OVERVIEW

Bonding in Today's Orthodontic Practice

PAUL GANGE

(Editor's Note: In this quarterly column, JCO provides an overview of a clinical topic of interest to orthodontists. Contributions and suggestions for future subjects are welcome.)

Over the past three and a half decades, orthodontists have progressed from attaching brittle plastic brackets with weak, messy, odiferous powder/liquid methyl methacrylate cements[1] to bonding sturdy, esthetic appliances with strong, durable adhesives. In fact, orthodontic bonding has advanced more in the last 10 years than in the previous 25. Wet-field adhesives, enamel-protective sealants, atypical enamel adhesives, and self-etching primers are only a few of the product developments that have made placing appliances more dependable.

Today, orthodontic attachments can be bonded successfully with a number of systems—chemical, photocured, or dual-cure—as long as the inherent variables are controlled. Chemically cured and light-cured systems are used about equally for full fixed appliance placement worldwide, but the light-cured adhesives gain market share every year.

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Chemically Cured Adhesives

The two types of chemically cured systems are "no-mix" and "two-paste mix". The no-mix system has two components: a single liquid primer (catalyst) and a single paste. The primer is applied to the etched, dried enamel and the bracket base. The paste is then applied to the bracket base, and the bracket is placed on the tooth. The primer serves as the catalyst for the paste and is thus the major variable of this system. Even though the adhesive is called "no-mix", the paste and primer are actually mixed directly on the tooth. Therefore, to achieve maximum strength, the bracket base must fit flush against the tooth surface. For a proper mix, it is also important to apply thin coatings of primer and paste to the enamel and bracket base.[2] To summarize the important variables involved in using a no-mix system:

- The bracket base must be flush against the tooth surface.
- A thin coat of primer should be applied to the tooth surface and bracket base.
- A thin layer of paste should be applied to the bracket base.

No-Mix Systems

Rely-a-Bond®*
Right-On®**
System 1®***
Unite™****

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**TP Orthodontics, 100 Center Plaza, La Porte, IN 46350.
***Ormco/"A" Company, 1717 W. Collins Ave., Orange, CA 92867.
****3M Unitek, 2724 S. Peck Road, Monrovia, CA 91016.

The two-paste adhesive, the most popular of the chemically cured systems, requires the mixing and application of two liquid bonding resins to the enamel and the mixing and application of two pastes to the bracket base. As long as the operator thoroughly mixes the two pastes and does not place brackets after the working time has expired, maximum strength can be consistently achieved. Two-paste systems have the fewest variables of any adhesive type, but as with any chemically cured composite, archwires should not be tied in for at least five minutes—preferably 10 minutes—after the placement of the last bracket.

Two-Paste Mix Systems

Concise™****
Phase II®*

Light-Cured Adhesives

Light-cured composites are increasingly popular for bracket placement because they offer the following benefits:

- Extended working time to position brackets and clean up flash.
- Ability to place archwires immediately.
- More efficient utilization of staff.

A light-cured composite is polymerized by a reaction between the catalyst in the adhesive and the photons emitted by the light source. The wavelength of the photons, measured in nanometers, must coincide with that of the catalyst. The intensity of the light source, which determines the length of curing time needed, is measured in mW/cm^2. The higher the light intensity, the faster the cure.

The greatest advances in light-curing technology have been made with curing lights, rather than with the composites themselves. Light sources have evolved from bulky, corded halogen lamps to lightweight, portable light-emitting diode (LED) units.[3] Diodes have a useful life of about 10,000 hours, compared to about 50 hours for a halogen bulb.

The key to quick polymerization and maximum bond strength is to bombard the adhesive with as many photons as possible. All curing lights have a common deficiency, however: they emit photons in a divergent manner. This means the light director must be placed as close as possible to the bracket base or the composite target. Therefore, the major variables that determine bond strength when using a light-cured system are:

- The light source must be of the proper wavelength to cure the specific catalyst within the composite.
- The light director must be placed as close as possible to the bracket base or composite (Fig. 1).
- The light source must maintain sufficient intensity long enough to cure multiple brackets.

LED Curing Units

Bluephase LED®†
L.E.Demetron 1®***
Ortholux LED™****
Tu Tu®‡

From a materials standpoint, recent innovations have included the development of light-activated color-change adhesives, which help identify excess adhesive for removal during the bonding procedure. A new fluorescing adhesive paste (Pad Lock) discloses not only the flash produced at bracket placement, but the adhesive remnants left after debonding and cleanup. Another recently developed adhesive, Pro-Seal, is a fluoride-filled, light-cured sealant with a proprietary catalyst that sets the resin without an oxygen-inhibited layer. Its complete polymerization prevents oral fluid absorption and reduces toothbrush abrasion. Consequently, this sealant can inhibit long-term decalcification, even in patients with poor oral hygiene.

