Light Curing Devices-A Clinical Review

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Abstract:

Curing light are an integral part of the daily practice of restorative dentistry. The mode of curing has regularly changed during the last 30 years. The different types of polymerization sources available today are Quartz-tungsten-halogen (QTH), Plasma arc (PAC), Argon laser and light emitting diode (LED) curing lights. This clinical review is principally focussed on assessing the clinical relevance of curing systems available; in terms of their selection and maintenance in the dental operatory; thus optimizing their clinical performance.

Key Words: Curing units, Eye protection, Radiometer.

Introduction:

Since the birth of dentistry there has been a continuous attempt to formulate a material and technique which fulfill aesthetic requirements, besides having the expected physical, mechanical and biological properties to behave favorably in the oral environment. Visible light cured resin-based composites are the predominant restorative materials for both anterior and posterior restorations. In 2000, 94% of U.S. dentists used visible-light curing units[1]. Light-cured composites allow the dentist to actively initiate the polymerization step being a significant advantage compared to auto cured composites[2].Furthermore, a meticulous layering technique was employed to reduce polymerization shrinkage to be applicable even in larger stress- bearing cavities in redentistry[3]. This enables the dentist to generate esthetic and durable restorations such as pit and fissure sealants, direct and indirect resin composite restorations, and luting of ceramic restorations. Even resin-modified glass ionomer rely on photopolymerization[4].

There have been three major evolutions in dental composite curing lights since 1991. At that time, the majority of practitioners used quartz-tungsten-halogen (QTH) units with power densities in the 400-600 mW/cm2 range. The relatively simple guidelines for clinicians involved three variables: light intensity, exposure duration, and incremental layeringof the composite material. Restorative dentists were instructed to routinely monitor their light's output to ensure that the intensity was above 300 mW/cm2, to cure each increment for at least 40 seconds, and to cure the composite in increments less than 2mm in thickness[5]. There are basically three types of visible light curing units: countertop units, gun type units, and fiber optic hand piece attachment units.

Countertop Units:

The countertop unit contains all the functional parts in one box. A fiber optic or fluid filled cord carries the light from the box to the patient. Some of these units have a control switch at the end of the cord so the operator does not have to leave the operating field to activate the light source. The advantages of countertop units are that the fan and working parts of the unit are out of the operating field and that they are generally less expensive than other designs. The disadvantages are that many units lack a switch at the cord end and many models do not have wide diameter curing tips. In addition, many countertop units have fiber optic cords that need periodic replacement because of fiber optic bundle break down.

Gun Type Units:

The second type of visible light curing unit has its light source in a gun handle. The light passes through a small fiber optic cord or glass rod that forms the barrel of the gun. Generally, these units are attached to an additional table top or wall mounted unit that

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contains the necessary transformers to operate the light. This type of unit is activated at the operator site. They typically have large diameters of cure with good intensity and are generally small and easily made portable. Gun type units have no fiber optic cords to be replaced since the gun barrels are usually inflexible. The disadvantages of gun type units are the fan in the handle, which can be noisy and become warm with extended use; gun bulk and weight (more bulky than fiber optic cord ends) and higher cost.

Fiber Optic Handpiece Curing Attachments:

The third type, the fiber optic hand piece curing attachment, is generally adapted to existing fiber optic hand piece light sources. Attachment units have curing tips that are usually smaller than but similar to those in countertop units. Some of these units generate considerable heat,owing to inefficient or missing blue light filters.These units are less expensive, especially if the fiber optic handpiece is already in place. They are small and require no additional counter space. Their drawbacks include, generally, a smaller diameter of cure, less intense light source, release of excessive heat (some units) and periodic need for replacement of fiber optic cords.

Curing Lamps / Curing Units :

There are four main types of light sources that have been developed for use in the polymerization of light-curable dental materials-

I. QTH - Quartz Tungsten Halogen Curing Lights
II. PAC – Plasma Arc Curing Lights
III. LED – Light Emitting Diodes Curing Light
IV. Laser Curing Lights

Out of these halogen lights and LED units are by far the most frequently used in daily clinical practice[6].

