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Review Article

AN OVERVIEW OF DENTAL ADHESIVE SYSTEMS

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ABSTRACT
Adhesive systems in dentistry have evolved through many generations and till now there is a desire to know extensively in the field of research. Improvements in the concept of adhesion is evident in terms of chemistry, mechanism of adhesion, clinical handling of the materials. Choosing a right adhesive system has become a challenge for a dentist. This review outlines the development of bonding agents and focuses on the mechanism of adhesion to enamel and dentin and describes the current strategies of adhesion.

Key words: - Dental Adhesives, bond strength.

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INTRODUCTION

Adhesive materials development in recent times has shown remarkable changes in restorative dentistry. These materials have shifted the philosophy of "surgical excising dental caries" towards "Minimally invasive care" [1].

Adhesives are resin monomer solutions which are primarily aimed to bond restorative materials with dental substrate. These adhesive systems comprises both hydrophilic and hydrophobic group of monomers, organic solvents, photo initiator system and fillers. Main aim of adhesive restoration is to have a good resin- dentin interface, although bonding to enamel is quite satisfactory but this task is difficult to achieve in dentin because enamel is purely inorganic in nature whereas dentin has high organic phase comprising type I collagen and presence of water. [2]

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Classification of Dental adhesive systems

Dental adhesives are classified based on generations and adhesive strategies.

Based on generations

First generation

First generation bonding systems were developed in 1956 by Buonocore who uses glycol phosphoric acid dimethacrylate (NPG-GMA) to bond acid etched dentin. Unfortunately, this produces low bond strength of about 1-3 Mpa. [3,4]

Second generation

These adhesive systems were developed in 1970's but this did not clear the smear layer effectively and produced low bond strength values 4-6 Mpa. [3]

Third generation

During late 1970's and early 1980's third generation bonding agents were introduced to modify the smear layer. Here dentin is first etched with 10% citric acid, 3% ferric chloride followed by 35% HEMA and self-cure adhesive resin application done. Thus, this adhesive evolved a new system containing conditioner primer and bonding agent. [4]

Fourth generation

In 1990's fourth generation bonding agents were presented. This adhesive system completely removes the smear layer, opens the dentinal tubules, and increases its permeability. It is composed of three components namely 30-40% phosphoric acid gels primer and a bonding agent. Here both enamel and dentin are etched for 15 -20secs with phosphoric acid but the surface of dentin must be moist to avoid collapse of dentinal collagen. An improved bond strength is seen 18 Mpa when compared to others. [3,12]

Fifth generation

These bonding agents were developed with an aim of reducing the total number of clinical steps and introduced single bottle system containing primer and adhesive solution. This system is applied once the enamel is etched with 35-37% phosphoric acid for 15-20secs. Finally, it yields a bond strength of 17-24 Mpa. [3,12]

Sixth generation

Sixth generation bonding systems were presented in late 1990's and early 2000. These bonding agents were developed to avoid the procedure of acid etching. It has two components one is acidic primer, and the other is adhesive solution. This generation has two step and one step self-adhesives. [3,12]

Seventh generation

Seventh generation bonding agents were developed in early 2005.This generation has simplified the steps of application and presented all the three components namely self-etchant, primer, and adhesive in one bottle. Unfortunately, it yields lowest initial and long-term bond strength. [4,12]

Based on adhesion strategies

First approach involves complete removal of smear layer (ie layer of debris formed after cavity preparation) and superficial demineralization of enamel and dentin which is referred to as "Etch and rinse" or "Total etch system" [5]

Second involves partial removal or modification of smear layer which is referred to as self-etch system.[6]

Recently a new system referred to as "Universal system" has been used which can be applied either in etch and rinse mode or self-etch mode. [6]

Etch and rinse strategies

In this approach first enamel and dentin is treated with phosphoric acid gels for 15 -20 secs followed by application of primer and adhesives. This mode is applied in 3 steps or 2 steps. In 3 steps first etchant is applied followed by separate application of primer and adhesive whereas in 2 steps primer and adhesives are combined to form a single solution in a bottle. [2,5,7,11]

Self-etch strategies

Here non rinse acidic monomers were used which conditions as well as prime enamel and dentin. This approach follows 2 steps and 1step application. In two step application first self-etch primer is applied followed by adhesive resin. In 1 step mode single bottle contains all the three components namely acidic monomer, primer and adhesive resin. [2,5,8,11]

GIC based adhesive

Glass ionomers remain as "self-adhesive" system. Here pretreatment with poly alkenoic acid conditioner improves bonding efficacy. This system follows one and two step mode. In two step mode poly alkenoic acid conditioner is applied for 10-15secs then it is rinsed and gently air dried which improves bonding efficiency.[1]

Adhesive bonding mechanisms to enamel and dentin

Bonding to Enamel

Enamel is the hardest tissue in our body composed mainly of hydroxy apatite crystals arranged in the form of prisms. In etch and rinse system application of phosphoric acid increases wetting phenomenon and surface energy of enamel. It forms two types of tags within etched enamel pits. Macro-resin tags fill the space surrounding enamel prisms and micro tags results from resin infiltration and polymerization. Although bond strength of enamel due to micromechanical bonding is lower when compared to dentin, it is relatively stable due to high inorganic phase. [9]

In self etch system acidic monomers with higher pH used as etchant did not produce porosities as compared to etch and rinse system. Also etching pattern is not so deep when compared to phosphoric acid application. Hence micro mechanical bonding to enamel in self etched system is critical.

Bonding to Dentin

Application of phosphoric acid to dentin completely removes the smear layer but partially demineralize hydroxyapatite in the inter tubular dentin to uncover the collagen fibrils followed by hybridization which involves infiltration and subsequent polymerization of resin. This micromechanical interlock was first described by

Nakabayashi, Kojima, and Masuhara in 1982 and is referred to as hybrid layer.[9]

In self etch system stronger self-etch monomer produces same degree of polymerization as in total etch system whereas mild self-etch monomers produces hybrid layer which is thin and irregular in nature. [10]

CONCLUSION

Goal of good adhesion is to have a strong and durable bonding. Current adhesive system attempts to simplify the clinical steps but the durability of long-term bonding effectiveness in self etch system is disappointing. However clinical performance continues to improve particularly with selective etching of enamel before using self-etch adhesive. Despite all the draw backs three step etch and rinse technique is still considered the benchmark for good adhesion.

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