Light Cure Bonding Systems: An Orthodontic Perspective

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Introduction

Orthodontists now are approaching 35 years of successful, reliable orthodontic bonding in offices around the world. The median bond failure rate for practitioners in the United States is presently around 5%. The only teeth that were banded routinely by a majority of orthodontists in a recent survey were the maxillary first molars, and all molars and premolars were banded less routinely than in the past. The prevailing concepts are challenged continuously by new developments and technical improvements.

Light Cure Bonding ...

The desire to cure on demand is driving an increasing number of orthodontic practices to use light-cured adhesives instead of the more traditional paste-paste adhesives requiring in-office mixing. The **light-initiated resins** by now have become the most popular adhesives for a majority of orthodontists. These resins offer the advantage of extended, though not indefinite, working time. This in turn provides the opportunity to place the brackets, with the orthodontist following up with any final positioning.

Fluoride-releasing, visible lightcuring adhesives are also available, but further long-term clinical testing of their bond strength, durability, and caries-preventive effect is necessary.

Types of Adhesives

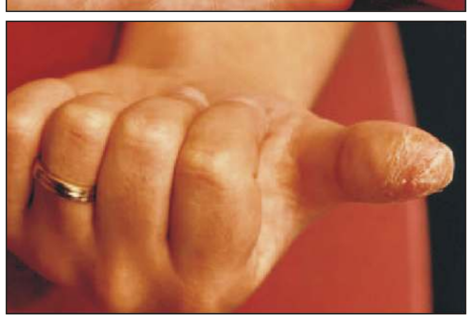
Two basic types of dental resins may be used for orthodontic bracket bonding. Both are polymers and are classified as ***acrylic*** or ***diacrylate*** resins. Both types of adhesive exist in filled or unfilled forms. The **acrylic resins** are based on self-curing acrylics and consist of methylmethacrylate monomer and ultrafine powder. Most **diacrylate resins** are based on the acrylic modified epoxy resin: bis-GMA or Bowen's resin.

A **fundamental difference** is that resins of the first type form **linear polymers** only, whereas those of the second type may be polymerized also by **crosslinking** into a three-dimensional network. This crosslinking contributes to greater strength, lower water absorption, and less polymerization shrinkage.

Several alternatives exist to chemically autopolymerizing paste-paste systems.

No-mix Adhesives

No-mix adhesives (e.g., Rely-a-Bond [Reliance Orthodontics] and System 1+ [Ormco Corporation, Glendora, California]) **set when one paste under light pressure is brought together with a primer fluid on the etched enamel and bracket backing** or when another paste on the tooth is to be bonded. As soon as the bracket is positioned precisely, the orthodontists presses the bracket firmly into place and curing occurs, usually within **30 to 60 seconds**.



In vitro tests have shown that liquid activators of the no-mix systems are definitely toxic; allergic reactions have been reported in patients, dental assistants, and doctors when such adhesives were used.

Light-Polymerized Adhesives

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Newer Systems

Metallic and ceramic brackets precoated with lightcured composite and stored in suitable containers **(Orange Box Bonding System, American Orthodontics)** `are practical in use and are becoming increasingly more popular among clinicians. Such brackets have consistent quality of adhesive, reduced flash, reduced waste, improved cross-infection control, and adequate bond strength.

Recently, some precoated brands (**APC Plus, 3M/Unitek**) are provided with a color change adhesive for easier and more thorough flash cleanup

Light Sources

The orthodontist has the following options for light sources:

1. Ultraviolet Curing System
2. Fast halogen lights
3. Argon lasers
4. Plasma arc lights

5. Light-emitting diodes (LEDs)

1. An Ultraviolet Curing System : Buonocore used originally, the **spectroline®** lamp with which the radiation from a 100 w, high pressure mercury discharge lamp was directed onto the tooth with the aid of a mirror. The **Nuvalite® LD** Caulk Company Milford, Del. As marketed at present is a 50 watt, medium pressure mercury arc lamp. This light is now marketed as **alphalite** (Amalgamated dental company limited, London). Another source of UV radiation in available from Blackray (UVP international incorporation, St. Grabriel, Calif) **BL 100 Unit**.

The UV emission **tends to decrease with use**, whereas the lamps of the visible light systems maintain a fairly constant throughout their life greater thickness, thereby reducing curing problem and reduction hazards from changes in light intensity.

Ultraviolet Light	Visible Light
Poorly transmitted tooth substance	Safety since the spectrum of light is UV radition.
Use perforated brackets or plastic brackets	Shorter curing time than UV/reliable.
Concern over harmful effects	Expensive light system

2. Fast Halogen Lights: In light-initiated bonding resins the curing process begins when a photoinitiator is activated. Most photoinitiator systems use camphoroquinone as the absorber, with the absorption maximum in the blue region of the visible light spectrum at a wavelength of **470 nm**. Until recently, the most common method of delivering blue light has been halogen-based light-curing units (e.g., **Ortholux XT**, 3M/Unitek).

Halogen bulbs produce light when electric energy heats a small tungsten filament to high temperatures. Despite their common use, halogen bulbs have several disadvantages. The light power output is less than 1% of the consumed electric power, and halogen bulbs have a limited **lifetime of about 100 hours** because of degradation of the components of the bulb by the high heat generated.

Limitations of filter technique and thermal problems make further improvements of conventional curing lights difficult.

