Adper™ Easy Bond

Self-Etch Adhesive

Technical Product Profile

3M ESPE

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Introduction

Product Description

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 ESPEs 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 a new 7th generation 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 is a light-curing bonding agent used in combination with light-curing composite or compomer filling materials, cements and core-build-up materials. This bonding agent can be polymerized using halogen, LED, or plasma curing lights.

Adper Easy Bond Self-Etch adhesive can be used for the following indications:

- All classes of fillings with light-curing composite or compomer
- Core build-ups made of light-curing composite
- Root surface desensitization
- Repair of composite or compomer fillings
- Intraoral repair of existing composite, porcelain fused to metal, and all ceramic restorations
- Cementation of indirect restorations made of composite or compomer, ceramic, and metal using RelyX™ ARC Adhesive Resin Cement, manufactured by 3M ESPE

Contraindications:

- Cementation of veneers and adhesive cementation of self-curing and dual-curing composites

Composition

The Adper™ Easy Bond Self-Etch Adhesive formulation includes a carefully balanced combination of phosphoric acid esters, water and methacrylates in order to optimize stability. In addition, a bonded nanosilica filler gives enhanced bond strength and does not require shaking before use. Adper Easy Bond Self-Etch adhesive contains the following components.

- 2-hydroxyethyl methacryate (HEMA)
- Bis-GMA
- Methacrylated phosphoric esters
- 1,6 hexanediol dimethacrylate
- Methacrylate functionalized Polyalkenoic acid (Vitrebond™ Copolymer)
- Finely dispersed bonded silica filler with 7 nm primary particle size
- Ethanol
- Water
- Initiators based on camphorquinone
- Stabilizers

Storage under refrigeration is recommended if the product is not in use. If the material is depleted within six months, no refrigeration is needed.

Background

The majority of dental adhesives fall into two categories, total-etch and self-etch. In total-etch adhesives, a phosphoric acid etchant is typically used to etch the surfaces of dentin and enamel. The adhesive subsequently forms a micromechanical bond with these etched surfaces, which provides a substrate upon which a composite material can be chemically bonded.

Mechanism of Adhesion to Enamel for Total-Etch Adhesives

Untreated enamel does not provide a suitable surface for dental adhesive bonding due to minimal porosities and a surface energy poorly suited for wetting with monomers. For total etch adhesives, a phosphoric acid etchant is used to superficially demineralize the hydroxyapatite of enamel. The demineralization greatly increases the surface area available for bonding, as shown in Figure 1.

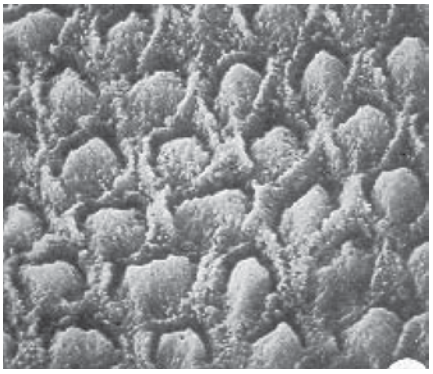


Figure 1:
Enamel etch pattern – 35% phosphoric acid.

This allows the low viscosity, polymerizable resins of the adhesive to penetrate the porosities revealed by the etching procedure to form an interlocking mechanical bond after curing. These interlocking resin tags are shown in Figure 2.

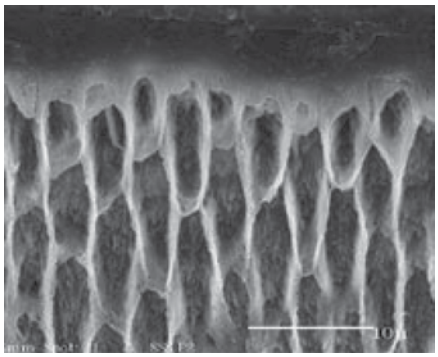


Figure 2:
Image courtesy of Dr. Patricia Pereira, University of North Carolina.

