Make it *STICK*! Predicatble and Durable Adhesive Dentistry

Edmond R. Hewlett, D.D.S.

Bonding to Enamel

- High inorganic (Hydroxyapatite) content
  - range: from 86% up to 98% HA in mature enamel
  - consistent, homogeneous structure
  - **∴ Enamel is a *very predictable* resin bonding substrate**

- Etching Enamel
  - Phosphoric acid (H3PO4), 32%-35%: IDEAL
  - Increases bonding surface area
  - Cleans debris and contaminants
  - **Bonding to etched enamel is very predictable/durable**

- Selective Etching (for Self-Etching adhesives)
  - Self-etching adhesives: minimal etch of enamel – adequate?
  - PRE-ETCH enamel w/phosphoric acid for best seal
    - Etch ONLY the enamel margins
    - Etch 30-45 seconds, rinse and dry thoroughly

- *Aprismatic* enamel at surface
  - must instrument surface to expose prisms for optimal bonding
  - use a coarse composite finishing disk
  - disk beyond the bevel

- White Lines at margins
  - Enamel cohesive failure
  - Space fills with polishing debris
  - Proximal margins: BEVEL
  - Occlusal margins: REMOVE SHARP EDGE
    - Remove unsupported enamel
  - Disk beyond the bevels
  - Etch with phosphoric acid
    - 30-45 sec. on *enamel*
  - Rinse thoroughly
  - WAIT 5-10 min. before finishing restoration margins

Bonding to Dentin

Dentin as a Bonding Substrate

- *COMPLEX* structure
  - Less HA (45%-65%) than enamel, PLUS collagen, tubules, water, tubular fluid, noncollagenous proteins
  - Direct connection to the pulp (via tubules)
    - "The general practitioner should handle dentin as a dynamic continuum of the pulp." (P. Lambrechts)

- Confusing array of products and techniques

- *COMPLEXITY + VARIABILITY* = **dentin is NOT a very predictable resin bonding substrate!**
  - Variable morphology – tubule density
  - Variable degree of mineralization
    - Intertubular dentin (less mineralized) vs. Peritubular (Intratubular) (more mineralization)
      - shallow dentin: more intertubular, more "etchable"
      - deep dentin: more peritubular, more acid resistant
    - Sclerotic dentin – HYPERmineralized!
      - How to optimize the bond?
        - Prepare? Longer etch? Glass ionomer v. resin?
    - Carious dentin – partially (?) DEmineralized

- Dentin as a Bonding Substrate – Summary:
  - No such thing as *"NORMAL dentin"*
  - Substrate variability = Bonding variability
  - Don't be complacent!

- Durability of Resin-Dentin Bonds
  - Dentin bonds made with newer simplified hydrophilic adhesives are subject to deterioration over time from
  - Hydrolytic breakdown
    - water sorption during and after bonding (Nanoleakage)
    - hydrolytic breakdown of resin and collagen
  - Degradation of demineralized collagen matrix by *host enzymes* (matrix metalloproteinases, or MMPs)
    - rinsing w/ 2% chlorhexidine cavity disinfectant between etching and resin placement may prevent this!

Dentin-Resin Bonding: What Can We Use?

(ALL systems employ variations of the following three steps)

- Acidic Conditioner (Dentin Etching)
  - removes smear layer, dissolves HA at dentin surface → exposes collagen fibers
  - opens tubules (dissolves smear plugs), widens tubule openings (funnel shape)
  - renders dentin surface highly *permeable*

- Hydrophilic Primer
  - hydrophilic resin monomer dissolved in a hydrophilic solvent
    - hydrophilic properties imparted by –OH and –COOH functional groups
  - diffusion of resin monomers into collagen fiber scaffold
  - formation of "Hybrid Layer" or "resin interdiffusion zone" composed of resin + collagen
  - penetration of monomers into tubules and tubule branches (resin tags)
  - conversion of surface from hydrophilic to hydrophobic

- Adhesive resin
  - stabilization of monomer-infiltrated (hybrid layer) dentin
  - copolymerization with the composite resin

