ACTA SCIENTIFIC DENTAL SCIENCES (ISSN: 2581-4893)

Volume 3 Issue 6 June 2019

Review Article

Dentin Bonding Agents – A Review

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Received: May 03, 2019; **Published:** May 30, 2019

DOI: 10.31080/ASDS.2019.03.0556

Abstract

Dentin bonding agents have evolved through different generations during the past few decades. These recent advances in adhesive dentistry have been exciting. There have been changes in chemistry, mechanism, number of bottles, application technique, and clinical effectiveness. The self-etching primers have been in widespread use for over 10 years, whereas the all-in-one adhesives have only been available for 2 years. The development of self-etching primer adhesive systems has greatly simplified resin bonding. A separate etching step is no longer required. No rinsing step is required. This review describes different dentin bonding agents, its evolution, mechanism of action and different commercially available dentin bonding agents.

Keywords: Bonding Agents; Dentistry

Introduction

Adhesive resins are designed to provide strong coupling between resin composites and enamel and dentin. The earliest dental adhesives were relatively hydrophobic and were placed directly on enamel and dentin smear layers although the presence of these layers were unknown at that time [1].

The principles of adhesive dentistry date back to 1955, Buonocore stated that acids can be used to treat enamel and dentin prior to adhesives and described the importance of rete pegs in adhesion [2].

Buonocore [2] discovered that acrylic resin could be bonded to human enamel that was conditioned with 85% phosphoric acid for 30 seconds of the enamel surface as well as micromechanical retention from the sealant. Eick 1970 [3] described the nature of the smear layer. Fusayama., *et al*. 1979 [4] were the first to report the successful use of phosphoric acid to remove smear layer, etch the dentin and restore with adhesive composite.

In 1982, Nakabayashi [5] and colleague used 3% ferric chloride in 10% citric acid as a conditioning agent to remove the smear layer and to demineralize the underlying intact. Kanca 1991 [5] introduced the All etch technique.

Classification of dentin bonding agent

Dentin bonding agents have evolved through different generations during the past few decades. Dentin bonding agents have been categorized into generations of products based on chemistry and the manner in which they treat the smear layer. The First Generation products were early, largely unsuccessful attempts at producing a bond between dentin and resins. They essentially ignored the smear layer. The Second Generation depended upon the smear layer for bonding while the Third Generation agents characteristically remove or heavily alter the smear layer prior to bonding.

First generation

The first generation dentin bonding agents were developed in the early 1960's [6]. Buonocore., *et al*. in 1956 reported that Glycerophosphoric Acid Dimethacrylate (GPDM) could bond to hydrochloric acid-etched dentin surfaces However, the bond strengths to dentin attained with this primitive adhesive technique were only 1 to 3 MPa [6].

The development of N-phenylglycine glycidyl methacrylate (NPG-GMA) was the basis of the first commercially available dentin bonding agent, Cervident (SS white).They bond by chelation with calcium [7].

The factors like Difficulty in bulk polymerization of the Cyanoacrylates, instability of NPG-GMA in solution in combination with very low bond strength prevent the successful use of these bonding agents.

Second generation

The second generation dentin bonding agents were developed in the late 1970's and early 1980's [8]. These systems leave the smear layer largely, if not wholly, intact when used. Second generation bonding agents produced variable results; they generally performed better than first-generation bonding agents. They routinely produced bond strengths that ranged from approximately 5 to 6 MPa [7].

Ethylmethacrylate, Phosphate ester, Polyurethane were incorporated in them.

Brands: Bondlite (S0S/Kerr), Creation Bond (Den-Mat), Prisma Universal Bond (Caulk), and Scotchbond (3M).

Disadvantages in this type were low bond strength, hydrolysis to oral environment and poor wetting leading to failure in restoration.

Third generation

The third generation dentin bonding agent were designed not to remove the entire smear layer but rather to modify it prior to dentin bonding agent application. With this system, dentin is etched with an aqueous solution of 10% citric acid and 3% ferric chloride, followed by the application of an aqueous solution of 35% HEMA and a self-curing adhesive resin containing 4-META, MMA, and tri-n-butyl borane (TBB), the last as a polymerization initiator [5].

Based on this technology, adhesive systems such as C&B metabond (Sun Medical), Super-bond D-Liner, and Amalgambond Plus (Parkell) are commercially available and have been reported to yield consistent results *in vitro* studies [7], regardless of dentinal depth.

Thus the third generation bonding agent came out with a system consisting of Conditioner, Primer and Bonding agent. This paved the way for the further development in bonding agents.