Mechanism for Adhesion to Dentin for Total-Etch Adhesives

For dentin bonding with total etch adhesives, a similar process is involved to form the micromechanical bonding. A typically prepared dentin surface will contain a smear layer as shown in Figure 3.

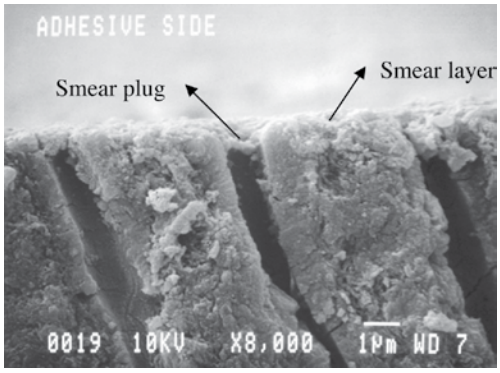


Figure 3:
Smear layer seen through a scanning electron microscope.

Upon acid etching the dentin surface, the smear layer is removed opening the dentin tubules. In addition, the intertubular dentin is demineralized, leaving a layer of collagen fibers as shown in Figure 4.

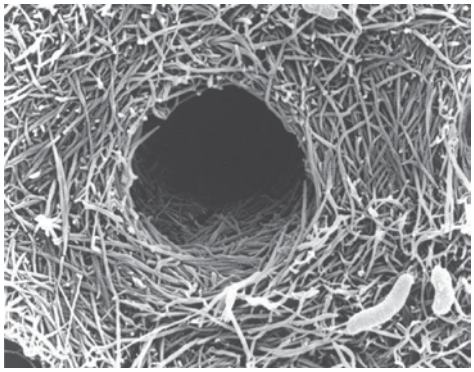


Figure 4:
Dentin tubule with surrounding collagen fibers. Image courtesy of Dr. J. Perdigao, University of Minnesota.

The open dentin tubules create a surface where adhesive can penetrate and form resin tags. In addition, the expanded collagen fiber network creates an additional bonding surface for the intertubular dentin, known as the hybrid layer. Figure 5 is a scanning electron micrograph (SEM) showing the formation of the hybrid layer and resin tags by the application of adhesive onto etched dentin.

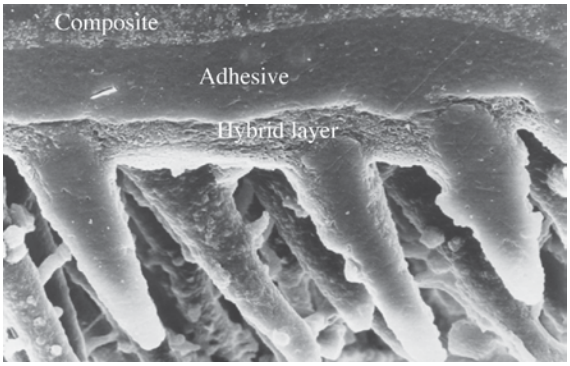


Figure 5:
Scanning electron micrograph showing hybrid layer and resin tags.

Provided the collagen layer remains hydrated, these fibers will remain expanded and the infiltration of adhesive resin monomers is maximized. Upon desiccation, however, the collagen layer collapses limiting the infiltration of resin monomers and impairing the formation of a hybrid layer. In this situation, localized adhesion may be compromised during polymerization contraction of the composite restorative material, contributing to gaps between the adhesive and dentin substrate. A possible outcome of this is post-operative sensitivity.

Bonding Mechanism for Adper™ Easy Bond Self-Etch Adhesive

Unlike the total-etch systems described in the previous section, the etching and subsequent penetration of resin monomers into the demineralized dentin and enamel is carried out as one step with Adper Easy Bond Self-Etch adhesive. A major benefit of this procedure for dentin bonding is that the etching depth and the depth of penetration of the adhesive are identical.