QTH Lamps:

QTH lamps have been the standard curing units for several years, despite a remarkably low efficiency compared to heat generation[7]. Since QTH lamps emit a rather wide range of wavelengths, band-pass filters are required to limit the wavelength between 370 and 550 nm in order to fit the peak absorption of camphoroquinone[8]. QTH lamps have a limited lifespan of 100 hours with subsequent degradation of bulb, reflector, and filter caused by high operating temperatures and considerable quantity of heat being produced during operating cycles[9].This implicates a reduction of curing efficiency over time by aging of the components. Many QTH lamps used in dental offices operate beneath the minimum power output specified by the manufacturers[10]. This may even deteriorate over time due to insufficient maintenance of the light sources and especially the light tips. With QTH lamps, 5% of the total energy is visible light, 12% heat and 80% light emitted in the infrared spectrum.[11,12]

PAC Lamps:

Plasma arc curing lamps emit visible light at higher intensities[13] and were primarily designed to save irradiation time as an economic factor.PAC units typically produce power density greater than 2000 mw/cm2, and have been shown to polymerize composite in the least amount of time.[14] The plasma arc lamps (short-arc xenon) used forpulse energy curing usually have a 5-mm spot sizeand a wide bandwidth covering 380 to 500 nm.They yield a power density up to 2500 mW/cm2.This is a tremendously powerful light energy sourcethat requires a wait time (minimum 10 seconds)after each use to allow the unit to recover.[15] Due to the described high energy output of plasma arc systems, the manufacturers of these lamps repeatedly claimed that 3 seconds of PAC irradiation would achieve similar material properties compared to 40 seconds curing with QTH lamps. However, this claim has been fully rejected.[16, 17-20] Today, recommendations for PAC lights are based on 3 x 3 seconds.[21]

Argon-IPN-Lasers:

Dental lasers were introduced and recognized as a tool for better patient care in the early 1990s.The wavelength of the argon laser(between 450 and 500 nm)has been used effectively to polymerize composite resins because it enhances the physical properties of the restorative material compared with conventional visible light curing[22].Lasers produce littleheat, because of limited infrared output. The argon laser is useful in class 2 composite restorations, not only because of the decreased curing time needed, but also the small fiber size allows for easy access of the curing light to the interproximal box area and provides a highly satisfactory result for the completed restoration. A major limitation of arc and laser lamps is that they have a narrow light guide (or spot size). This requires the clinician to overlap curing cycles if the restoration is larger than the curing tip.[23]

LED– Light Emitting Diodes Curing Light:

To overcome the shortcomings of halogen bulb visible light curing units, Mills proposed using a solid-state light emitting diode, or LED technology in 1995 to polymerize light activated dental materials.[24] The spectral emittance of gallium nitride blue LEDs cover the absorption spectrum of camphoroquinone so that no filters are required in LED light curing units.[25] Recent reports revealed that blue LED lamps offer the highest photo polymerization efficiency[26.] LEDs use junctions of doped semiconductors for generating light. LEDs have a lifetime of more than 10,000 hours and undergo little degradation of output over time. LEDs are resistant to shock and vibration and consume little power on operation. The newer Gallium nitrides LEDs produce a narrow spectrum of light (400-500nm) that falls closely within the absorption range of camphoroquinone that initiate the polymerization of resin monomers. Halogen based lights have a much broader light spectrum in comparison. LEDs are more efficient converters of electrical power intovisible blue light, and do not generate the large quantities of heat associated with halogen lamps.[27] Much of the spectral radiant intensity of many blue LEDs lie in the 468 nm region peak absorption of the photo initiator, and therefore produces an almost ideal bandwidth of the light that is required. LEDs, unlike halogen lamps, lend themselves to being driven by a pulsed supply.[28] Today, LED technology has considerably changed towards high power LEDs being capable of delivering a rather high output with one single diode inside the curing unit[29].

Light-Curing Unit Selection and Maintenance:

Selection: There is no one best visible light-curing unit, since different units work better for specific applications.A unit with a larger diameter of cure saves chair time by curing larger portions of composites and veneers during each curing cycle. There are several factors that must be evaluated before purchasing a visible light curing unit- Maximum diameter of curing tip, Heat generation by curing unit; ease of use of controls and timer; durability of curing tips to sterilization; size and portability of unit; voltage regulation; price: performance ratio.

