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Review Article

Bonding Materials: Know them Better in Order to Use them Better?

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Abstract

Adhesive cosmetic dentistry has experienced great progress over the past ten years, thanks to the evolution of bonding materials. Bonding has not only turned the paradigms of joint prosthesis upside down, but it has made tissue saving in dentures possible.

It is now accepted that the success of an adhesive prosthesis depends exclusively on the bonding, which is why the practitioner must not only master the bonding techniques but must also choose the appropriate bonding product.

Faced with the panoply of dental bonding materials that exist on the market, the practitioner is confused, which is why in this article we will try to guide their choice.

Keywords: *Bonding Materials; Cosmetic Dentistry; Adhesive Prosthesis*

Introduction

More than twenty years ago, Alain Rochette proposed to apply to dentistry a method of assembly reserved until then for industry: bonding [1].

Optimization of the optical qualities of ceramic material has long been associated with significant mutilation of dental tissue; this rule also remains valid for peripheral coronary preparations intended to receive ceramic-metal crowns and sealed jacket crowns [2].

But thanks to gluing, it is now possible to claim a satisfactory aesthetic result with a ceramic shell whose thickness is between 3 and 5/10th of a mm [3].

Definitions

Collage: According to the dictionary: "collage is assembly by adhesion". In dental prosthesis, bonding is an assembly by physico-chemical bond which ensures contact between dental tissues and prosthetic restorations. The strength of the bond depends on the intensity of the forces present [4,5].

Membership: It is the force that binds two materials of different natures in contact with each other [6,7].

To obtain adhesion, the two materials must have close contact [15] between them, this will only be possible if the adhesive has characteristics compatible with these surfaces, i.e. the adhesive must wet perfectly. these surfaces [6].

There are two theories of the adhesion phenomenon [7]:

- Mechanical theory: According to which the adhesive after hardening mechanically engages in roughness and surface irregularity.
- The absorption theory which applies to all kinds of chemical bonds of the adhesive and the adherent

The durability of bonded restorations requires obtaining quality adhesion [2].

The primer [7]

When two materials that are to be bonded do not have a particular affinity for each other, adhesion promoters are used which will react with the two materials and restore their adhesion.

Primers are adhesion promoters which are especially essential for bonding to dentin. The "Primer" is responsible for the chemical adhesion with the dentin.

The objective of this conditioning is to transform a hydrophilic dentin surface into a hydrophobic and spongy layer, allowing, during the last step, the adhesive resin to penetrate and effectively impregnate the exposed collagen network.

Adhesive/Bonding

This fluid resin, which precedes the placement of the bonding composite, is responsible for the micromechanical adhesion with the dentin: the resin penetrates the demineralized dentin surface and the canaliculi and polymerizes *in situ* [6].

The adhesive must be able to ensure the intimate contact of the two surfaces - that is to say, perfectly wet what is possible only if the characteristics of the surfaces are compatible with the adhesive [7].

Classification of adhesives

Different classifications have been proposed according to [2]:

- Generation: 7 generations have been described.
- The number of steps necessary for their implementation: the application of the adhesive will be done either in one, two or three steps.
- The classification of Vanmerbeck., *et al*. (1999): Based on the treatment of dentinal mud.
- The Desgrange classification (2003): Which groups adhesives into 2 main classes, those which require prior etching of the enamel and dentin and those which are applied directly to dental surfaces:
    - E & R: Etching and rinsing before adhesion: can be done in 3 or steps.
    - SES: Self-etching systems direct application without preliminary: can be done in 2 or 1 step.

E & R

E & R3: Application of the adhesive with prior etching and rinsing according to the following protocol:

- 30 seconds etching for enamel
- Etching 15 seconds for dentin
- Rinsing and drying
- Application of the primer 20 seconds
- Drying 2 seconds
- Resin, light-curing 20 seconds.

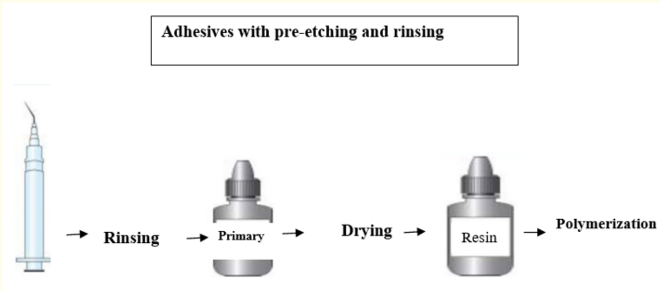

Figure 1: E & R3: adhesive with pre-etching and rinsing. Source: https://fr.slideshare.net/AbdeldjalilGadra/les-adhsifs.