Eliminating the need for a separate etching step allows for the simultaneous etching and adhesive penetration. In the case of dentin bonding, this keeps the collagen fibers from collapsing and eliminates dependence on “moist” bonding which is characteristic of the 5th generation “one-bottle” systems. This is important because technique sensitivity associated with bonding systems requiring a “moist” bonding technique may be associated with post-operative sensitivity.

A possible adhesion mechanism for the original Prompt™ L-Pop™ adhesive was described by Professor Reinhardt (University of Münster) and can also be used to describe, in part, the mechanism of Adper Easy Bond Self-Etch adhesive.

Adper™ Easy Bond Self-Etch Adhesive includes phosphoric esters, which under aqueous conditions will etch the surfaces of dentin and enamel to allow for the micromechanical bonding of a restorative material. Moreover, the phosphoric esters and the Vitrebond™ Copolymer in Adper Easy Bond Self-Etch adhesive form a chemical bond to the hydroxyapatite by forming a complex with the calcium ions.

Bonding to dentin with Adper Easy Bond Self-Etch adhesive involves dissolving the inorganic smear layer and the demineralization of the intertubular dentin. Simultaneously the adhesive penetrates the demineralized dentin to form the hybrid layer and flows into the dentin tubules to create resin tags. The depth of the demineralized zone corresponds to the depth of penetration of the monomers to be polymerized. Nanoleakage, resulting from an insufficient penetration depth of the adhesive can be prevented by this mechanism.

Figure 6 shows the hybrid layer formed from Adper Easy Bond Self-Etch adhesive. This image was created using Transmission Electron Microscopy (TEM) methodology. Adhesive and dentin are clearly labeled, while H indicates the acid-resistant hybrid layer. Adper Easy Bond Self-Etch adhesive displays a well defined, submicron hybrid layer.

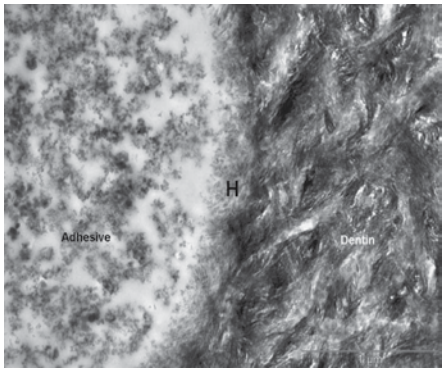


Figure 6:
Hybrid layer for Adper Easy Bond Self-Etch Adhesive. Image courtesy of J. Perdigao, G. Gomez, S. Duarte, University of Minnesota.

Test Results

Bond Strengths to Dentin and Cut Enamel

Adper™ Easy Bond Self-Etch Adhesive demonstrates bond strengths on dentin and cut enamel comparable to the leading self-etch adhesives.

Tensile Study from Professor Nara

A tensile bond strength study was performed by Professor Nara, Nippon Dental University. A tensile measurement device invented at Nippon Dental University was used to measure bond strengths. Human teeth were used for this study, and the bond strengths were measured immediately after sample preparation. Data from this study is shown in Figures 7-1 and 7-2.