II. The Products

III. Clinical Technique Considerations

- Dentin "Wetness" (NOTE: this applies ONLY to etch & rinse adhesives)
  - *Overdrying* of etched surface → collagen fiber collapse → ↓↓ *permeability!*
    - if not addressed: no resin diffusion, no hybrid layer, no resin tags, NO BOND!
    - *wet surface is critical for Acetone-based primers*
  - *Overwet* dentin → voids in bonded interface
    - optimal "wetness" is *critical for Acetone-based primers*

- Avoiding collagen collapse
  - Don't overdry – *blot dry* instead of using compressed air
    - suction-off excess water after rinsing, then use cut 2x2 non-linting gauze or dry applicator to absorb remaining excess in prep
    - overdried? re-wet with water and blot
  - Ethanol- or Water-based primers (simultaneous rewetting and priming)

  - Rewetting agents
    - water
    - cavity cleaners, e.g. Consepsis® (2% chlorhexidine) (Ultradent) or Tubulicid Red® (EDTA + benzalkonium chloride + NaF) (Global)

  - Self-etching primers
    - usually dissolved in water
    - less sensitive to dentin wetness/dryness
    - most work best on DRY dentin

- Don't rush the priming step!
  - Apply/agitate for 30 seconds
    - Need ***TIME*** for resin interdiffusion into dentin
    - Facilitates evaporation of solvent

- "Air dry" = evaporate remaining water or solvent with compressed air
  - use GENTLE air stream to avoid displacement of primer monomer
  - dentin surface will still appear shiny due to presence of resin

- Sequential Etching (for Etch & Rinse adhesives)
  - ***Avoid overetching dentin!***
    - Etch enamel for 30-45 seconds
    - Etch dentin for 5-10 seconds

- Isolation
  - moisture control is *critical*!
  - high surface energy of etched enamel is attractive to *all* liquids (water, saliva, blood, sulcular fluid)
  - *biofilm* contamination will result in reduced wettability of a hydrophobic adhesive

BONDING CHECKLIST – Etch & Rinse (4th or 5th generation)

1. Etch…
   - enamel for 30-45 seconds
   - dentin for 5 seconds
   - Rinse thoroughly (5-10 seconds)
   - *BLOT* dry (don't overdry!)
     - primers need *MOIST* dentin surface
     - **re-wet** and blot dry if necessary
   - *Apply 2% chlorhexidine for 2 min., then blot dry*
2. Prime…
   - Don't dispense until needed!
   - Re-cap bottle IMMEDIATELY (EVAPORATION!)
   - Apply and agitate
   - RE-apply and agitate
   - GENTLY air dry for 10 seconds
   - Not shiny? Re-apply and dry
3. Bond (apply adhesive resin)…
   - SLIGHTLY air thin
   - Cure for 20 seconds

BONDING CHECKLIST – Self-Etch (6th or 7th generation)

- *Selective enamel etch with phosphoric acid*
  - *30-45 seconds*
- *Apply 2% chlorhexidine for 2 min., blot/air dry*
- Apply primer per mfr.'s DFU
- Apply/cure resin per mfr.'s DFU

Resin-Dentin Adhesion: Neutralizing the Variables – Part I

Posterior Composites: Risk factors for restoration longevity

- Size of restoration
  - Larger outline → higher risk of wear
  - Larger volume → resin/dentin interface is at risk (***shrinkage stress*** at composite-dentin interface)

- Site
  - More posterior → more force during function
- Opposing occlusion
  - "plunger" cusp → force is concentrated in a small area

- Configuration ("c") -factor
  - c-factor = ratio of bonded surface area to unbonded (free) surface area
  - e.g. flat dentin surface: c=1; occlusal Class I cavity: c≅ 5
  - higher c-factor→ higher polymerization contraction forces on walls
  - Compensating for a high c-factor:
    - incremental insertion of composite
    - very small 1st increment
    - flowable composite as 1st increment
      - lower shrinkage stress and higher elasticity than packable/sculptable hybrids

- *Bulk Fill* Flowable Composite
  - Lower shrinkage stress
  - Higher depth of cure
  - Excellent radiopacity