Improving Adhesives

Modern restorative dentistry is unthinkable without enamel/dentin adhesives. In the last couple of years, the desire of patients for esthetic restorations has significantly increased. Tooth-colored, inconspicuous fillings with undetectable margins are in demand, as are esthetic veneers, inlays, onlays, and crowns bonded with an inconspicuous composite luting cement according to the adhesive technique.

In contrast to the mainly function-focused reparative dentistry of the 20th century, restorative dental treatment today is more concerned with a minimally invasive approach, which starts with caries diagnosis and risk assessment as a basis for a proper treatment concept. Based on the result of the analysis, different possibilities for the management of initial caries lesions are established: noninvasive management by arresting the caries process and remineralization or surgical intervention. In the case of operative treatment, a minimally invasive preparation technique is demanded. The principles of cavity design for amalgam restorations established by Black and his concept of “extension for prevention” are no longer valid. The current concept is “prevention of extension”, as retentions no longer have to be prepared. However, it was not until the breakthrough of effective enamel/dentin adhesives in the 80s and 90s that dentistry was able to establish the concept of minimally invasive restorative treatment.

Over time, along with increased adhesion performance, the technique itself has become more and more simple. In the case of total-etch systems, one-bottle adhesives in combination with an etching gel are proven and clinically reliable. In the last couples of years, developers of adhesive systems have concentrated their work on the design of self-etching systems which are based on polymerizable acidic monomers that simultaneously condition and prime dentin and enamel.

Most of the common self-etching adhesive systems involve two application steps: dentin and enamel conditioning with a self-etching primer, followed by the application of an adhesive resin. Clinically, it has been shown that self-etching systems are relatively technique insensitive with regard to the dentin surface conditions, resulting in a very low incidence of postoperative sensitivity. Some concerns still exist about enamel adhesion especially if the enamel is unprepared. Based on the concept of keeping adhesive systems as simple as possible, one-component adhesives have recently appeared on the market.

Due to the necessity of ionic reactions of acidic monomers with dentin or enamel, self-etching adhesives are water based with a pH value in the range of 1 to 2. Under these conditions, methacrylates are not hydrolytically stable. Such adhesives are “living” systems, losing their function over time. However, chemical solutions are available to improve the hydrolytic stability of monomers. Another problem which remains to be solved is the incompatibility with initiator components and phase separation of acetone-based systems. The question about the real performance of one-component self-etching adhesives cannot be answered at the moment, because nearly all investigated systems are not stable in storage: by the time their performance is tested, they have already partly degraded “on the shelf”.

For the adhesive cementation of indirect restorations, self-adhesive composite-based luting cements have been recently marketed. Self-adhesive cements, such as glass ionomers, hybrid glass ionomers, or compomers, are already known. In contrast to the compomers, the new hybrid cements are based on monomers with phosphoric acid instead of carboxylic acid groups. However, at least one of the new hybrid cements offers the option of additionally using an adhesive.

It is safe to assume that adhesives for highly esthetic restorations will also be needed in the future; hence, the question arises as to which improvements are possible or necessary. Meeting the long-standing challenge of attaining perfect marginal adaptation through the reduction of composite polymerization shrinkage or shrinkage stress buildup at the composite/adhesive interface requires that attention be given to the type of adhesive employed. Especially if cationic polymerizable systems are developed, compatibility with existing adhesives has to be adjusted. Self-adhesion does not seem feasible in such systems.

Substrate destruction either by demineralization through acid produced by cariogenic bacteria or by enzymatic collagen degradation influences the long-term stability of adhesion between composite and tooth structure. Antimicrobial additives are generally eluted relatively quickly; thus, to ensure the long-term activity of the additives, ways must be found to immobilize the antibacterial group. One product which possesses this ability is already commercially available. Further, some published studies have shown that collagen degradation can be avoided by inhibition of the relevant enzymes.

In addition to the challenges of storage stability, self-adhesion, and longer-term antimicrobial activity mentioned above, there is ample room for other product improvements, for instance, in x-ray opacity, visibility during placement, particle reinforcement, to name just a few.

There is still much to be done to improve adhesives. Let's do it.

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