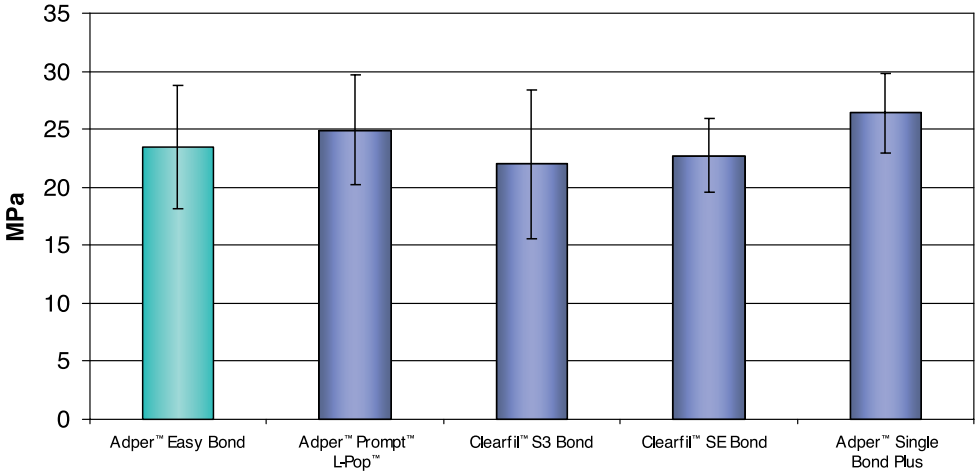


Figure 7-1:
Bond strength to cut enamel.

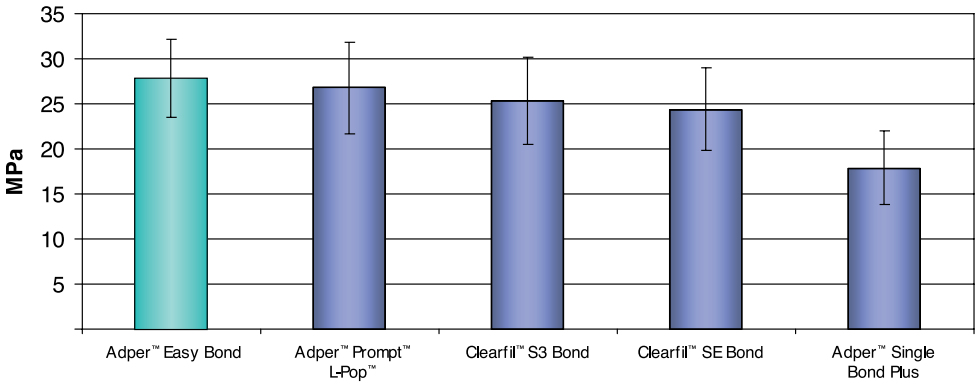


Figure 7-2:
Bond strength to dentin.

Shear Bond Study at Loma Linda University

A notched-edge shear bond strength test was conducted by Lu H, Dunn JR at Loma Linda University comparing Adper™ Easy Bond Self-Etch Adhesive to other one-bottle self-etch adhesives. Human teeth were used in this investigation. Data from this study is shown in the following graphs (Figures 8-1 and 8-2).

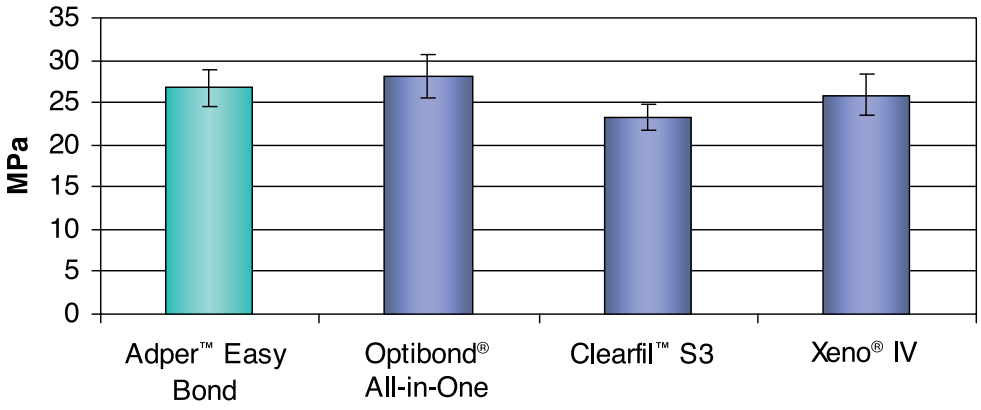


Figure 8-1:
Shear bond strength to cut enamel.