Light-Cured Systems

Blugloo®***
Eagle No Drift®††
Enlight®***
Light Bond®*
Pad Lock®*
Pro-Seal®*
Transbond XT™****

Fig. 1 Light source positioned as close as possible to bracket base for curing.

Dual-Cure Adhesives

Dual-cure systems, which are currently the least popular for placing brackets, involve both chemically cured adhesives and light activators. The main advantage of the two-part system is that the operator has additional working time (as long as four minutes) to place the brackets and remove excess adhesive. The composite can then be hardened immediately by light-curing to prevent bracket movement and protect against contamination. The chemical adhesive will continue to cure after exposure to the light, ensuring complete polymerization.

The major variables involved with a dual-cure system are:

- The operator cannot place or move appliances after the chemical curing time has expired.
- The mixed composite must be light-cured at some point, or additional time must be allowed for the chemical adhesive to set adequately.

Dual-Cure Systems

Phase II Dual Cure®*

†Ivoclar Vivadent, Inc., 175 Pineview Drive, Amherst, NY 14228.
‡G&H Wire Products, Inc., P.O. Box 248, Greenwood, IN 46142.
††American Orthodontics, 1714 Cambridge Ave., Sheboygan, WI 53082.

Surface Conditioning

Bonding success or failure starts with the tooth surface. Proper conditioning of the surface, whether it is enamel, composite, porcelain, or metal, is critical. A surface that is not conditioned properly or that becomes contaminated cannot achieve satisfactory bond strength, regardless of adhesive type.

Enamel is prepared by one of two methods: traditional phosphoric acid etching or a self-etching primer. Both systems require a clean tooth surface, which means a thorough prophylaxis, preferably with a rotary instrument and medium pumice.

The recommended etching time with a conventional 37% phosphoric acid liquid or gel is a minimum of 15 seconds and a maximum of 90 seconds per tooth. Barkmeier and colleagues reported no significant difference in bond strength whether a 37% phosphoric acid was applied for 15 seconds or 60 seconds.[4] Wang and colleagues evaluated several phosphoric acid concentrations, from 2% to 80%, and found the best bond strength was achieved with 30-40% concentrations.[5] A University of Michigan group found 47% higher bond strength in enamel etched for 15 seconds with 37% phosphoric acid, compared to etching for the same time with a 16% concentration.[6] Etching for longer than 90 seconds may be harmful, because overetching causes dissolution of the enamel rods and the formation of insoluble calcium phosphate crystals. Any enamel surfaces etched with phosphoric acid must be thoroughly rinsed (five seconds per tooth with a liquid etchant, 10 seconds per tooth with a gel) and dried before application of the bonding resin.

Self-etching primers have recently gained popularity because they eliminate the rinsing step and subsequent application of the adhesive. Unlike phosphoric acid, which is dabbed onto the enamel, the self-etching primer mixture should be scrubbed onto the surface for five seconds before drying.[7] The dried enamel should appear "resin shiny", not "wet shiny", which could indicate the presence of water—a component of self-etching primers that could weaken the bond if it is not removed. Although self-etching primers are

hydrophilic, meaning they will adhere to slightly wet surfaces, they must still be reapplied if they become contaminated after placement. Clinical applications of self-etching primers include:

- Initial bracket placement.
- Rebonding.
- Bonding of ceramic brackets (to avoid enamel damage during debonding).
- Bonding of short-term acrylic appliances.
- Wet-field bonding with powder/liquid glass ionomer cements.

Self-Etching Primers

First Step®*
Transbond Plus™****

Bonding to Unusual Surfaces

Deciduous teeth and fluorosed or hypocalcified enamel surfaces produce inconsistent results when conditioned in the conventional manner. New hydrophilic universal bonding resins have been successful in achieving acceptable bond strengths with these atypical enamel surfaces.[8] After etching with phosphoric acid, multiple coats of the hydrophilic universal resin are applied, and the last coat is lightly dried. Attachments can then be bonded with any chemical or light-cured system.

Hydrophilic Systems

Assure® Universal Bonding Resin*
Enhance® Adhesion Booster*
Ortho Solo® Universal Bond Enhancer***
Transbond MIP™****

Adult patients pose different problems because of the need to bond to dentin, bleached enamel, composite restorations, and porcelain or metal crowns. Preparation of these surfaces with phosphoric acid or self-etching primers will not produce satisfactory bond strengths. The recommended procedure for bonding to dentin is as follows:

1. Prophy, rinse, etch for 30 seconds with phosphoric acid, rinse, and dry lightly. Leave the dentin moist, not desiccated.
2. Apply four coats of a hydrophilic universal bonding resin, and dry lightly after the last coat.
3. Attach the bracket to the conditioned dentin surface with a chemically cured or light-cured paste.

