An Overview of Dental Adhesive Systems and the Dynamic Tooth–Adhesive Interface

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KEY POINTS

- There are 2 adhesive strategies of contemporary dental adhesive systems to bond to enamel and dentin. Strategies can be accomplished in 1 to 3 steps.
- Resin acidity and hydrophilicity increase the susceptibility for degradation of the adhesive interface; altered forms of enamel and dentin can negatively affect bonding to enamel and dentin.
- Adhesive interfaces are susceptible to biodegradation.
- Degradation includes interaction with the dental biofilm, active bacterial enzymes, and activation of endogenous enzymes.
- Some restorative strategies that might influence the long-term outcome of the dynamic tooth adhesive–interface are summarized.

Adhesion has revolutionized contemporary restorative dentistry with 3 groundbreaking research advances:

1. Dental surfaces modification by acid etching,
2. The development of methacrylate-based resin composite chemistry, and
3. The development of hydrophilic resin chemistry.

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Adhesive restorative dentistry affects virtually every dental practice because it is integral to many procedures, including dental sealant placement, bonding of orthodontic brackets, direct composites restorations, intraradicular posts cementation, cementation of inlay or onlay tooth-colored restorations, full-coverage all-ceramic crowns, bonded bridges, and root canal obturation. This review focuses on dental restorative applications of dental adhesives.

CLASSIFICATION OF CONTEMPORARY DENTAL ADHESIVE SYSTEMS

Dental adhesives are often commercially categorized into generations reflecting the handling technique or advances in formulations rather than new adhesion concepts or mechanisms. A close look into the chemistry of dental adhesives and their mechanism of adhesion to dentin yield 2 major adhesive concepts:

1. Reliance on the complete removal of the smear layer (ie, the layer of debris formed after cavity preparation) and superficial demineralization of dentin and enamel, and
2. Partial superficial dissolution and incorporation of the smear layer into the adhesive interface.

Both concepts promote adhesion by micromechanical retention to the underlying dental tissues. However, an additional chemical bond to the substrate is present, particularly in the latter concept.

Multiple or single steps are commercially available within the 2 major categories of systems, being referred to as etch and rinse and self-etch (Fig. 1). Etch-and-rinse systems (also known as total etch) require separate acid etching and rinsing steps followed by the application of the primer and adhesive in 2 separate or one combined step (see Fig. 1). Self-etch systems do not require a separate etching step; rather, acidic primers are used to promote partial dissolution of the smear layer and infiltration of primers by an etching or primer step followed by an adhesive application (2-step systems) or through a single formulation with an adhesive resin (all-in-one system; see Fig. 1). More recently, the term universal systems has been used to define dental adhesive systems that can be applied either in etch-and-rinse or self-etch modes (see Fig. 1).

THE CHEMISTRY OF DENTAL ADHESIVES SYSTEMS

Overall, adhesion is attainable when the following are present: clean dental surfaces, good surface wettability, diffusion of the adhesive resin monomers within enamel and

Contemporary Dental Adhesive Systems					Characteristics			Longevity
System Mode	Delivery	Adhesion Steps			Acidity	Hydrophilicity	Bond Stability[b]	
		Etching	Primer	Adhesive				
Etch-and-rinse	3-step				+	+	++++	Stability ↑ Degree of Conversion Solvent Evaporation ↓ Acidity Hydrophilicity ↓ Degradation
	2-step				++	++	+++	
Self-etch	2-step				+++	++	++++	
	1-step				++++	+++	+	
Universal	1 or 2 steps[a]				+++	++	+ (+) +	

Fig. 1. Current contemporary dental adhesives systems and characteristics affecting the long-term stability of dentin–resin interfaces. Symbol (+) indicates scale ranging from lowest (+) to highest (++++). [a] The adhesive system support optional pre-etching of enamel or dentin (2- step) or self-etching mode (1-step). [b] Depicts relative values of dentin bond strength, note that average bond strengths can greatly vary among brands, studies and application modes (for universal systems). Degree of conversion = polymerization rates of adhesive.