

Light Curing Matters

Advances in dental restorative materials and light-curing adhesive technology have changed the way dentists use light to cure their resin-based restorations. However, despite these advances, many resin-based restorations fail prematurely,^{14,19} potentially resulting in more tooth decay, larger restorations, endodontic treatment, or other costly procedures. Indeed it has been recently reported that, in one North American dental school, Class II resin composite restorations were ten times more likely to be replaced at no cost to the patient than Class II dental amalgam restorations.¹⁵ The most common reasons for the failure and replacement of posterior resin restorations are bulk fracture and secondary caries caused by microleakage between the tooth and restoration.⁸ These failures may be attributed to inadequate light curing of the resin.

Microleakage suggests that there is failure of the adhesive bond between the tooth and the restoration. Many bonding systems and restorative resins show excellent *in vitro* results. However, in general, resin systems are tested in the laboratory under optimal light-curing conditions that often do not reflect what happens clinically. For example, most bonding and depth of cure studies are conducted with the curing light directly against the resin. This does not correspond to clinical reality, where the light tip is often at least 7 mm away from the margin at the floor of the proximal box in Class II restorations.¹⁶ This region is where secondary caries most often occurs.¹³ Restoration failures in this region may be due to inadequate polymerization of the resin; it has been well reported that even a small distance between the light tip and resin may adversely affect the light irradiance available to photo-activate the resin,¹ thus reducing the subsequent bond strength between the tooth and the restoration.²¹

Most research studies use curing lights that have been verified in the laboratory to meet the manufacturers' specifications. However, the curing lights used in many dental offices worldwide have been shown to perform well below acceptable levels and may not be able to deliver sufficient light to cure all of the resin.^{2,3,9,10} Another important clinical variable is the operator's ability to effectively use the curing light.¹⁷ Even when the same properly functioning

curing light was used on the same tooth for the same exposure time, there was a large variation (2.6—11.7 J/cm²) in the energy density delivered by twenty dental professionals to simulated restorations in a dental mannequin.¹⁷ The majority (82%) of these operators delivered less than 10 J/cm². This is an inadequate energy density to cure most resin composites, and, consequently, it will adversely affect the physical properties of the resin restoration.^{5,11} These findings may help to explain why the median longevity of direct posterior resin restorations placed in dental offices has been reported to be as low as only 6 years.^{14,19}

Additionally, *in vitro* bond strength tests and the ISO 4049 depth of cure test assume that the light-beam profile from the curing light is uniform and that all areas of the specimen will receive the same irradiance. This does not always occur.^{18,20} Depending on where the irradiance is measured across the face of the light tip, the irradiance can range from very high (> 10,000 mW/cm²) in some places to low in others (< 300 mW/cm²). The problem of inhomogeneity within the light beam has been compounded by the introduction of polywave LED curing lights that not only deliver an inhomogeneous irradiance output, but also deliver different wavelengths of light at different locations across the face of the light tip.¹⁸

Finally, powerful light-emitting diodes (LED) have replaced quartz-tungsten halogen lights as the popular choice for clinical practice—some new lights claim curing times of less than 3 s and deliver an average irradiance (> 6000 mW/cm²). This is at least 20x greater than the irradiance from most lights that were on the market 15 years ago. However, many bonding systems and resin composites have yet to be tested using these very powerful curing lights. This is of concern, because rapid light curing of dental resin may increase the polymerization contraction stress and decrease the resulting bond strength.^{6,7} Current information indicates that any benefit from using different light exposure modes is highly dependent on the specific restorative material used, the curing light, and the clinical situation.^{4,12}

Recently, experts in dental restorative materials from North America and Europe met to discuss these issues

and their impact on the worldwide problem of poor patient outcomes involving light-cured resin-based restorations. At the "Symposium on Light Sources in Dentistry", funded by the Canadian Institutes of Health Research, held at Dalhousie University on October 10–12, 2012, the participants formulated an action plan to improve patient outcomes. The plan calls for the development of guidelines for effective light curing, increased awareness of issues associated with dental resin photopolymerization, instructions for dental professionals in the safe and effective use of a curing light, and the development of restorative materials that are less technique sensitive than currently available resin composites.

Sincerely yours,



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