The Physics of Light Curing and its Clinical Implications
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Dentists have many choices in devices for light curing dental restorative materials. Not all light-curing devices are equivalent in their features, such as power density, energy delivered to the tooth and the restorative being placed, timing, availability of accessories, configuration of curing probes/tips, and energy source to power the device, among others. Also, recent research demonstrates that orientation and diameter of the light probe tip can have a significant impact on the ability of the unit to produce better physical properties and improved adhesion to tooth substrates. Although practitioners are looking for time savings when light curing, shorter time increments for light curing when placing restorations may not be the best choice.

GENERATION OF CHANGES

Light-curing resin composites were introduced to restorative dentistry in 1969. The earliest light-cured materials were photopolymerized with ultraviolet light-polymerizing devices. This use of light curing ushered in an era of command set. When the light irritated the restorative material, it initiated the setting-photo-polymerization reaction of composite resins. The use of light curing paralleled the introduction of adhesive bonding of composites to enamel. These early curing lights had limited depth of cure due to the shorter wavelengths (10 nm to 380 nm) of UV radiation energy. In the mid-to-late 1970s, UV light-curing devices were phased out and replaced with visible light-curing devices using quartz-halogen bulbs (QTH) to light cure restorative materials that used photosensitive chemistries in the 460 nm to 480 nm wavelength, typically camphorquinone (CQ) for polymerization of composites. The longer wavelengths of this visible light spectrum allowed for a more penetrating curing light and light energy. This increased energy of photopolymerization introduced an era of improved physical properties with resin-based composites that were set by exposure to relatively safe, high-intensity light sources.

In the 1990s, there were significant improvements in light-curing devices. QTH devices had improvements that increased the energy to at least 6,000 mW/cm², and in some cases using specialized turbo tips, more than 1,300 mW/cm². At the same time, high-intensity light sources (a fluorescent bulb containing plasma) for resin-based composite curing and plasma-arc curing (PAC) with an irradiance range of 400 nm to 500 nm were introduced. A comparison of QTH- and PAC-cured composite resins demonstrated variation based on the composites and individual lights for different physical properties, but no one light type performed better than another.

A significant change in how resin-based composites were light cured occurred in the late 1990s, with the introduction of light-emitting diodes (LED) that provided light in the blue-visible spectrum with a range of 450 nm to 490 nm. Currently, the latest generation of LED curing devices provide consistent energy outputs of greater than 1,000 mW/cm². The benefits of the latest generation of LED curing lights can include: higher, consistent light-energy output through emitter life; lightweight cordless features with rechargeable batteries; heat sink or quieter cooling fan; broader light spectrum with multiple LEDs for photopolymerization of resin-based composites with both CQ and other photoinitiators; and more useful light transmitted in ranges because of wavelength-specific emitters.

PHYSICS OF LIGHT CURING

LED curing lights have been a positive development for photopolymerization of composites. Considerations to light cure composites must include: knowing the disaggregated irradiance–light spectrum values of the curing light; the light spectrum of the LED(s); and how the distance, angulation, diameter, and use of barriers of the light guide tip impact on polymerization of the restorative. Most adhesives and composites are cured in the spectrum of 450 nm to 480 nm, but some have photoinitiators below 420 nm; clinicians should ask the manufacturer about which photoinitiator(s) are being used. It would be useful to know the disaggregated irradiance values (knowing the specific wavelengths in the ranges of 380 nm to 540 nm). Understanding that irradiance multiplied by the duration of light curing equals total energy in joules/cm² that a composite would need for curing provides information on what additional light-curing energy (increased times for curing) is necessary for very light shades (bleaching shades), very dark shades.
of composite resin, flowable composite resin, and microfill composite resins.\textsuperscript{13,14}

Light guide tip placement, stabilization, and orientation are very important when light curing restorative materials. While many preparations provide for excellent clinical access for curing lights, hard-to-reach areas of the oral cavity can compromise the energy delivered.\textsuperscript{15,16} To facilitate optimal light curing of restorations, a unique and innovative device, MARC\textsuperscript{TM} (Managing Accurate Resin Curing), was developed by Dr. Richard Price at Dalhousie University in Halifax, Canada. MARC is a laboratory-grade, clinically relevant, light-curing energy measurement tool. The sensors to measure the light energy delivered are embedded in a typodont head and jaws with immediate results, and data is collected following the guidelines presented will ensure maximum photopolymerization of the restorations being placed.

2 mm to 3 mm in depth (especially the proximal box of Class II preparations) increase curing time.

10. Air cool the tooth and restoration or wait several seconds between each light-curing cycle.\textsuperscript{15,17-19}

CONCLUSION

Light curing cannot be taken for granted. If adhesives and composite resins are not cured completely, there is potential for problems involving lower bond strengths, increased microleakage, increased potential for color changes within the composite resin and surface staining, increased wear, and possible recurrent caries. Following the guidelines presented will ensure maximum photopolymerization of the restorations being placed.

REFERENCES


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