E & R2

- Acid etching: 30 seconds for enamel 15 s for dentin.
- Rinsing and drying.

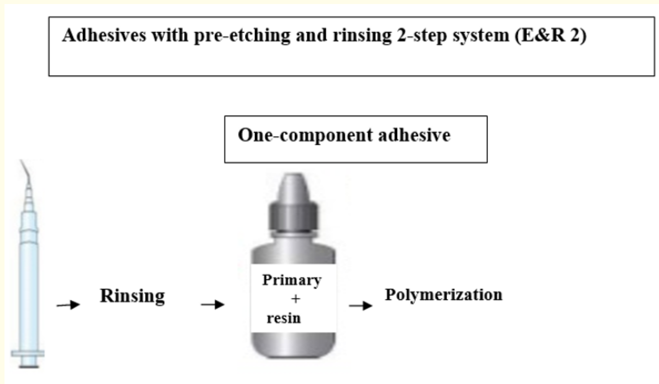

Figure 2: 2-step system (M&R 2). Source: https://fr.slideshare.net/AbdeldjalilGadra/les-adhsifs.

SES

SES2: Adhesives without prior etching:

- Demineralization will be ensured by applying the resin from the first bottle which contains the acid and the primer.
- No rinsing: dentin sludge is infiltrated and is not removed unlike M&R.
- Polymerization.

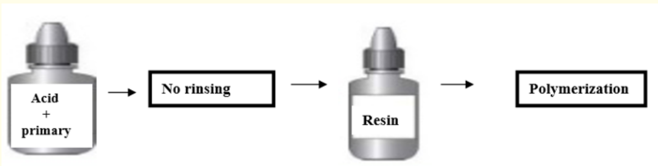

Figure 2: Self-etching systems: SAM2 two-step systems.
Source: https://fr.slideshare.net/AbdeldjalilGadra/les-adhsifs.

SES1

The acid, the primer and the adhesive are packaged in a single bottle which will simplify the clinical protocol Limit the risk of errors at each step.

Self-etching systems [16] should be avoided for several reasons:

- They adhere less to the enamel, which is a major drawback because most of the periphery of our restorations is enamel so this can affect the quality of the dento-prosthetic seal.
- They behave like semi-permeable membranes which can cause them to detach in the medium or long term.

Principles of bonding to dental tissues

Principle of bonding to email

Enamel is the hardest of dental tissue; its elasticity and permeability are practically zero. Enamel is made up of 2.30% water, 96% mineral elements and 1.70% organic elements. It is by mineral elements called prisms of the enamel separated by the interprismatic substance which is mineral and organic. This structure is more visible if the enamel is etched with phosphoric acid.

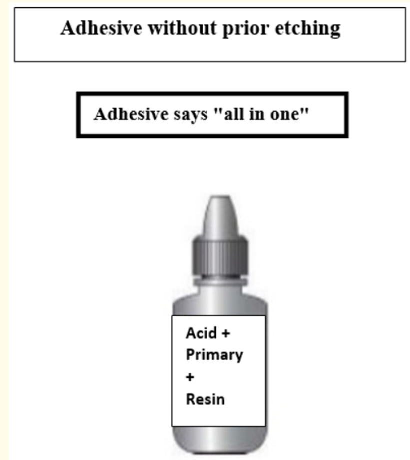

Figure 4: One-step system (SAM1).
Source: https://fr.slideshare.net/AbdeldjalilGadra/les-adhsifs.

Figure 5: Surface of a tooth observed under a scanning electron microscope.
Source: http://webapps.fundp.ac.be/umdb/histohuma/histohuma/index.php?go=img&chap=65&pos=17.

The mode of subscription to the email

Untreated enamel has a very low surface energy and is not suitable for bonding. It is covered with a bio film of polysaccharides coming from the saliva. Enamel milling eliminates the superficial aprismatic enamel which is not very conducive to bonding [8] as well as this biofilm. Etching the enamel with 37% phosphoric acid will increase the surface energy of the enamel and create a microretentive surface to a depth of 10 to 20µ which can be optimally penetrated by the resins hydrophobic di-acrylics.

Principle of dentine bonding

Dentin has a very heterogeneous chemical composition: to the inorganic part of hydroxyapatite (70%) is added a fairly large organic part, consisting of collagen (18%) and water (12%). The irregularly arranged hydroxyapatite contains the organic matrix composed mostly of collagen fibers.