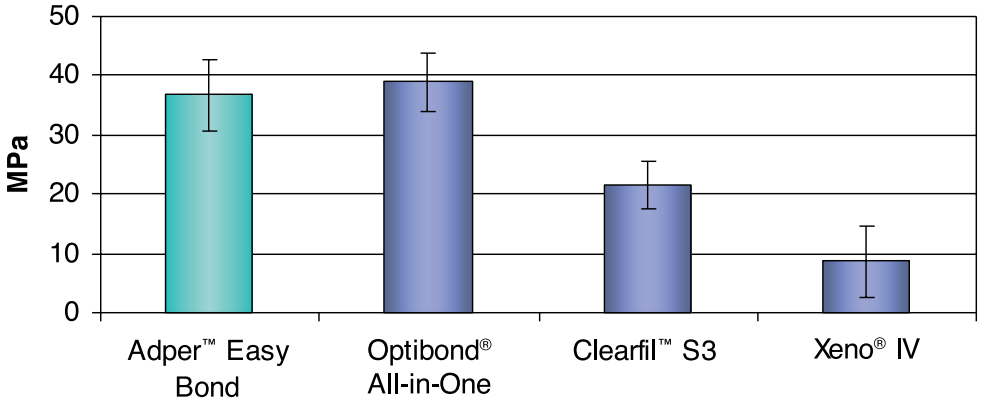


Figure 8-2:
Shear bond strength to dentin.

3M™ ESPE™ Shear Bond Study

An internal study was conducted comparing Adper™ Easy Bond Self-Etch Adhesive to leading 7th generation self-etch adhesives on bovine cut enamel and dentin (Figures 9-1 and 9-2). A notched-edge shear test method was used with Filtek™ Z250 Universal Restorative. The data shows that Adper Easy Bond Self-Etch adhesive has statistically higher bond strengths to dentin than the other adhesives studied in this investigation.

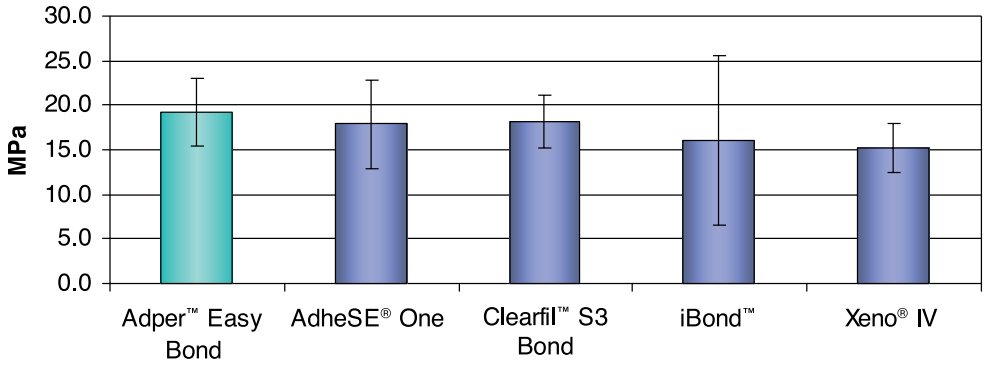


Figure 9-1:
Shear bond strength to cut enamel.

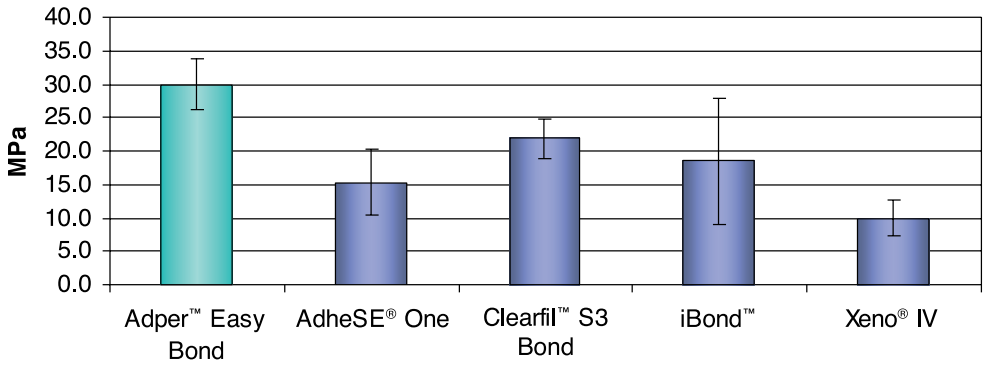


Figure 9-2:
Shear bond strength to dentin.

