Bonding In Dentistry – Latest Advancement

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ABSTRACT - *Adhesive dentistry has been progressing with rapid pace over the past decade. Composite resin is the most esthetic restorative material currently available for restoring teeth. In spite of it being in use since a decade, still failure cases are seen which are mainly due to polymerization shrinkage and subsequent inadequate adhesion to cavity walls, leading to micro leakage. Various generations of dentin bonding agents have been introduced to overcome the shortcoming of composite resin.*

INTRODUCTION

Today we are in the age of adhesive dentistry. The traditional mechanical methods of retaining restorative materials have been replaced to a large extent by tooth conserving adhesive methods. The concepts of large preparation and extensions for prevention proposed by G.V.Black have been gradually replaced by more conservative technique.

The development of an adhesive approach to restorative dentistry has brought many advantages such as better esthetics, conservation of tooth, improved crown strength, reduction in microleakage. Adhesive technique has expanded the range of possibilities for esthetic restorative dentistry. This is important as todays patient pays more attention to cosmetics than ever before.

ADHESION :

The word adhesion comes from the Latin word “adhaerere” – means “to stick to”.

Adhesion is the force or the intermolecular attraction that exists between molecules of two unlike substances when placed in intimate contact with each other. The substance added to produce the adhesion is known as the “adhesive” and the material to which it applied is known as “Adherend”.

ADHESION in dentistry usually is of 3 types and involves the following mechanisms :

1) Chemical adhesion is based on primary valence forces, such as ionic, covalent or metallic bonding.

2) Physical adhesion relies on secondary vatence forces. Such as polar forces, dipole moments.

3) Mechanical adhesion on penetration of one material into different material at a microscopic level. The bond between dentin and adhesive is due to micromechanical interlocking / entrapment of resin with the tissue substrate.

The phenomenon of adhesion is dependent upon certain factors – the main factors are ;

1) Surface energy

2) Wetting

3) Contact angle

Surface Energy: Enamel is crystalline substance with high surface energy. It has high melting point and strong intermolecular force. Because of high surface energy, liquid will readily spread over the surface.

Dentin: Dental collagen has low surface energy. They have low melting point and weak intermolecular forces. Hence they are not easily wetted.

Wetting: It is difficult to force two solid surfaces to adhere. Regardless of how smooth these surfaces may appear, they are likely to be extremely rough when viewed on an atomic or microscopic scale. Consequently, when they are placed in opposition, only the ‘peaks’ are in contact. Because these areas usually constitute only a small percentage of total surface area, no perceptible adhesion takes place. One method of overcoming this difficulty is to use a fluid that flows into these irregularities to provide contact over a greatest part of the surface of the solid.

For Example : When two polished glass plates are placed one on top of the other and are pressed together, they exhibit little tendency to adhere for reasons previously described. However, if a film of H_2O is introduced between them, considerable difficulty is encountered in separating the two plates. The surface energy of the glass is sufficiently great to attract the molecules of H_2O.

To produce adhesion in this manner, the liquid must flow easily over the entire surface and adhere to solid. This characteristic is known as wetting. IF the liquid does not wet the surface of the

adherend, adhesion between the liquid and adherend will be negligible or non-existence. When surface energy is more wetting is proper.

CONTACT ANGLE :

The extent to which an adhesive wets the surface of an adherend may be determined by measuring the contact angle between the adhesive and the adherend. Contact angle is the angle formed at the interface of the adhesive and the adherend[1].

If the molecules of the adhesive are attracted to the molecules of adherend as much as, or more than they are attracted to themselves, the liquid adhesive will spread completely over the surface of the solid and no contact angle will be formed. Thus the smaller the contact angle between the adhesive and the adherend, the better the ability of adhesive to glow into and fill in irregularities within the surface of adherend Complete wetting occurs at a contact angle of 0^o and no wetting occurs at an angle of 180^o.

SMEAR LAYER:

Preparation of dental cavities produces smear layer. This layer is between 1-10 μm thick contains hydroxyapatite, denatured collagen and remnants of cariogenic bacteria. If this layer is not removed, it tends to weaken the bond strength between the restorative material and the cavity wall. Thus, etching of the cavity is recommended to remove smear layer.

Regarding Smear Layer Treatment There are 2 options:

1) Some believe it acts as an effective natural cavity liner that seals the dentinal tubules and reduces permeability making the smear layer a clinical asset.

2) Other argues: It interferes with adhesion of restorative materials serving as a focus for bacteria and therefore it should be removed.

3) Various technique of smear layer treatment has been introduced for the past few years to achieve high bond strength.
   I. No Treatment at all:
   In this technique the resin would infiltrate through the entire thickness of smear layer and even bond to underlying matrix or penetrate into tubules. Eg. Scotch bond and prisma bond.
   II. Dissolution of the smear layer :
   This dissolved smear layer plays an vital role in chemical attachment of dentin bonding agent to dentin. Eg. Scotchbond-2.
   III. Removal of smear layer by acid etching:
   Acid etching agents are used to remove smear layer and develops attachment directly to intact dentin (through primers).
   IV. MODIFICATION OF SMEAR LAYER:
   Modification of smear layer allows between interactions of dentin bonding agent with the smear layer.
   Eg. Bonding agent – Prisma 2, XR Bond, All bond.
   V. REMOVAL AND REPLACEMENT OF SMEAR LAYER: Removal of smear layer by acid etching and replacement with another mediation agent. Tenure replaces smear layers with oxalate crystals which are deposited in dentinal tubules.

ADHESION TO ENAMEL:

Bunocore introduced acid etch technique

Acid etching transforms smooth enamel into irregular surface and also increases surface free energy. When a fluid resin based material is applied to irregular surface, the resin penetrates into the surface aided by capillary action. Monomers in the material polymerise and the material become interlocked with the enamel surface. The formation of resin microtags within enamel surface is the fundamental mechanism of adhesion of resin to enamel[2].