The dentin is traversed by canaliculi or tubuli, which contain the extensions of odontoblasts and pulp fluid that filters from the pulp to the enamel-dentin junction.

The tubuli increase in number and diameter as one approaches the pulp.

This microstructure continuously varies due to physiological and pathological changes.

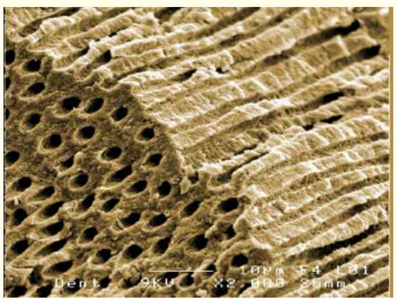

Figure 6: Transverse arrangement of dentinal tubuli.
Source: http://webapps.fundp.ac.be/umdb/histohuma/histohuma/index.php?go=img&chap=65&pos=17.

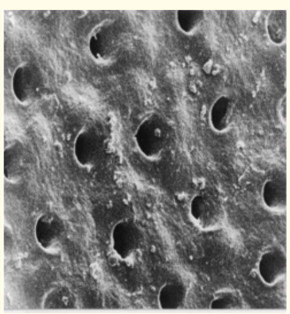

Figure 7: Electron microscopy image of the dentinal tubules constituting dentin.
Source: http://webapps.fundp.ac.be/umdb/histohuma/histohuma/index.php?go=img&chap=65&pos=17.

The mode of adhesion to dentin

Dentin bonding is more complex and more difficult than enamel bonding. Therapeutic approaches have changed the philosophy of treatment:

- The dentin must be etched, which does not injure the pulp;
- Considering the presence of water in the dentin; hydrophilic resins should be used so that they can penetrate the etched dentin surface despite its wet state [9].

During the mechanical preparation of a tooth (milling); a 1 to 5 µm thick dentin sludge is formed, made up of soft elements which plug the dentinal tubules.

Etching dissolves the mineral components of this dentinal mud as well as the hydroxyapatite of the underlying dentin to a depth of a few micrometers [10].

The application of a hydrophilic primer, on the dentinal tubili thus opened will facilitate the diffusion of the adhesive in the collagen network. This infiltration in the collagen will result in the formation of a mixed layer called the "hybrid layer" or resin-dentin inter-diffusion zone [11].

Principle of ceramic bonding

Special feature of ceramic [1,7]

There are two types of ceramic with respect to their reaction to treatment with hydrofluoric acid.

Etchable ceramics

These are ceramics that contain a greater or lesser amount of silicates. This vitreous phase can be etched with hydrofluoric acid, which creates a relief conducive to bonding. This acid must be applied with great caution because of its toxicity and volatility (wearing glove, mask and glasses). It should be rinsed thoroughly and neutralized in a bicarbonate bath.

This type of ceramic being sufficiently translucent, it is possible to use a light-curing adhesive system.

Reinforced non-etchable ceramics

In the case of ceramics reinforced with alumina or zirconia, treatment with hydrofluoric acid is ineffective and does not make it possible to create on the surface of such ceramics a relief suitable for bonding [14]. There is no such thing as a universal protocol.

Sandblasting the underside of the prosthesis with 50 μm alumina simply improves final retention.

An artificial deposition of silica by spraying or by fusion makes it possible to use the properties of silanes.

As these ceramics are more or less opaque, it is important to use an adhesive system that is partially or totally chemopolymerizing, and not just light-curing.

The method of adhesion to the ceramic [10,12]

To bond an etchable ceramic restoration, one should start with a surface treatment: etching followed by silanization.

Etching in this case will allow:

- The creation of micro-retentions.
- The increase in the developed area;
- The increase in surface energy;
- Decrease in surface tension;
- Chemical surface cleaning.
- Dissolution of organic waste.

The acid etching of the ceramic is selective because it acts only on the vitreous phase of the ceramic creating micro retentions, while the sanding which consists of the projection of silica particles will give rise to a rough surface.

An application of 7.5% hydrofluoric acid for 3 minutes is sufficient. Different ceramics bite differently, for example ceramic like alumina bite very poorly.

Alumina or zirconia ceramics that do not contain a silica phase are very resistant and therefore cannot be etched: the acid has no effect on these ceramics: they cannot become rough by etching with hydrofluoric acid. Special treatments are indicated. for these types of ceramics.

The second ceramic treatment is represented by silanization, which optimizes adhesion: the application of a silane increases the wettability of the surface and thus improves the flow and distribution of the assembly material.