Maintenance:

A number of features must be checked to ensure that a visible light-curing unit is operating at full capacity. Because the filters can pit, crack, or peel, they must be checked regularly and replaced as needed. Resin contamination on the curing unit tip tends to scatter the light, considerably reducing the effective output.[30] Therefore the tip should be cleaned of cured resin, when necessary, using an appropriate rubber wheel on a slow speed hand piece. A study by Friedman showed that polymerization units used in dental practices have lost 45-89% of their initial light intensity[31].

Problems with curing bulbs:

Bulb frosting: Bulbs become frosted when the glass enclosing the filament becomes cloudy or white. This occurs as a result of either deposition of metal oxides, which vaporize and form a film on the glass bulb. Frosting can result in a 45% drop in curing light output[32].

Reflector degradation: Reflector degradation occurs when there is a lossof the reflector film or a white or yellow coatingof oxides develops over the reflector surface. Thiscan result in a 66% drop in curing light output. Because of these problems, curing lights graduallylose intensity.[33] Light-emitting diodes have generally fewer maintenance problems than halogen bulbs but must be checked for decreased power density owing to heat accumulation during long curing times. Heat can also result in LED degeneration over time.

Radiometers:A radiometer is a specialized light meter that quantifies blue light output; a radiometer determines the effectiveness of a curing unit by measuring the intensity of 468 nm light coming out of the tip of the light guide. Radiometers are sold as small handheld devices or may be built into curing units. It is important to test a curing light when it is new to obtain a baseline for future reference. Most radiometers measure light in the 400 to 500 mm bandwidth. This is broader than is required by most photoinitiators and makes these units less reliable in evaluating curing units with narrower spectral outputs (i.e. LEDs and lasers). A specialized radiometer capable of measuring a narrower band width around 468 nm would give a more precise measurement of any unit’s spectral bandwidth.

Ocular Hazards of Curing Lights:

The blue light used to polymerize composite is not well tolerated by the human eye.All light-cured polymerization systems use light that is harmful to vision.[34] A number of studies show that blue light is damaging to the retina.It has been shown that blue light forms free radicals in the eye, just as it does in composite resins. However, in the retina, these free radicals react with the water-content of cells, causing peroxides to form in the visual cells. These peroxides are reactive and denature the delicate photoreceptors of the eye.[35, 36] Researchers estimate that blue light is 33 times more damaging to the photoreceptors of the retina than is UV light. As exposure duration increased, the burns became more severe. This damage has been named "SOLAR RETINITIS".[37] Some laboratory studies indicate that exposures of under 2 minutes to visible light-curing units (total daily dose from 25 cm) may be safe.[38] Younger eyes are more susceptible to blue light damage. It is important to educate staff about this so they can ensure that children are prevented from staring at curing lamps during treatment. The resulting damage could be profound and lifelong.

Eye Protection:

The best eye protection is to completely avoid looking at the curing light source. Covering the curing site with a dark object would be ideal. Some clinicians cover the curing site with their hand. This may prove an unsafe practice.A simple yet effective way to provide shielding from curing lights is to cover the curing field with the reflective side of a mouth mirror. This prevents excess blue light from reflecting back against the restorative and improves curing.If it is necessary to look at the light source for placement, eye protection is warranted. Unfortunately, most optical glasses and plastic contact lenses transmit blue light and near-UV light radiation with little attenuation. A number of colored plastic glasses and handheld shields are available.[39] It is easy to test the effectiveness of a light shield. The wavelengths that harm the eye are the same ones that cure composite. To test a shield (or pair of protective glasses), try to cure composite by shining the curing light through the shield onto composite. If the composite can be cured, the shield is ineffective for eye protection.

Conclusion:

It is recommended that clinician purchase curing lights of reasonable quality and develope a periodic evaluation and maintence schedule to assure adequate power output. Dentists should pay particular attention to degradation of bulb, reflector and fibreoptic curing tips. Appropriately polymerized material will have a positive influence on both the physical and biological properties of the restoration and should aid in promoting clinical success.

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