Exposure Times for Contemporary Composites

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Adequate photocuring of composite resin materials requires a sufficient delivery of visible light energy, defined as the mathematical product of the curing light irradiance (mW/cm^2) multiplied by the exposure duration (seconds). Traditionally, quartz-tungsten-halogen (QTH) units with relatively moderate irradiance values were used to activate composite. Most composites required a 40-second exposure to adequately polymerize a typical 2-mm increment.

With those curing devices, composite materials were previously classified as easy, difficult, or traditional cure. However, like many other things in life, much has changed since those "good old days." Currently, decisions about appropriate exposure times have become much more difficult. Differences among light types, exposure modes, and composite compositions make such a classification, and any related standard recommendations for exposure times, impossible to provide.

Confounding factors in the correlation between exposure duration and light-curing unit (LCU) type now include a multitude of issues. Many contemporary restorative materials contain only the conventional photoinitiator camphorquinone (CQ), which works very well with blue light. However, there are significant drawbacks to that initiator, as it leaves a yellowish tinge in restorations, and is also very inefficient, requiring more energy (longer exposures) to adequately polymerize resin-based materials. However, CQ will function quite adequately with a light emitting diode (LED) LCU emitting blue-only light.

In addition, manufacturers have incorporated a variety of other photoinitiators into light-activated restorative materials to minimize the yellowing effect and inefficiency of CQ. These "alternative" initiators do not leave a yellow tinge and are much more efficient than CQ, but require light of a much shorter wavelength (in the violet range). These compounds are added in various amounts to materials when high value or translucency is required. Their downside is that violet light will not penetrate deeply into restorative materials, and thus CQ must always be present. To activate a product containing both of these photoinitiators, the LCU must be capable of emitting in both the violet and blue regions. Thus, an LCU that generates photons continuously between 400 nm (violet) and 500 nm (just past the blue region), such as the QTH or plasma arc lights, will work well. However, both of these LCU types are currently being replaced by much more efficient and less expensive battery-powered LED lights. To be capable of activating the alternative initiators, LED lights must provide a violet output as well as the conventional blue one, and units that do this are termed the "poly-wave" LEDs (or third-generation LED lights).

Recent literature indicates that use of LCUs with very high irradiance values may actually require *longer* exposures to adequately cure composite than those suggested by the manufacturers. It had been thought that all restorative materials obeyed the "energy reciprocity law," meaning that, as long as a material received the same amount of total irradiant energy (the mathematical product of exposure duration and irradiance), then the extent of cure and the resulting

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physical properties of the material would be similar. However, recent research is finding that such a relationship does not universally apply to dental materials. Without some sort of personal, custom testing, it is impossible to predict how any given composite or shade of material will react to a particular curing unit.

To further complicate matters, not every shade within a given brand of composite will predictably contain the same photoinitiators. Thus, for some shades of the same commercial product, a poly-wave LED will work much better at polymerizing the top, exposed surface of a composite than a blue-only LED will. However, on other shades of the same brand, just the opposite may be true! With the myriad of possible combinations of contemporary LCUs and restorative materials, it is obvious that no one specific light can be universally applied to all restorative materials for a given time and predictably render optimal polymerization results, and vice versa. In addition, LCU curing mode, spectral emission profile, and irradiance level must be taken into account when "matching" possible performance with any given photoactivated restorative material. Thus, it is no longer possible to provide clinicians with an easy, chairside table to correlate LCU and composite with recommended exposures to provide optimal polymerization. Even manufacturer's recommended exposure durations are only a gross approximation of what is truly needed. Instead, a simple scrape test can be used to determine customized curing times for any combination of light source and composite material.

To accomplish this test, the plunger is removed from a composite compule, and the curved compule spout is sectioned from the main cylindrical compule body. This process leaves the bolus of uncured composite paste retained within the plastic cylinder. A Mylar strip is placed on a countertop, and the end of the compule previously retaining the plunger is placed on top of that strip. The flat end of a dental hand instrument is used to compact the composite paste against the Mylar. The composite is light-activated from the Mylar end of the compule. Various exposure times can be used. Tip-to-target distance is easily controlled by removing the Mylar strip and wrapping Scotch tape around the compule end that is held away from the cylinder by known, clinically relevant distances—say 2, 4, 6, 8, or 10 mm. Following light-activation, the compule is placed into a gun-type dispenser, and the composite contents are ejected. A plastic spatula is used with manual pressure to remove the residual, uncured composite paste. Thickness of the remaining, hard composite specimen is measured with a digital micrometer. The scraped thickness is then plotted against the exposure duration at a fixed tip-to-target distance, or a fixed exposure duration scarping depth can be plotted as a function of tip distance. In this manner, the clinician can easily make customized exposure guides to use chairside in determining how to adjust exposure duration to compensate for loss of irradiance due to composite shade or changes in tip distance. This table is of particular use when a clinician is using an LCU from one provider and a composite material from another vendor, and neither manufacturer will provide accurate guidelines on how to use its competitor's product. This simple scraping test has been proven to be an accurate indicator of composite biaxial flexural strength and thus an indirect measure of its degree of conversion.

It boils down to this—contemporary clinicians *must* know the characteristics of their lights as well as those of all their restorative materials. They have everything readily available in their offices to fabricate custom exposure guides that will accurately indicate how long a specific composite must be exposed with a given LCU at a certain tip distance to optimize restoration curing. Without such a guide, the clinician is just guessing at these parameters, and is increasing the risk of future restoration failure.

SUGGESTED READING

Caughman WF, Rueggeberg FA. Shedding new light on composite polymerization. Oper Dent 2002;27:636–8.

Hadis M, Leprince JG, Shorthall AC, et al. High irradiance curing and anomalies of exposure reciprocity law in resin-based materials. J Dent 2011;39:549–57.

 DOI 10.1111/jerd.12017

Pelissier B, Jacquot B, Palin WM, Shortall AC. Three generations of LED lights and clinical implications for optimizing their use. 1: From past to present. Dent Update 2011;38:660–2, 664–6, 668–70.

Peutzfeldt A, Asmussen E. Resin composite properties and energy density of light cure. J Dent Res 2005;84:659–62.

Price RBT. Fast Light Curing: Is It Advisable? Available at: http://www.jcda.ca/article/jcda_express_issue_2_2012#sts=Fast light curing: is it advisable? (accessed February 21, 2013).

Price RBT, Felix CA. Effect of delivering light in specific narrow bandwidths from 394-515 nm on the micro-hardness of resin composites. Dent Mater 2009;25:899–908.

Rueggeberg FA, Cole MA, Looney SW, et al. Comparison of manufacturer-recommended exposure durations with those determined using biaxial flexure strength and scraped composite thickness among a variety of light-curing units. J Esthet Restor Dent 2009;21:43–61.

Zhu S, Platt J. Curing efficiency of three different curing modes at different distances for four composites. Oper Dent 2011;36:362–71.

Contemporary Issues
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