Dentist Panel Study

A panel of 30 dentists participated in a study with Adper™ Easy Bond Self-Etch Adhesive and selected other adhesives. Each dentist placed a set of three adhesives on bovine cut enamel and dentin according to their instructions for use for a total of 180 specimens. A notched-edge shear test was then conducted using Filtek™ Z250 Universal Restorative. Data from this study is shown in Figures 10-1 and 10-2. The data helps to demonstrate the robustness of Adper Easy Bond Self-Etch adhesive over a large group of dentists.

Figure 10-1:
Shear bond strength to cut enamel.

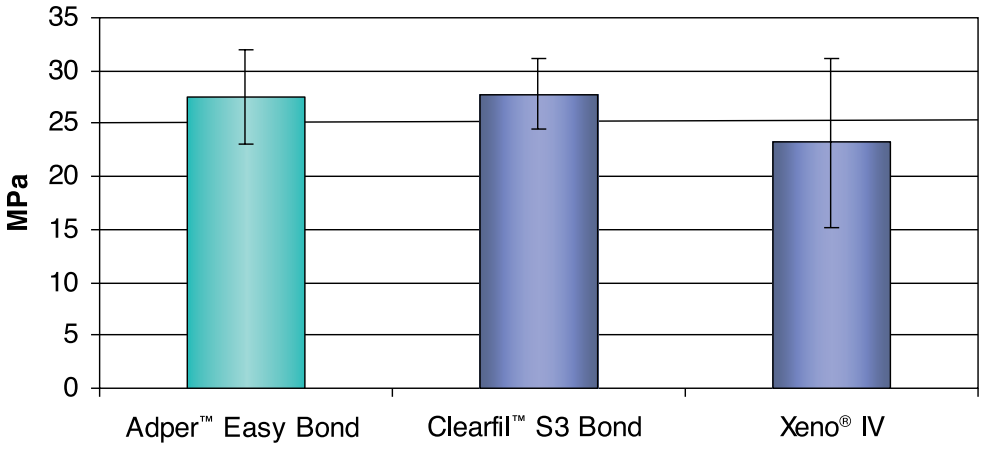
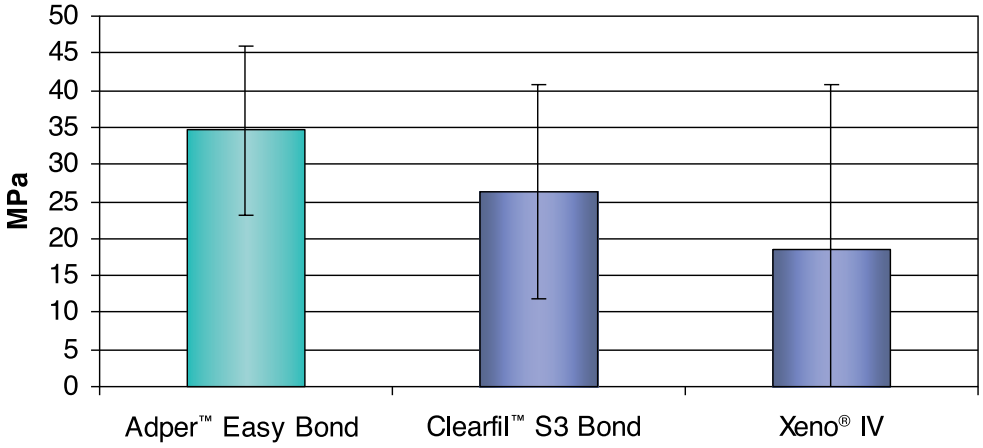


Figure 10-2:
Shear bond strength to dentin.



