Building stronger bonds

Dr Julian Caplan discusses how to achieve the best adhesion to enamel and dentine for maximum bond strength

If you believe the success rates of the leading cosmetic dentists for their indirect adhesive restorations you may go along with this. If you have had adhesive failures, you most probably do not. Is it down to luck, better technique or good case selection?

At dental school, we all learned about MG Buoncore in the 1950s discovering he could bond acrylic to enamel if he treated the enamel surface with 37 per cent phosphoric acid. By etching the enamel, he removed the biofilm, increased the surface energy, produced a microretentive surface and managed to achieve bond strength in the region of 30MPa. It was a small step to extrapolate this to bonding BisGMA resins to enamel. But what actually happens. What is required to bond two materials together?

Here’s the problem

The two key issues in dental bonding are:
• Can a mechanical lock be produced?
• Can we get the intermolecular forces to produce true adhesion?

Under an SEM image, it is apparent that contact between two surfaces is not as intimate as it first appears with the naked eye. In fact, they only touch in sporadic places along their surfaces when viewed on an SEM image.

This means in order to get mechanical interlocking or to allow the intermolecular forces, such as the Van der Waal forces, to work to achieve adhesion we have to use something to fill in the many gaps to give us the necessary intimacy. A fluid material is needed that will easily coat the two surfaces. For good wet ability, the contact angle of the intermediary material needs to be very shallow.

The intermediary material must ‘like’ the surface we want it to get close too. In dentistry, the surfaces to be bonded to can be divided into:
• Surfaces that can be dried (as with enamel)
• Surfaces that can not be dried (as with dentine)

The intermediary material can also be divided into whether it is:
• Hydrophobic
• Hydrophilic

As would seem obvious a hydrophilic material works best on enamel and a hydrophilic material is required for bonding to dentine.

Dentine bonding

Enamel bonding is very predictable. The bond resin that is hydrophobic will readily bond to acid etched enamel. However dentine is another matter because:
• There is always water present in vital teeth
• There is pulpal pressure
• There is a collagen matrix
• A smear layer is formed when dentine is cut.

The etchant is used to remove the smear layer, to demineralise the dentine to expose a network of collagen fibres and to remove some hydroxyapatite from the intertubular dentine. The dentine is kept moist to maintain the for...
1. Etching.
   - Over-etching can lead to a deep layer of exposed collagen fibres that are too deep to be penetrated completely by the primer. This leads to an area bereft of primer and causes nanoleakage unprimed collagen. Nano-leakage is much less extensive than micro-leakage and has probably no short-term clinical relevance. However, the long-term stability of the adhesive bond between dentine and the restorative material might be adversely affected.
   - After rinsing the etchant off, the dentine needs to be kept wet to prevent the collagen matrix from collapsing. However if the dentine is too wet the primer will be diluted. This will affect the bond strength.

2. Prime
   - The primer must penetrate to full depth of the exposed collagen. Over-etching may produce nanoleakage as discussed above.
   - The primer is a hydrophilic monomer (for example, Hydroxethyl methacrylate-HEMA). This may attract water after bond- ing causing "water trees" to develop at the dentine adhesive interface. There is a possibility that this may cause long-term degradation of the dental adhesive.  

3. Bond resin
   - This is a hydrophobic material that can separate from the hydrophilic primer if left to stand. In systems that have primer and resin separate, as in fifth-generation bonding systems, they must be vigorously shaken to recombine the solutions prior to use.
   - Over-thinned primer orsetting the bond strength can be rejected.
   - Some bonds contain filler particles at a level that makes them relatively thick. It is paramount that the hybridised layer is set prior to seating of the restoration to prevent the collagen matrix from collapsing with the pressure from the luting cement. This is where most of the bond strength is developed from. However this thick layer can prevent the correct seating of indirect restorations. To try and overcome this, the idea of immediate dentine bonding has been proposed. In this technique the dentine is etched, primed and bond applied and set immediately after the preparation has been completed. The enamel is cleaned with a finishing bur to expose fresh, unbounded enamel. The impression is now taken after the oxygen inhibition layer has been removed with alcohol from the bonded dentine. This prevents this unset bond on the bond surface from reacting with the impression material and affecting its correct setting. The working model produced from this impression has the thickness of the bond on the dentine recorded on the working dies. At the seating appointment the enamel is etched and bond applied. The bond on the dentine is roughened with air abrasion using 50 micro aluminium oxide particles, the enamel etched in the usual way and bond applied. The restoration is silanated, dried and bond applied to the fitting surface. Luting cement is placed and the restoration seated. Following excess cement removal the luting cement and the bond are set with a suitable light-curing unit. As the bond is set after the restoration is seated an intimate fit is achieved. Some research shows that the bond strengths produced are as good as or better than conventional delayed dentine bonding techniques.

Classification of bonding systems

There are two main ways to classify the present bonding systems. They can be classified chronologically by using the fourth to eighth generation system or sometimes by the number of bottles and whether the etch is rinsed off or not. For simplification the chronological classification will be described:

- Fourth generation. These are three bottle systems comprising of separate etch, prime and...
Materials. At this time if a sixth, seventh and eighth-generation bonding systems are not included.

Looking at a number of recent studies it would appear that fourth-generation bonding systems are still the gold standard but, following close behind, sixth-generation bonding systems are giving clinically aceptable good long term bond strengths.

References are available on request.

**Conclusion**

Unfortunately there are few studies that compare all the different generation systems. For example one study when looking at microleakage compared different bonding systems (etch and rinse and self-etch systems) and concludes that etch and rinse systems produce less microleakage. However, sixth-generation systems are not included. Another study compares sixth and seventh-generation systems and concludes the sixth-generation bonding systems appear to have the least amount of nanoleakage after six months. However, fourth and fifth-generation bonding systems are not included.

Looking at a number of recent studies it would appear that fourth-generation bonding systems are still the gold standard but, following close behind, sixth-generation bonding systems are giving clinically acceptable good long term bond strengths.

References are available on request.

**About the author**

**Dr Julian Caplan** qualified from Sheffield University in 1988. He is a Director on the board of the BACD, a senior instructor for the Larry Rosenthal Aesthetic Continuum course and lectures internationally on CAD/CAM dentistry, specifically Cerec. He has completed all levels of occlusion courses run by Peter Dawson in Florida, USA. He owns Aviva Cosmetic Dentistry, a dental practice aimed at providing high-end cosmetic and functional dentistry in Hertfordshire.

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