Patients who have their enamel bleached regularly should not have appliances bonded for at least two weeks after a bleaching application. Lai and colleagues reported that the compromised adhesive qualities of peroxide bleach can be reversed by applying sodium ascorbate to the enamel before bonding.[9] The recommended technique for consistent results in bonding to bleached enamel:

1. Prophy the enamel with a medium pumice, rinse, and dry.
2. Prophy the enamel a second time with a slurry of water and a crushed vitamin C tablet. The vitamin C will neutralize the effects of the residual peroxide on the enamel. Allow the slurry to remain on the surface for one minute, then rinse and dry thoroughly.
3. Etch for 30 seconds with phosphoric acid, rinse, and dry thoroughly.
4. Apply four coats of a hydrophilic universal bonding resin, and dry lightly after the last coat.
5. Attach the bracket as usual to the conditioned enamel.

A composite restoration must be roughened mechanically with a fine diamond bur (Fig. 2) or microetcher, rinsed, and dried. The surface is treated with a plastic conditioner or bonding enhancer, followed by an adhesive or a universal resin that will bond to composite. The surface then is ready for bonding with a conventional paste.

Fig. 2 Composite restoration roughened with fine diamond bur before bonding.

Composite Surface Conditioners

Assure® Universal Bonding Resin*
Enhance® Adhesion Booster*
Ormco Plastic Conditioner***
Reliance Plastic Conditioner*

The best procedure for bonding to porcelain is to break the glaze by roughening the surface. The glass and porcelain are then etched for four minutes with hydrofluoric acid,[10] using a rubber dam or gingival barrier gel to protect the soft tissues. The etchant is rinsed into suction, and the surface is dried thoroughly. A porcelain conditioner (silane) is applied and allowed to dry before the bracket is bonded. Unfortunately, some of the most esthetic veneers are the most difficult to bond, because of their high content of alumina oxide in relation to glass. Adhesion to alumina oxide is impossible; only the glass can be etched and bonded.

Porcelain Etchants and Conditioners

Ormco Porcelain Primer***
Porc-Etch®*
Reliance Porcelain Conditioner*
Ultradent® Porcelain Etch & Silane‡‡

When bonding to a metal surface such as gold, amalgam, or stainless steel, microetching is imperative.[10] A sandblasted metal surface has twice the bond strength of enamel roughened with a medium bur. The mechanically prepared metal is treated chemically with a 4-meta metal primer, a bonding enhancer that bonds to metal, or a universal bonding resin that bonds to metal. The surface can then accept a bracket with a conventional paste. If a light-cured composite is used, it should be cured longer than when bonding to enamel, because metal does not reflect light as effectively.

Metal Primers

Assure® Universal Bonding Resin*
Enhance® Adhesion Booster*
Reliance Metal Primer*

Wet-Field Bonding

At some point, every practitioner will have to bond attachments in a wet field. In situations of extreme wetness, as when bonding lower second molars, a powder/liquid glass ionomer cement is the most hydrophilic material available. Fuji Ortho LC®§ is the most practical powder/liquid cement because it is dual-cured and able to withstand forces applied five minutes after light activation. Applying a phosphoric acid etchant or self-etching primer before the cement will improve its bond strength.[11]

For a smear layer of wetness, as when the cheek touches the buccal surface of the tooth, any of the hydrophilic bonding resins listed above will be dependable. They all require acid etching of the enamel. It is important to remember that if a hydrophilic resin becomes contaminated by saliva after placement, the bond strength will be compromised, and a new layer of hydrophilic resin must be applied.

Occlusal Buildups

One of the most effective ways to create a biteplane effect in deep-overbite patients is to bond composite to the occlusal surfaces of the posterior teeth—usually the first molars (Fig. 3). The adhesive can be gradually reduced in height as the bite opens. Bonding may be difficult if the first

‡‡Ultradent Products, Inc., 505 West 10200 South, South Jordan, UT 84095.
§GC America, Inc., 3737 W. 127th St., Alsip, IL 60803.