Marginal Integrity

Professor Dr. B. Haller, University of Ulm measured several parameters pertaining to Class V restorations before and after thermal cycling to determine marginal integrity. Adper™ Easy Bond Self-Etch Adhesive displayed very good marginal adaptation.

The following graphs show the percent continuous margins with dentin and cut enamel before and after thermal cycling for Adper Easy Bond Self-Etch adhesive and other adhesives (Figures 11-1 and 11-2). The percent continuous margin after thermal cycling is very high for Adper Easy Bond Self-Etch adhesive (99.9% for enamel, 97.7% for dentin).

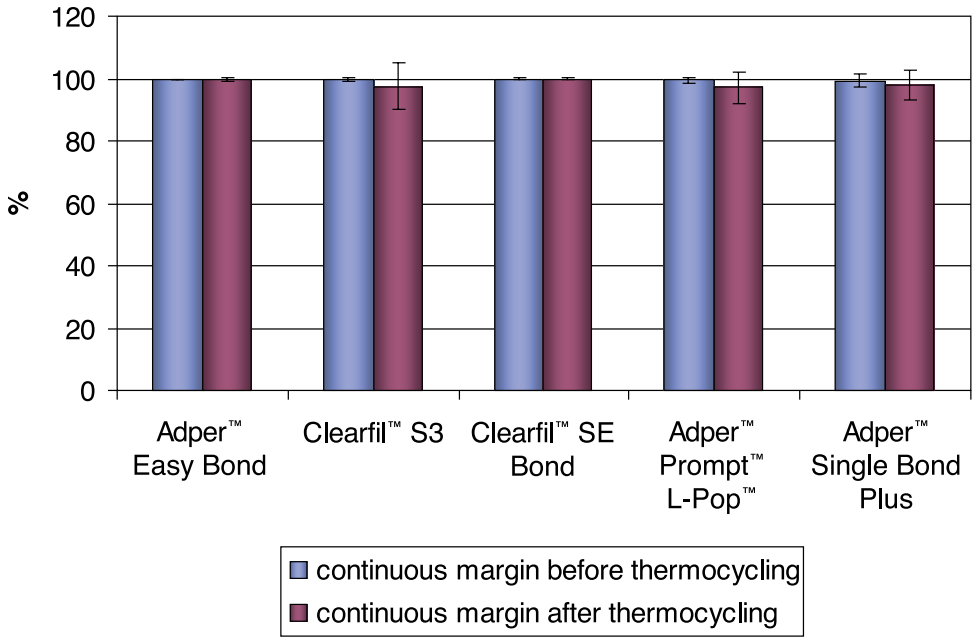


Figure 11-1:
Continuous margin, cut enamel.