The adhesion of a silaned ceramic surface can be up to 7 times greater than that of a non-silaned ceramic treated only with hydrofluoric acid.

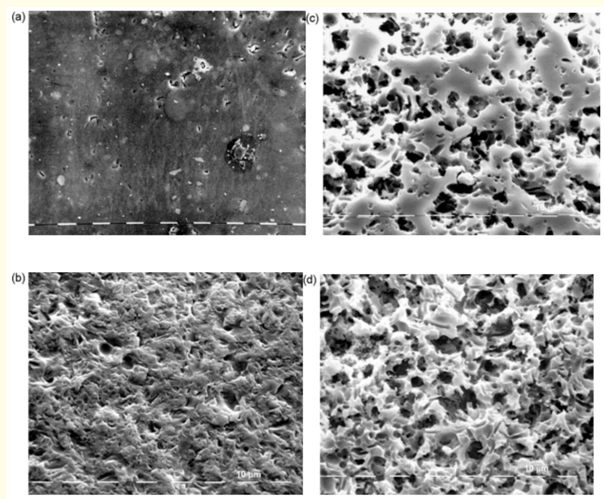

Figure 8: View at M.E.B. of the surface of a ceramic: (a) polished ceramic, (b) sandblasted ceramic, (c) etched ceramic, (d) sandblasted and etched ceramic (Hooshmand; 2002).

Principle of bonding to metal

Bonding to metal alloys was first obtained by mechanical retention:

- First in the form of macroretention (perforated fins of Rochette bridges);
- Then micro-retention by sandblasting with alumina.

Thanks to type 4-META adhesives, the adhesion values obtained on the alloys are of the same order of magnitude as the adhesion to dental tissue. However, bonding to a noble alloy is less effective than to a non-precious alloy.

To increase adhesion, surface treatments have been proposed, which consist in depositing silica on the surface of the metal. This silica is then coupled to the sizing resin by the application of a silane.

Sandblasting of the underside is a necessary preliminary treatment but insufficient for noble alloys. It has the merit of increasing the contact surface with the glue and creating micro-retentions, but it is necessary to add chemical treatments to it to optimize the durability of the glued joint.

Should we seal or glue?

Bonding is essential for all ceramics, for the following reasons:

- Material stability: the fixation of all-ceramic restorations by bonding improves their resistance to fracture.
- Micro-sealing defects.

In vitro studies have shown that there are far fewer micro-leaks with bonding composites than with conventional fixing agents (phosphate-zinc oxide cements).

Which glue should you choose?

Faced with the panoply of bonding materials, the practitioner will have difficulty choosing.

In fact, the choice of the bonding material meets 2 objectives:

- The mechanical and adhesive quality of the bonding polymer and the optical behavior of the enamel-ceramic interface.
- The material that best meets these two objectives is the bonding composite.

Example

To bond a veneer, a bonding composite is recommended.

We have exclusively photopolymerizable bonding composite and dual bonding composite (auto and photo) so which one to choose?

Bonding of ceramic veneers with a thickness of less than 0.5 mm can be achieved using a light-curing bonding composite.

On the other hand, if the thickness of the facet exceeds 0.5 mm, it is necessary to use a dual bonding composite because the polymerization light cannot reach in depth there is a risk of poor bonding and therefore the composite located on the surface will be photopolymerized while the auto reaction will ensure the polymerization of the composite in depth.

For the bonding of a metal-based restoration, the choice will necessarily be a chemopolymerizable or dual adhesive.

As prosthetic restorations are diverse, the choice of adhesive is guided by the following table 1.

	Veneers Cm, Co	Inlay/ Onlay Cm, Co	Cour/ Bridge Cm, Co	Cour/ Bridge Ccm, Me	Inlay/ onlay Me	A.C/ B.C Me
Glues associated with an adhesive system (1)	+++	++	+	-	-	-
Glues containing reactive mo-nomer (2)	+	+	+	++	++	+++
Self-adhesive glue (3)	-	++	++	++	++	-

Table 1: *Indication of the different adhesive families (Azevedo, 2005) [15,16].*

Cm: Ceramic, Co: Composite, Ccm: Ceramic-Metal, Me: Metallic, A.C: Compression Splint, B.C: Compression Bridge.

Conclusion

Thanks to bonding, it is now possible to make dental preparations that are less and less invasive, which has given rise to a “new” dentistry: adhesive dentistry.

However, the success of a bonding assembly closely depends on an understanding of the adhesion mechanisms, knowledge of the different bonding polymers as well as the nature and nature of the prosthetic parts.

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