Fourth-generation

Essential to the enhanced adhesive capacity and responsible for the improved clinical effectiveness of fourth-generation adhesive systems is the pretreatment of dentin with conditioners and/or primers that make the heterogeneous and hydrophilic dentinal substrate more receptive to bonding. The fourth-generation adhesive generally come with 30% to 40% phosphoric acid gels and is referred to as three-step etch-and-rinse adhesive. The total etch technique permits the etching of enamel and dentin simultaneously using phosphoric acid for 15-30 seconds. The surface must be left moist however, in order to avoid collagen collapse [7].

The fourth generation can be used in cavities for both enamel and dentin. Some of their components can also be used for bonding to substrates such as porcelain and alloys.

Representative adhesives in this group include All-bond 2, Optibond FL, Permaqui (Ultra dent), and Scotchbond Multipurpose etc. Composition of some of the commercially available fourth generation bonding agents are All Bond 2, Scotch bond Multipurpose

Fifth-Generation

Because of the complexity and number of steps of compounds involved with the fourth-generation systems, researchers and manufacturers have worked to develop simpler adhesive systems. In this generation bonding agent include etching enamel and dentin simultaneously with 35-37% phosphoric acid for 15-20 seconds followed by application of one bottle containing primer and bonding agent which has a general composition of HEMA, Bis-GMA, dimethacrylate, patented polyalkenoic acid copolymer ,Water and ethanol. Though they require fewer steps in achieve dentin bonding, these agents are inferior to fourth generation bonding agents in terms of their bond strength [9].

Representative commercial products of this generation include excite (Ivoclar Vivadent), One-step (several versions, Bisco), Optibond Solo (several versions, Kerr), Prime and Bond (several Versions, Dentsply), and Single Bond or Scotchbond 1 (several versions).

Sixth generation

Further demand for simplification has urged manufacturers to develop adhesives with even fewer clinical steps. The sixth generation consists of self-etch adhesives. Sixth-generation adhesives are characterized by the omission of a separate conditioning phase and are composed of two different solutions. This generation of adhesives contains two-step self-etch adhesives and one-step, two-component self-etch adhesives, respectively [8].

Representative sixth-generation two-step self-etch adhesives include AdheSE, clearfil SE Bond and clearfil Protech Bond, Optibond Solo Plus.

Seventh-generation adhesives

The latest generation of adhesives consists of single-component, one-step self-etch adhesives, Seventh-generation adhesives combine conditioning, priming and application of adhesive resin, but unlike sixth-generation adhesives they do not require mixing. As a consequence, adhesives belonging to this generation are intricate mixes of hydrophilic and hydrophobic components [7]. So far, a number of shortcomings of the seventh-generation adhesives have been documented but to the complex nature of the mixed solutions, the seventh-generation adhesives have attained consistently lower bond strengths that the fourth- and fifth generation adhesives [7]. Representatives of seventh – generation adhesives include Clearfil S Bond (Kuraray), G-Bond (GC), i-Bond, and Xeno IV (Dentsply).

Discussion

The ideal interface between dental restorative material and tooth tissue would be one that simulates the natural attachment of enamel to dentin at the DEJ. Molecular contact between the two parts is a prerequisite for the development of strong adhesive joints. This means that the adhesive system must sufficiently wet the solid surface, have a viscosity that is low enough to penetrate the micro porosities, and be able to displace air and moisture during the bonding process. Thomas Pioch., *et al*. 2002 [10] Assessed the degree of nanoleakage of Class V restorations with three bonding agents: Scotchbond 1, Gluma CPS, Prime and Bond NT using wet and dry bonding. The effect of drying had a significant influence on both the acetone-based and ethanol-based material thereby reducing nanoleakage. Third-generation dentin bonding systems: These systems alter or remove the smear layer prior to bonding and produce bond strengths ranging from 16 -26 MPa [11].

The dissemination of residual monomer molecules to the pulp chamber via the dentinal tubules has been reported to involve a significant degree of cytotoxicity [12]. However, *in vivo* biocompatibility studies have demonstrated that resin , whether fully or partially cured, cause little pulpal irritation if the cavities are sealed to prevent ingress of bacteria from the oral environment.

Some general health concerns have been expressed related to the use of resin systems. One concern is that leakage of bisphenol-A from bis-GMA-based resin composites and sealants and may have estrogenic effects. Soderholm and Mariotti13 stated that, considering the dosages and routes of administration, the short-term risk of estrogenic effect from treatment using bisphenol A-based resins is insignificant and therefore should not be of concern to the general public.

Conclusion

The excellent uses for current-generation dentin bonding agents are prior to the luting of cast ceramic, composite restorations with resin cements when dentin is exposed; advantages may include increased bond strength, reduced microleakage, reduced post-treatment sensitivity. Dentine adhesive systems have created a new era in the field of dentistry. Owing to its property of adherence to the tooth structure by both micromechanical and chemical means, if finds a wide range of application in various fields. It has lead to the most desired forms of treatment needs, which is the conservation and esthetics of tooth.

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