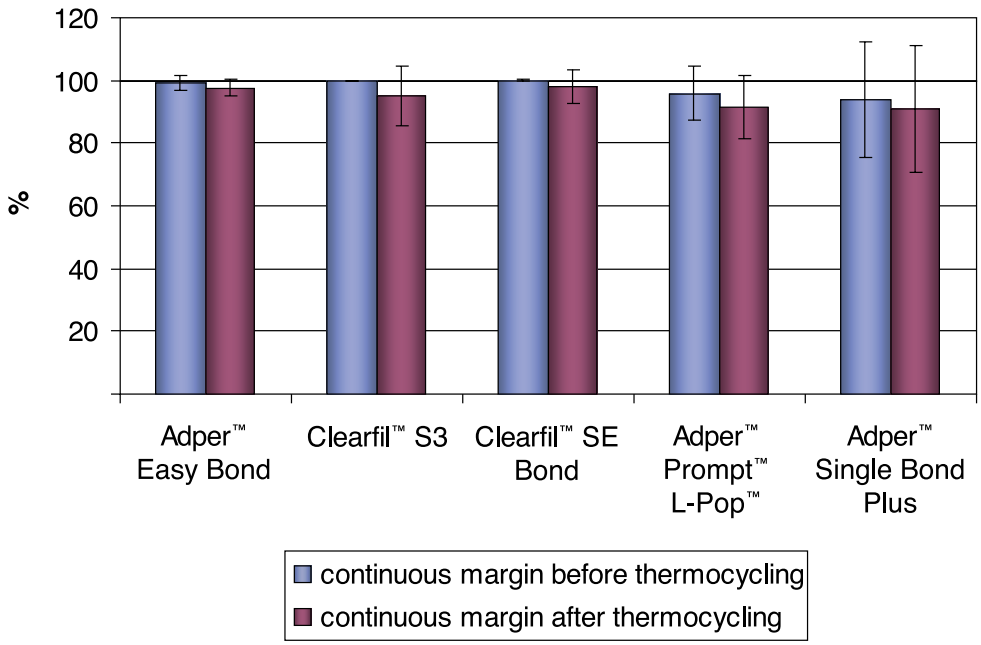
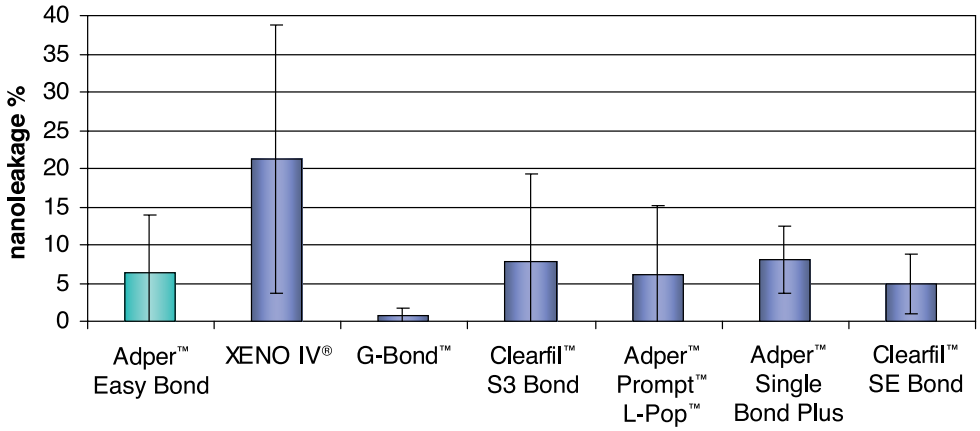


Figure 11-2:
Continuous margin, dentin.

Nanoleakage

Dr. Perdigao conducted a nanoleakage study on human teeth with Adper™ Easy Bond Self-Etch Adhesive and selected other adhesives. Class V cavities were prepared, and the adhesive was applied per manufacturer's instructions, followed by Filtek™ Z250 Universal Restorative. The prepared specimens were immersed in an ammoniacal silver nitrate solution for 24 hours, followed by eight hours in a photo-developing solution. After further specimen processing, the specimens were cross-sectioned through the center of the restoration. The cross-sections were viewed using field-emission scanning electron microscopy (FE-SEM). Nanoleakage was calculated as a percentage of the dye penetration into total preparation wall length. The study indicated a low percentage of nanoleakage for Adper Easy Bond Self-Etch adhesive. Figure 12 shows the nanoleakage results.

Figure 12:
Human teeth nanoleakage.



Low Post-Operative Sensitivity

An *in vivo* field evaluation was conducted in Germany and the U.K. involving 100 dentists. Over 5,500 restorations were placed using Adper Easy Bond Self-Etch adhesive. Dentists were asked to record instances of post-operative sensitivity. Table 1 shows the results, in which a very low rate of post-operative sensitivity was observed for Adper Easy Bond Self-Etch adhesive.

Table 1:
Post-operative sensitivity results.

Total number of dentists	**100**
Number of dentists encountering post-operative sensitivity	**7**
Total number of cases of post-operative sensitivity	**26**
Total number of restorations placed	**5572**
Percentage of restorations having post-operative sensitivity	**0.47%**

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3M ESPE

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