Understanding Light Curing, Part 2: Delivering Predictable And Successful Restorations

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Delivering Predictable, Successful Restorations

For anterior restorations, composite resins (and to a much lesser degree, glass ionomers) are the primary res - torative materials because of their aesthetics.
Further, when restoring posterior teeth, there has been a shift to using tooth-colored adhesive restorations. While tooth restoration using these materials is a multifactorial procedure needing attention to diagnosis, tooth preparation, and placement techniques, the clinical success of light-cured resin composite restorations hinges on optimally polymerizing the adhesive and composite resin.

Part 1 of this 2-part article discussed the importance of adequate photopolymerization, as well as the characteristics of the curing light, which are the first of the 4 sets of light-curing variables referred to as a CORE checklist (CORE is an acronym for Curing light characteristics, Operator technique, Restora tion characteristics, and Energy requirement of the composite). Part 2 discusses the remaining 3 CORE variables and other important factors for successful light curing.

REMAINING THREE CORE VARIABLES Operator Technique Reducing Variability in Light Delivery

The ability to light cure composite resins based on the position and orientation of the curing light is an important aspect of radiant energy delivery to the restoration.1,2 While many preparations provide ex - cellent clinical access for curing lights, there are hard-to-reach areas of the oral cavity.In some cases, the curing light tip itself is a limiting factor in how close the light can get to the surfaces being light cured and whether or not it has the correct orientation.Dentists and dental assistants are not well trained in the art and science of light curing.2 In most cases, the only reference to light curing is the duration of curing, eg, “light cure for x amount of seconds.” The orientation of the light tip, diameter of the light tip, and type of light are rarely noted.1,3,4 Poor orientation of the light tip will lead to dental resins being inadequately light cured.5 Inadequate resin polymerization has been implicated in adverse effects on the resin’s physical properties,6-9 reduction in adhesion to the tooth, 10,11 a negative impact on the biocompatibility of the resin restoration,12-14 an increase in marginal deterioration and wear,15 and an increase in bacterial colonization at the margins of the restoration. 16

Even when using the same brand and model of curing light, in the same mode and for the same time, different curing light operators get very different results. This has been well demonstrated in studies completed using BlueLight Analytics’s MARC Pa - tient Simulator, a unique curing light operator training device now being used in dental schools throughout Europe and North America. 2,5,17,18MARC contains a laboratory- grade spectroradiometer and is a clinically relevant, light-curing energy measurement tool. The sensors to measure the light energy delivered are embedded in teeth in a typodont head and provide immediate results from data collected by a chairside computer. This innovative device provides clinically relevant measurement of the amount and type of light-curing energy delivered to simulated restorations. It al - lows immediate feedback so that one can train with the device to improve one’s lightcuring skills. In an evaluation of 35 dentists, even though the dentists being tested knew they were being evaluated using the MARC, there was a tenfold variation in energy delivery among operators (Figure 1).3

There has been concern based upon research evidence that high-intensity blue light from curing lights can place dental personnel at risk for ocular damage.2 As dental professionals, we must be vigilant and use proper protection from the blue light hazard. The most damaging wavelength range for the retina is blue light, near 440 nm, which is the peak wavelength from many LED curing lights.

19 Blue light is transmitted through the ocular media and absorbed by the retina. While high levels of blue light cause immediate and irreversible retinal burning, chronic exposure to low levels of blue light may cause accelerated retinal aging and degeneration. This chronic photochemical injury to the retinal- pigmented epithelium and choroid can Accelerate age-related macular degeneration. 20,21Most countries follow in - ternational guidelines, such as those from the International Com mission on Non-Ionizing Radiation Protec - tion and the Ameri can Conference of Governmental Industrial Hygien ists (ACGIH) to limit optical exposure to dangerous amounts of light.19,20 A recent study found that these ACGIH limits19 may be easily reached during a normal workday by dental personnel using high-power curing lights.22 If the operator does not wear orange protective glasses and looks at the light for just the first second of the curing cycle before averting the eyes, it would take as little as 7 curing cycles to exceed the maximum daily cumulative exposure to the PAC light used in this study.22 It should also be noted that the maximum recommended exposure times are for individuals with normal photosensitivity; pa - tients or dental personnel who have had cataract surgery or are taking photosensitizing medications have a greater susceptibility for retinal damage, and ocular injury may occur with even shorter exposure times.19 Most manufacturers of dental curing lights also supply protective eyewear, but these items are not universally used.23 Anyone who uses a curing light should be aware of the ocular risk and should wear protective eyeglasses that have been de signed to filter out the harmful wavelengths from the lightcuring unit (LCU).3,23