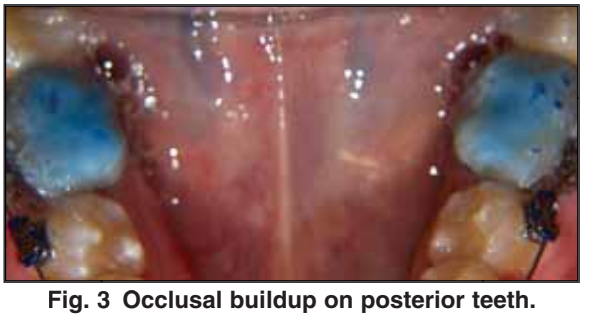

Fig. 3 Occlusal buildup on posterior teeth.

molars have been restored, in which case the second premolars and second molars may be built up. The bonding material should have a wear factor similar to enamel and should contrast in color to the enamel to facilitate removal. These composites can also be used to bond stops or incisal ledges on the lingual surfaces of the maxillary incisors, allowing placement of lower incisor brackets in deep-overbite cases.

Occlusal Buildup Materials

FlowTain® Flowable Light Cure Composite*
Herculite®§§
Ultra Band-Lok® Blue*

Bonding Large Acrylic Appliances

In the early 1980s, McNamara and Howe developed the acrylic-splint Herbst®§§§ appliance as an alternative to the breakage-prone banded Herbst.[12,13] The maxillary portion of the acrylic-splint Herbst appliance can be either bonded or removable, while the mandibular part is always removable. Several other acrylic appliances, including the bonded acrylic-splint expander, have also been designed for orthodontic procedures.

These large acrylic appliances are fabricated from 2.5-3mm splint Biocryl.§§§§ Prior to bonding, the buccal and lingual enamel surfaces and the distal surface of the terminal molar are etched. To facilitate later appliance removal, however, the occlusal surfaces should not be etched. The acrylic is first treated with a plastic conditioner, then bonded with an adhesive that has a thin viscosity and an extended working time. The two types of bonding materials that satisfy these criteria are light-cured resins and two-paste, chemically cured mixes that are specifically formulated for bonding large acrylic appliances. Careful placement of the bonding paste over the buccal, lingual, and occlusal surfaces of the appliance will eliminate any voids that might cause decalcification.

§§Kerr Corporation, 1717 W. Collins Ave., Orange, CA 92867.
§§§Dentaurum, Inc., 10 Pheasant Run, Newtown, PA 18940.
§§§§Great Lakes Orthodontics, Ltd., 200 Cooper Ave., P.O. Box 5111, Tonawanda, NY 14151.

Adhesives for Large Acrylic Appliances

Band-Lok®*
Excel® Regular Set*
OptiBand®***
Transbond LR™****
Ultra Band-Lok®*

Indirect Bonding

Indirect bonding allows fast and accurate placement of an entire arch of brackets at one time, using a tray delivery system.[14] Although virtually every orthodontist has at least experimented with indirect bonding, only about 15% of all brackets are placed indirectly.

In the original indirect technique, known as "clean base", brackets are bonded to the stone working cast with a water-soluble cement, then transferred to the mouth with a chemically cured bonding paste. The main drawback to this method is that excess adhesive is difficult to remove and can later trap plaque.

In the newer "custom base" technique, the working cast is treated with a separating medium before the brackets are bonded with a self-curing, light-cured,[15] or heat-cured composite.[16] A custom pad of hardened composite is thus formed to the anatomy of each tooth, and the brackets are transferred to the mouth with a two-paste, chemically cured bonding resin. This eliminates the problem of peripheral flash, but if the custom pad does not fit flush against the tooth surface, bond strength will be compromised.

Custom-Pad Adhesives for Indirect Bonding

Blugloo®***
Eagle No Drift®††
Enlight®***
Light Bond®*
Therma-Cure®*
Transbond XT™****

Indirect Bonding Resins

Custom I.Q.® Indirect Bonding Sealant*
Maximum Cure® Sealant*
Sondhi Rapid-Set™****

More recently, flowable light-cured composites have been used to transfer custom-pad brackets to the mouth (Fig. 4). The flowable material is a lightly filled (50-60%) paste that can be dispensed precisely from a needle tip to fill any voids between the custom pad and the tooth surface. The paste is cured through a clear tray, which requires a longer curing time because the light source is farther from the composite.

Flowable Light-Cured Composites

FlowTain® Flowable Light Cure Composite*
Flow-It ALC™ Flowable Composite#

Direct bonding can be tedious, time-consuming, and frustrating, but is still the preferred method of attaching orthodontic brackets. Clinicians find it more reliable because there are fewer variables to account for, including proper bracket adaptation to minimize the amount of composite underneath the bracket base. Orthodontic adhesives have low film thickness, and are therefore stronger in thin layers than in thick layers.

#Pentron Clinical Technologies, 53 N. Plains Industrial Road, Wallingford, CT 06492.

Fig. 4 Flowable composite used for custom-pad transfer in indirect bonding.

Conclusion

Either direct or indirect bonding can be successful in achieving maximum bond strength if the correct technique is used. While no adhesive is foolproof, any system will produce the desired results if handled properly.

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