Review Article

Dentin Bonding Agents – Current Status: An Update

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ABSTRACT: Most modern adhesive systems are superior to their predecessors, especially in terms of retention that is no longer the main cause of premature clinical failure. Recent adhesives also appear less sensitive to substrate and other clinical co-variables. Various recent trials have been conducted on various issues like the antibacterial properties of self-etching dental adhesive system, hydrolytic degeneration, moisture-insensitive primers and moisture-active adhesives, and next-generation bonding agents. The purpose of this article is to provide a comprehensive and updated insight to the current status of dental adhesive systems.

Keywords: Microleakage; Nanoleakage; Moisture-Active Adhesives; Moisture-Insensitive Primers; Nano Adhesives; Dental Adhesive Systems.

INTRODUCTION

In current times, development of new products is occurring at an unprecedented rate. Dentin adhesives are currently available as three-step, two-step and single-step systems, depending on how the three cardinal steps of etching, priming and bonding to tooth substrate are accomplished.

The newer concepts of self-etching primers and adhesives have proven to be good both scientifically and clinically. They reduce the clinical steps, can be placed inexpensively, provide adequate bonding to enamel and dentin, and most importantly, ensure postoperative comfort for patients.[1] Among proprietary dentin bonding systems (DBS), the products which contain glutaraldehyde or have an acidic property exhibit some antibacterial effects.[2,3] However, the antibacterial properties shown by these products are only side-effects which are derived from the constituents included to produce superior bonding characteristics, and appear to be unreliable.

Inclusion of antibacterial components into DBS has also been attempted using several methods, and the results of in vitro tests indicate that some of the trials seem promising.[4] Knowledge about hydrolytic degradation and nanoleakage phenomena is an important contribute to the reduction in the bond strength created by dentin adhesives overtime.

Antibacterial Properties of Self-Etching Dental Adhesive Systems: In vitro studies have shown that the tooth-restoration interface created when using self-etching adhesive systems do not eliminate microleakage and bacterial penetration, which can lead to secondary caries, the most common reason for dental restoration failure.[5,6] Therefore, the antibacterial properties of adhesive materials are important.

Studies have shown the antibacterial effect of adhesive materials is due to their low pH or to specific antibacterial components, such as glutaraldehyde or 12-methacryloyloxydodecyl pyridinium bromide (MDPB).[7] Since copolymerization should immobilize MDPB in the adhesive material, adhesives containing MDPB may be effective against bacteria that invade through microleakage.

All of the materials lost their antibacterial properties within 14 days: Adper Prompt l-Pop after 24 hours, AdheSe and Xeno III within 48 hours and Clearfil Protect Bond after 14 days. It is reasonable to assume that their antibacterial components decomposed at varying rates into the surrounding aging liquid.[8,9] Current studies hypothesize that not all MDPB molecules copolymerize, and those that do not; are able to leach and manifest their antimicrobial properties. The application of self-etching adhesive materials could contribute toward completely eliminating bacteria or minimizing it during tooth preparation. Since none of the self-etching adhesive systems tested had long-lasting antibacterial properties, they did not provide a solution to the main cause for secondary caries: Bacterial invasion owing to

microleakage.[10,11] However, it is worthy of continuing the attempts to develop DBS which can inhibit invading bacteria after the placement of restoration as well as residual bacteria in the cavity.

Hydrolytic degeneration and Nanoleakage in DBS: Water is a common component in self-etch adhesives for demineralization of dental hard tissues. It has been postulated that minimum bond strength of 17 to 20 MPa is needed to resist contraction forces of resin composite materials, for enamel and dentin.[12] Clinical experiences confirm that this bond strength is sufficient for successful retention of resin restoration. All adhesive systems used achieved the optimal bond strength values for both enamel and dentin (except G Bond, which showed a slightly lower value). However, the total etch system prime and bond NT showed better bond strength, as compared to the self-etching adhesives – Clearfil S3, Xeno III, Clearfil Protect Bond and G Bond1 (Table 1).[1]

Self-etching adhesive systems rely on acidic monomers to simultaneously demineralize and infiltrate enamel and dentin. This acidity must be neutralized by the mineral content of the tooth structure, to allow complete polymerization of the adhesive film. With total etch adhesive, smear layer and dissolved mineral are removed during the rinsing step. Because of some questions about residual acidity and the fact that the smear layer is not removed, the issue of long-term hydrolytic stability of the self-etching adhesive systems still remains unresolved.[13,14]

Table 1: Composition of few single-step, self-etch adhesives

Self-etch adhesive/ Manufacturer	Type	Composition
Prompt l-Pop/ 3M-ESPE, Seefeld, Germany	Unfilled	Water', stabilizer, parabenes; methacrylated phosphoric acid esters; Auoride complex; photoinitiator (BAPO)
Etch and prime 3.0 / Dentsply, Degussa AGHanau, Germany	Unfilled	Universal: Water', ethanol, HEMA, stabilizers, Catalyst: Pyrophosphate, HEMA, stabilizers, photoinitiator
One-up Bond F / Tokuyama Corp, Tokyo, Japan	Filled	Water', MMA, HEMA; coumarin dye; methacryloyloxyalkyl acid phosphate; methacryloxyundecane dicarboxylic acid; multifunctional methacrylic monomer; fluoroaluminosilicate glass; photoinitiator (aryl borate catalyst).
Reactmer Bond/ Shofu Inc, Kyoto, Japan	Filled	Reactmer Bond A: Water', acetone, F-PRG fillers, FASG fillers, initiators(TMBA, p-TSNa). Reactmer Bond B: 4-AET, 4-AETA, HEMA, UDMA, photoinitiator