Enamel etching results in three different micromorphologic patterns.

Type I : Involves the dissolution of prism core without dissolution of prism periphery.
Type II : Opposite of Type I
Type III : Both etching patterns are evident.

OTHER ALTERNATIVE ETCHANTS :

Phosphoric acid is said to be a more aggressive acid, so alternative etchants have been suggested :

- EDTA (24%; pH =7)
- Citric acid
- Tannic acid
- Maleic acid
- Polyacrylic acid
- Crystal growth of enamel surface (proposed by R. Maijer and D.C. Smith)
- Lasers
- Air abrasion – Al_2O_3 particles

Crystal growth of enamel surface (By R.Maijer and D.C. Smith)

This system consists of treating a clean tooth surface with a 50% solution of polyacrylic acid containing sulfate ions (SO_4^-).

↓

The liberated calcium ions will react with these sulfate ions forming $CaSO_4.2H_2O$ in 1-2 minutes

↓

These crystals are nucleated within tooth and grow outwardly in a spherulitic habit, with irregular surfaces they are similar to etched enamel without loss of tooth structure.

NEW CONCEPT OF ETCHING :

Combined action of different etchants, phosphoric acid on enamel and EDTA (24% pH 7). On dentin may be a better alternative than etching the entire cavity with single etchant.

ADHESIVE (CRITERIA FOR IDEAL DENTIN BONDING AGENT) :

A dental adhesive system bonds a restorative material to enamel and/or dentin. Criteria for an ideal dentin bonding system were enumerated in 1961 at a workshop held at the university of Indiana Dental School (Phillips and Ryge, 1961).

The basic chemical composition of these dentin bonding adhesives is illustrated as :

M – R – X

Group X can be phosphates, Aminoacids, Aminoalcohols (or) Dicarboxylates.

PRIMERS:

- Hydrophilic monomers dissolved in solvents such as H_2O, acetone or ethanol and are applied to the etched or conditioned dentin substrate but are not rinsed off.
- Organic solvents aid in displacing H_2O and thus promoting the infiltration of monomer into the submicron or nanometer sized spaces within the collagen fiber network.
- Primers are bifunctional compounds. The hydrophilic group has affinity to dentin where as the hydrophobic group has an affinity for adhesive resin.

  Ex. Primers are HEMA, NTG-GMA, BPDM, PENTA, $PMDM^3$.

ADVANCES IN SELF ETCHING SYSTEMS :

NANO-BOND :

Nano-Bond is another self-etching primer/bonding agent.

It is a two bottle system (an etchant / primer and an adhesive)

This system contains two unique components

- Sulforic acid group
- Nanoparticles that contain surface functional groups
- The nanoparticles filler is silica, which is structured, but contains specific functional groups to control properties of bonding agent (hardness, modulus strength, viscosity).
- Particles – Polyhedral oligomeric silsesquioxanes (POSS) is so small that it contains only 8 silicon atoms and 12 O_2 atoms.

HALLMARKS OF NANOBOND include

1) Complete penetration of the bonding system into the intercollagneous spaces, bonding and chemical union with the remaining or underlying hydroxyapatite.
2) Structured nanoparticles
3) Clinical versatility

Apply the etchant / primer, agitate it continuously for several seconds, leave it undisturbed for 30 seconds and then air disperse. For the Nano bond adhesive, apply 2 coats, leave undisturbed for 10 seconds, air disperse and then light cure for 10 seconds.

XENO III :

Xeno III is the most recent addition to dentin bonding agent. IT is two component system consists of two parts (liquid A and liquid B) self etching adhesive.

Liquid A contains : HEMA, Ethanol, H_2O, Aerosil, Stabilizer.

Liquid B contains: Pyro-EMA multifunctional monomer, PEM-F-Effectively releasing fluorides, UDMA, Stabilizer, Camphor quinone.

- Liquid A is clear and B is yellow when mixed together, the resulting clarity is homogenous. When liquid B is added to A, a clear separation

can be observed, yielding a "FRIED EGG" appearance.

- When one drop of liquid from bottle A is mixed with a drop of liquid from bottle B a chemical reaction is commenced. This reaction results in highly acidic solution (pH <1) which contributes to the etching of enamel and dentin and partial dissolution of smear layer and smear plug. The calcium salts liberated from dissolution of enamel and dentin then neutralizes the phosphoric acid groups of the hydrolyzed PYRO-EMA. The light curing results in the copolymerisation via methacrylate groups of UDMA.

- Pyro EMA etchant.

CONCLUSION:

Advances in adhesive dental technology have radically changed restorative dentistry. Bonding between tooth and the restorative material should be good. Various technique have been mentioned to achieve this goal. Following the correct clinical procedure and using the right material contributes to the success of bonding. The advent of new resin technologies like self-etching primers, simplified the procedure and is comparatively less technique sensitive than the total etches technique. However long term clinical studies are essential for the material[4].

[1] Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, et al. "*Buonocore memorial lecture. Adhesion to enamel and dentin: Current status and future challenges*". Oper Dent. 2003; 28:215–35.

[2] Mjor IA, Shen C, Eliasson ST, Richter S. "*Placement and replacement of restorations in general dental practice in Iceland*". Oper Dent. 2002; 27:117–23.

[3] Van Meerbeek B, Vargas S, Inoue S, Yoshida Y, Peumans M, Lambrechts P, et al. "*Adhesives and cements to promote preservation dentistry*". Oper Dent. 2001;26:S119.

[4] Mjor IA, Gordan VV. "*Failure, repair, refurbishing and longevity of restorations*". Oper Dent. 2002;27:528–34.