From the research, there are clear recommendations that in order to maximize energy delivered when placing restorations, the operator should wear orange blue-light-blocking glasses or use orange shields for eye protection, watch what he or she is doing, stabilize the light during curing, and hold the light both close and perpendicular to the restoration (Figures 2 to 7).3-5 Placement of the light source at a less-than-perpendicular angle to the cavity preparation can lead to incomplete photopolymerization (Figure 8).

Restoration Characteristics

Restoration characteristics refers to location, size, and depth of the cavity relative to the position of the light tip. These restoration characteristics also include anatomic considerations and limitations that can present themselves as the operator is positioning the light tip to cure a restorative material. 2-5

. The patient’s mouth opening can limit positioning of the light guide for light curing. For some light guides, the size of the head of the LCU or the angle of a fiber-optic tip can limit access to light cure a restorative material. Also, tooth position in an arch or the surface being restored can be a limiting factor. It may be impossible to position the light guide at right angles and as close as possible to the tooth surface.Increased curing times may then be necessary. Access limitations can result in the light tip being angled, resulting in light reflection, refraction, and shadowing issues.

. Many light guides for LED curing lights have a small tip diameter of 9 mm or smaller. It may be necessary to cure each portion of a restoration, overlapping surfaces to ensure complete photopolymerization.

. curing time needs to be increased. This increase in curing time translates into additional heat generation. The tooth, soft tissues, and pulp should be air-cooled during polymerization.

.Increase curing time for Class II restorations in proximal boxes, as well as for any deeper-than-routine restoration. Matrix bands and rings can move the light guide an additional 2 to 6 mm farther away from the cavosurface margins of a tooth. Cusp height can often keep the light guide at least one mm away from a cavosurface Margin of the occlusal aspect of a posterior restoration. Again, as curing time in creases, cool the tooth during light curing.

Energy Requirements of the Composite for Complete Photopolymerization

Every brand of composite and every shade of that brand has different energy requirements to polymerize the material.1,24 However, most manufacturers do not specify the energy required to cure their resin. In recent years, some resin manufacturers have changed or added photoinitiators to their composites so that a combination of both blue and violet light is needed to light cure. Some curing lights have both blue and violet LEDs to compensate for these changes. There is not enough known at this time about the clinical implications of these changes to make any recommendations for different curing lights and irradiance values.

With the current generation of composites, we know that increasing curing time can assure adequate polymerization.There are some guidelines that can be helpful in selecting curing times. More opaque shades and darker shades of composite re - quire increased curing times.1,3,4 Flowable composites often require increased curing times. Micro filled composites may require increased Curing times. 25,26 Check the complete manufacturer's instructions for any recommendations for light-curing times.

CURING LIGHT MONITORING AND MAINTENANCE TO ENSURE OPTIMAL LIGHT CURING

For optimal operation of a curing light, it is important that there is a routine evaluation of the curing light's status. When a curing light is activated, it is impossible for the clinician to evaluate the quantity and quality of the light being discharged to polymerize a restoration. The brightness of the light can provide a false sense of security that the light is adequately polymerizing the restorative material. A number of studies have demonstrated that irradiance delivered by many curing lights used in private practices is often inadequate and the lights are not providing maximal photopolymerization of the composite restoration.27-31 As the curing light gets older, there can be a decrease in the light output due to degradation of the QTH bulb,32 autoclaving the fiber-optic light probe,33 breakage and fracture of the light tip,34 and the presence of cured composite resin or debris on the exposed light tip (Figure 9).34,35