Optilux™501

A visible light curing unit designed to polymerize adhesives and composite materials. Unit has a variety of features not found in previous models, which include an LCD 4-digit radiometer display, Ramp, Boost and Bleach mode and Count-up display timer in all modes both direct and indirect bonding and for rebonding loose brackets.

3. Argon Lasers: In the late 1980s, argon lasers promised to reduce the curing times dramatically. Argon lasers produce a highly concentrated beam of light centered around the **480-nm wavelength**. Recent studies have shown that argon laser irradiation significantly reduces enamel demineralization around orthodontic brackets.

Although the curing times could be reduced to **5 seconds** for unfilled and 10 seconds for filled resins with argon laser, their use in orthodontics at present is not extensive, probably because of their high cost and poor portability.

4. Plasma Arc Lights: In the mid-1990s, the **xenon** plasma arc lamp was introduced for high-intensity curing of composite materials in restorative dentistry. This lamp has a **tungsten anode** and a cathode in a quartz tube filled with xenon gas.

PowerPac plasma arc unit.

Plasma arc lights are ***contained in base units rather than in guns*** because of the high voltage used and heat generated. The light guide is stiff because of the gel inside. The white light is filtered to blue wavelengths, with a narrow **spectrum between 430 and 490 nm**.

Recent clinical studies indicate that **exposure times of 3 to 5 seconds** for metal brackets and even shorter times for ceramic brackets yield similar bond failure rates as for brackets cured with a conventional halogen light for 20 seconds.

Therefore plasma arc lights significantly reduce the curing time of orthodontic brackets without affecting the bond failure rate.

The heat generated by the high-intensity lights and the possibility of harming the pulp tissue have been addressed in several publications. In primates, ***Zach and Cohen*** reported permanent pulp damage when the pulpal temperature rose above 42.5° C.

5. Light-emitting diodes (LEDs): The most recent light source category is the LED sources . In ***1995 Mills et al.*** proposed solid-state LED technology for polymerization of light-initiated resins to overcome the shortcomings of conventional halogen lights. Light-emitting diodes **use junctions of doped semiconductors to generate the light**. They have a lifetime of more than 10,000 hours and undergo little degradation of output over this time.

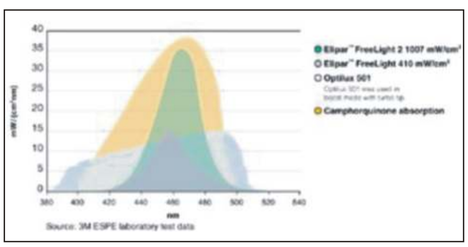
Light-emitting diodes require no filters to produce blue light, resist shock and vibration, and take little power to operate. New-generation LEDs with higher-intensity diodes may shorten the curing

times further (e.g., the new Ortholux LED by 3M/Unitek has recommended **curing times of 10 seconds for metal and 5 seconds for ceramic** brackets), but further studies and clinical trials should be performed before validation

Ortholux LED.

Light Source Emission Distribution

Prior to the introduction of LED technology, not much was mentioned about the physical characteristics of the curing light with regard to the emission distribution. **Emission distribution is the pattern of light that the curing instrument exhibits.**



Emission Spectrum and Camphorquinone* Compatibility. (Source: 3M ESPE laboratory test data) *Camphorquinone, or CPQ, is a photoinitiator that is used in approximately 90 percent of all dental materials.

Infection Control For Curing Lights

With the increasing popularity of light-cured adhesives, the curing light has become a standard item in many orthodontic offices. Several types of barrier covers have been introduced to prevent contact of the fiberoptic lightcuring tip with bodily fluids during bonding procedures. Such covers may attenuate the light transmission at the tip and thus affect polymerization of the adhesive.

Four types of curing-tip covers

1. The **Cure Sleeve** Model 4500 light-tip cover,* a prepackaged translucent sleeve made of ethylene methacrylate copolymer.

Pinnacle Cure Sleeve Model 4500 light tip cover. B. Note seam in sleeve where copolymer material is joined together.

2. A **translucent latex finger** cot** that is rolled over the curing tip .

3. **Curelastic Cure Light B**arrier,*** a translucent non-latex alternative to the finger cot

4. A 6"×5" sheet of polyvinyl chloride (PVC) Perforated 920 **Cling Film**, tightly wrapped around the curing tip.

Reynolds Perforated 920 Cling Film is supplied in roll of 6" ×5" perforated sheets of polyvinyl chloride (PVC).

The seam of the Cure Sleeve and the

bubbles at the end of both the latex and non-latex barriers may prevent the curing tip from being held as close as possible to the adhesive. Any of these three covers can also slip down the curing tip during use. A3/16" latex or vinyl orthodontic elastic can be used to keep the cover tightly secured to the tip . The PVC film, with no latex or powder, is the least expensive of the four barriers tested, at a cost of less than a half-cent per sheet . It can also be used as a barrier for the handle and trigger of the light-curing unit.

Conclusion

In conclusion regarding the use of different light sources and light-initiated adhesives, the studies provided the following results:

- The light source and adhesive must be compatible.
- All new light sources cure resins faster than conventional halogen lights.
- Fast halogen sources are more brand specific but generate low heat and are less expensive than plasma lights and LEDs.
- Plasma arc lights offer the shortest curing times but are expensive and generate heat.
- Light-emitting diodes have small size, are cordless, are quiet, generate minimal heat, and perform favorably compared with conventional and fast halogen sources.