.0) A</td>
<td>100</td>
<td>47.5 (6.5) B</td>
<td></td>
</tr>
<tr>
<td>15s SEE R0D</td>
<td>100 A</td>
<td>88.9 (7.9) A</td>
<td>100</td>
<td>51.0 (6.6) B</td>
<td></td>
</tr>
<tr>
<td>15s SEE dentin 5s</td>
<td>100 A</td>
<td>86.3 (9.4) A</td>
<td>100</td>
<td>49.8 (5.3) B</td>
<td></td>
</tr>
<tr>
<td>15s SEE dentin 10s</td>
<td>100 A</td>
<td>88.9 (8.3) A</td>
<td>100</td>
<td>59.3 (6.4) A</td>
<td></td>
</tr>
<tr>
<td>15s E+R</td>
<td>100 A</td>
<td>87.3 (10.1) A</td>
<td>100</td>
<td>57.5 (7.8) A</td>
<td></td>
</tr>
<tr>
<td>30s E+R</td>
<td>100 A</td>
<td>91.0 (9.3) A</td>
<td>95.4 (3.5)</td>
<td>40.4 (9.4) C</td>
<td></td>
</tr>
</tbody>
</table>

Same superscript letters mean $p > 0.05$ in columns.

Conclusion: Selective enamel etching or etch&rinse had a beneficial effect on enamel margins bonded with Adper Easy Bond. In dentin, phosphoric acid etching lead to an increase in gap-free margins when carried out for 10–15 seconds.
5. Marginal Integrity and Leakage

Microleakage of Recent Self-etch Adhesive Systems Under Thermocycled Repeated-load Stress

Authors: T. Maseki, M. Hara, T. Yamada, A. Shirota, T. Suzuki, T. Kimishima, and Y. Nara, The Nippon Dental University, Tokyo, Japan; I.L. Dogon, Harvard University, Boston, MA, USA

Reference: IADR 2008, Toronto, Canada, Abstract # 961

**Aim of the Study:**
The purpose of this study was to examine the sealing property of recent self-etch adhesive systems under a combination stress load simulating an oral environment.

**Method:**
Two types of self-etch adhesive systems, three one-bottled all-in-one systems; Tokuyama Bond Force (BF, Tokuyama Dental), Adper Easy Bond (EB, 3M ESPE) and Clearfil Tri-S Bond (TS, Kuraray medical), and Clearfil SE Bond (SE, control, Kuraray medical) were used. Standardized V-shaped cavity with occlusal margin on enamel and gingival margin on dentin was prepared in the cervical region of 50 extracted human lower premolars. The cavities were pretreated with the adhesive systems (n = 10) according to the manufacturer’s instructions. The pretreated cavities were filled with composite restorative in a bulk, and were light cured. The restored specimens were subjected to the dye penetration test under a combination stress load condition; thermal cycling (4°C/60°C x 1,250 sets) and simultaneous repeated load (12kgf x 105 times) performed by a custom made multi-function apparatus. Microleakage in occlusal and gingival walls of sectioned and polished specimens were evaluated by a graded criterion. The data of microleakage were statistically analyzed using Kruskal-Wallis rank test and Wilcoxon’s signed rank sum test.
5. Marginal Integrity and Leakage

Microlakage of Recent Self-etch Adhesive Systems Under Thermocycled Repeated-load Stress (cont.)

Results: Both occlusal and gingival microleakage of BF, EB and TS were statistically similar to those of SE, at p <0.01. Gingival microleakage of EB and TS were statistically smaller than occlusal microleakage at p <0.05. No difference in BF and SE between occlusal and gingival microleakage was recognized.

Conclusion: The sealing property of recent three one-bottled all-in-one adhesive systems were similar to that of SE. Adper Easy Bond performed in a similarly to Clearfil SE Bond.
Nanoleakage of Self-Etch Adhesives—An in-vitro Study

Authors: J. Perdigao, University of Minnesota, Minneapolis, MN
Reference: Unpublished

Aim of the Study: To study the degree of nanoleakage in the dentin hybrid layer with different dentin adhesives. Silver dyes have been used to test the sealing ability of dentin adhesives. It has been shown that the hybrid layer is porous and is accessible to silver dyes. Nanoleakage results from open penetration paths through the network of interfibrillar spaces with the size in the range of a few nanometers.

Method: Standardized class V’s were prepared in 25 intact human molars on the buccal and lingual surfaces. Specimens were randomly assigned to different Dental Adhesives (DA): one total-etch DA: Adper Single Bond Plus (3M ESPE) and six self-etch DA’s: Clearfil S3 Bond (Kuraray), Adper Prompt L-Pop (3M ESPE), Adper Easy Bond (3M ESPE), Adper Scotchbond SE (3M ESPE), G-Bond (GC), and Xeno IV (Dentsply). The adhesives were applied per manufacturers’ directions and restored with Filtek Z250 (3M ESPE). Upon restoration, specimens were isolated with nail varnish except for a 2.0mm rim around the restoration, immersed in 50 wt% ammoniacal silver nitrate solution (pH = 9.5) for 24 hours followed by 8 hours in photo-developing solution to reduce the silver ions to metallic silver (Tay et al., 2002). The specimens were fixed, dehydrated, and processed for FeSEM and TEM. Silver penetration was measured along the cervical wall and data analyzed with Kruskal-Wallis non-parametric tests (p <0.05).
Nanoleakage of Self-Etch Adhesives—An in-vitro Study (cont.)

Results: The mean percentage (with standard deviation) of silver penetration length for each adhesive is shown in the graph. Except for the Adper Scotchbond SE, for which there was no sign of nanoleakage, the other adhesive resulted in some degree of silver penetration along the resin-dentin interface. Xeno IV resulted in the greatest amount of leakage.
Interfacial Analysis

Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) are powerful tools for characterizing how adhesives interact and bond to the enamel and dentin surfaces. These tools provide the researcher with highly magnified images to study the effects of adhesive systems on the organic and inorganic components of the tooth and provide insight into the bonding mechanism for the system.

The following pages provide images of the bonding interface of Adper™ Easy Bond Self-Etch Adhesive to enamel and dentin in both the self-etch and total-etch modes of application.
TEM Evaluation of the Interface Between Adper Easy Bond and Dentin and Enamel when used in the Self-Etch Mode

Authors: Dr. Bart Van Meerbeek, Catholic University of Leuven, Belgium

Reference: Unpublished

Aim of the Study:
To use TEM to evaluate the bonding interface for Adper Easy Bond to dentin and cut enamel.
SEM and TEM Evaluation of the Interface Between Adper Easy Bond and Dentin and Enamel when used in the Total-Etch Mode

Authors: W. Stratton, 3M Corporate Analytical Research Laboratory
Reference: Unpublished

Aim of the Study: To use SEM and TEM to evaluate the bonding interface for Adper Easy Bond to dentin and enamel after the surface has been treated with phosphoric acid.
The graphs in this brochure were reproduced by 3M ESPE according to the data mentioned in the respective sources. Based on this data, 3M ESPE has also prepared “Aim of the Study” and “Results” summaries.

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70-2013-0247-1