Abbreviations: 4-AET, *4-acryloxyethyltrimellitic acid;* 4-AETA, *4-acryloxyethyltrimellitic anhydride; BAPO, bisocyl phosphine oxide;* F-PRG, *full reaction-type prereacted glass-ionomer filler;* FASG, *fluoroaluminosilicate glass;* HEMA, *2-hydroxylethyl methacrylate;* MMA, *methyl methocrylate;* p-TSNa, *p-toluenesulfinic acid sodium salt;* TMBA, *trimethyl barbituric acid;* UDMA, *urethane dimethacrylate*

MOISTURE-INSENSITIVE PRIMERS & MOISTURE-ACTIVE ADHESIVES: During recent years manufacturers have sought to enhance the performance of bonding systems in the presence of moisture by introducing novel materials (Kahl et al., 1993).[15] The inefficiency of adhesive systems in the presence of moisture has long been known through studies showing substantial decreased bond strength for adhesive systems bonded to wet substrates (Bishara et al., 1975).[16]

The detrimental effect of moisture on bonding may relate to water adsorption and exertion of a plasticizing effect in the polymer network from the creation of hydrated zones at polar monomer sites, and oxidation of pendant C=C bonds attached to the network which release by-products such as formaldehyde, so producing a plasticizing effect (Cook, 1984).[17]

While some manufacturers claim acceptable performance for their moisture-insensitive products in a wet environment, others have introduced moisture-active adhesives (MAD). The former type of product, which may be termed a moisture resistant adhesive, is available in a primer formulation that replaces the conventional bonding agents

applied to the enamel surface, and consists of an aqueous solution of methacrylate-functionalized polyalkenoic acid co-polymer and hydroxyethyl-methacrylate.

In contrast to the moisture-insensitive primer (MIP), MAD require rather than tolerate the presence of moisture to induce polymerization initiation. The moisture-active adhesive represents a distinct material available as a cyanoacrylate-based paste formulation, applied to intentionally-wetted etched enamel without the use of a primer.[18]

Transbond™ MIP is a hydrophilic or "moisture friendly" material that allows to bond in a moist environment without compromising bond strength. A single coat of Transbond primer over a water or saliva contaminated, etched tooth surface makes the application technique fast and easy. Laboratory testing and clinical evaluations using Transbond™ XT Light Cure Adhesive have proven that Transbond MIP primer offers comparable bond strength in a moist environment as in a dry environment with a conventional primer.

Smartbond™ is a single-phase, particle-filled adhesive based on cyanoacrylate chemistry, which sets in the presence of water, and this may be considered as an inherent advantage of the material. The setting reaction of this product involves two steps. First, isocyanate groups react with water, forming an unstable carbamic acid component, which rapidly decomposes to carbon dioxide and the corresponding amine, and secondly, the amine reacts with residual isocyanate groups, cross-linking the adhesive through substituted urea groups.

IS THIS THE FIRST 8TH-GENERATION BOND?

Nano dentistry with its technologically advanced clinical tools and devices has influenced every field of dentistry including restorative dentistry. Nano composites and nano adhesives are one of the greatest contributions of nano dentistry which contain nano sized fillers.

Nano adhesives are solutions with nano particles which prevent agglomeration thus producing high dentin and enamel bond strength, high stress absorption, longer shelf life, durable marginal seal and the release of fluorides.[19,20] Although most bonding agents are unfilled, some products contain inorganic fillers ranging from 0.5 % to 40 % by weight. Filler particles include micro fillers, also called nano fillers and sub-micron glass. Filled bonding agents tend to produce higher in vitro bond strength.[21]

Recently dentin adhesives that contain nano fillers have been introduced. The manufacturers of one such system of nano filler containing dentin bonding agent (Futurabond DC, Voco, Germany) have claimed them to be the eighth generation.

Futurabond DC Dual-Cured[22]

- It is dual-cured and works with all light-, self- or dual-cured resins.
- It works in a self-cured mode without any light: Great for post cementation.
- It takes only 35 seconds from start to finish.
- It needs only one coat.
- It comes in unit dose providing the freshest chemistry each time.
- It does not need to be refrigerated or shaken before use.
- No sensitivity.
- Over 30 MPa bond strength to dentin and enamel.[23]

CONCLUSION: Adhesive dentistry has revolutionized restorative dental practice during the past 30 years. Today, we all are in the age of adhesive dentistry. Improved adhesive materials have made resin-based composite restorations more reliable and long standing. As we enter the new millennium, it is important to examine the past keeping abreast of the fast rapidly spreading advances in the practice of adhesive dentistry with the latest trends.

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