How can a practitioner monitor the energy delivered by a curing light? The irradiance and energy out-Put of a light-curing device can be checked using a dental radiometer that can be either incorporated into the LCU, or as a separate unit. A radiometer measures the light output of a curing light through a small fixed window on the unit.36,37 While a relatively inexpensive portable radi ometer or a built-in radi ometer do not provide the accuracy of a laboratory- grade power meter, they do provide useful data that al lows the clinician to monitor any changes in the light-energy output of the curing light by keeping a log of light output measured with his or her in-office radiometer.37,38 When comparing results using a radiometer, it is important that the same light-tip diameter be used.For the same light, the smaller the diameter of light tip, the higher the irradiance re corded.37 Also, use a ra diometer calibrated for the light source Being evaluated. A de - crease in output of a curing light can be compensated for by increasing the curing time. Further more, longer light-curing times are necessary for very light shades of composite resin (bleaching shades), very dark shades of composite resin, flowable composite resin, and microfill composite resins.25,26,39

Within a dental practice, approximately 1,000 composite restorations are placed yearly. The ability of the LCU to cure these composites is critical. To ad - dress the deficiencies in handheld, in-office dental radiometers, a laboratory grade spectroradiometer, CheckMARC (Blue Light Analytics) (Fig ure 10) that accurately measures curing light output, has been developed. Using Check - MARC—a specialized service providing practitioners with a quick, accurate, and documented verification of the light output of the curing lights within a dental office—a report is generated that not only provides an accurate measurement of the irradiance output of the LCU, but also provides the information on the factory specifications of the light from the manufacturer that can be cross referenced to these measurements and future reports. The report provided to the dental office is specific to each curing light in the dental office. Any changes in the light's output will be seen, and corrective action can be taken. During a recent field test of the CheckMARC device, 211 LCUs in 79 dental offices were evaluated; 80 of the lights tested either did not meet the manufacturer's specifications or the curing light had no specifications to be compared to due to the age of the light. Several of the curing lights delivered irradiance values that were only 10% of the manufacturer's stated specifications. In addition, 87 curing lights were contaminated with cured composite on the tips of the light, 43 lights had damage to the tip that affected the amount of energy being delivered to the restoration, and 29 of the lights had damage to the LCU itself which has the potential to affect light output.

In light of the evidence that dentists in private practices around the world are unaware that they are using LCUs that are delivering an inadequate amount of radiant exposure or the wrong wavelengths of light to completely cure their resinbased composite restorations, it has been suggested that regulatory bodies should consider the need for mandatory testing of light-curing devices in private dental offices, similar to regulations enforced for x-ray units.3,20

MANAGING INFECTION CONTROL

It is recommended to use infection control barriers for curing lights and light guides. Unfortunately, the preformed barriers that slip over a light guide are not standardized to optimize light transmission. Research has shown that some barriers can reduce irradiance from a curing light up to 40%.40,41 Food wrap has been shown to be a highly effective and inexpensive infection control barrier that has minimal effect on light delivery.40 When using cold sterilizing techniques to clean a curing light, approved cleaning solutions should be used. The light guide should be re - moved from time to time and the lens or filter inside the curing light housing checked to ensure it is clean, as are both ends of the light guide. Some - times the sterilization fluids can erode o-rings used to stabilize the light guide, and the residual fluid can cook onto the lens inside the housing.

CONCLUSION

Do not take light curing for granted.There are many factors that affect optimal photopolymerization of the res - torative materials being used. Den tists can follow 7 steps to ensure better light curing.4,5 These steps are as follows:

1. Position the patient to provide the best access to the restoration with the LCU.

2. Wear blue-blocking orange glasses to allow the clinician to watch what he or she is doing when light curing.

3. Position the operator so that one can see what one is doing and optimally position the light tip.

4. Adjust the light guide to provide the optimal straight-line access to the restoration; the light-guide diameter must cover the surface be - ing light cured (for smaller tips, it may be necessary to overlap the curing area and cure the restoration in multiple sites).

5. Stabilize the LCU during curing with the light tip at right angles to the preparation.

6. To prevent uncured resin from adhering to the LCU, start curing at a distance of one mm from the preparation and then move as close as possible after the first second of curing.

7. Air-cool the tooth during the curing cycle to avoid any undesired consequences due to overheating the oral tissues.

Following these guidelines will help ensure maximal photopolymerization of the restorations that you are delivering for your patients.

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