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LIGHT CURING UNITS-A REVIEW

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ABSTRACT The majority of modern resin-based oral restorative biomaterials are cured via photopolymerization processes. Light curing in dentistry has truly revolutionized the practice of this art and science. A variety of light sources are available for this light curing of dental materials. Quartz-tungsten-halogen (QTH) light curing units (LCUs) have dominated light curing of dental materials for decades and are now almost entirely replaced by modern light emitting diode light curing units (LED LCUs). Most curing lamps are hand held devices that contain the light source and are equipped with a relatively short, rigid light guide made up of fused optical fibres. These light-curing units (LCUs) must deliver both sufficient energy and light at the correct wavelengths to produce an acceptably cured restoration. This review will explore the different types of light curing units available and the factors we need to consider while using them.

KEYWORDS : Light curing units, LED lights, QTH lights, plasma arc curing lights

Introduction

There is hardly a clinical procedure performed in contemporary dentistry where photocuring of some material is not required. Dr. Mohammed Bassoiuny of the Turner School of Dentistry, Manchester, on February 24, 1976, placed the first visible light-cured composite restoration on Dr. John Yearn[1]. There is an increasing demand for aesthetic restorative dentistry, using primarily direct or indirect composites, or composite bonded porcelain veneers.

Light activated resins must not only receive sufficient energy, but they must also receive this energy within the appropriate wavelength range in order that sufficient numbers of free radicals are produced for adequate polymerisation[2]. The manufacturers of most resin composites recommend that a 2 mm increment of composite should be irradiated for 10 to 40 seconds[3].Factors influencing the degree of convergence of resin based cements: irradiance, light exposure duration, radiant exposure, emission spectrum, tip end temperature rise, type of light guide and distance between light guide tip and RBC[4]. If the restoration does not receive sufficient total energy, various problems may arise, e.g., reduced degree of conversion, increased cytotoxicity, reduced hardness, increased pigmentation, decreased dynamic elasticity modulus, increased wear, increased marginal breakdown and weak bond among the tooth, adhesive and the restoration[2][5]

Quartz–tungsten–halogen lights

The QTH light became the mainstay of dental light curing for many years, into the late 1990s (fig 1). The unit consisted of a quartz bulb with a tungsten filament in a halogen environment having heat absorbing glass and a bandpass filter allowing only light between 400 and 550 nm to pass: the wavelengths required to activate the photoinitiator, camphorquinone. The light from the bulb is collected by reflecting it from a silverized bulb from behind the mirror toward the path down the fiber-optic chain to the tip. The surface of the mirror should be kept clean. When this surface gets heated up, vapors from the mercury, bonding agent solutions or moisture might get condensed over it. The surface should be routinely cleaned using alcohol or methyl ethyl ketone solvents on cotton swabs to renew its effectiveness[1] The units irradiate both UV and white light that must be filtered to remove heat and all wavelengths except those in the violet blue range (400nm-500nm). Orange filters are widely used because they are complimentary to blue and absorb blue radiation. they emit light intensities up to 400-800mW cm-2[6] .The intensity of the bulb diminishes with use, so a calibration meter s required to measure the output intensity. Slow curing time of 15 sec-20sec. The units are large and cumbersome, have limited depth of cure, low energy performance and generate high temperatures[6]. Direct retinal burning and advancement of macular degeneration were now a potential for ocular damage, as the wavelength needed to initiate the visible-light initiated systems fell directly within the frequencies known to cause immediate, and permanent damage resulting from retinal burning. Thus, practitioners were advised to place a filtering film between their eyes and the curing light to preclude ocular damage, while also allowing high levels of longer wavelengths to pass in order to adequately visualize the treatment field while curing: the so-called "blue-blockers"[7].

Fig 1: QTH curing light

Plasma arc lights

PAC lamps use a xenon gas that is ionized to produce plasma (Fig 2). The high intensity white light is filtered to remove heat and to allow blue light to be emitted. The source consists of two tungsten electrodes separated by a small distance, encased in a high pressure gas-filled chamber, having a synthetic sapphire window through which the light emission was directed from a parabolic reflective surface. A high electrical potential is developed between the two electrodes, which then forms a spark, ionizing the gas, and providing a conductive path (a plasma) between the electrodes. Once the initial spark is established, electronics then adjust the operating current to maintain light generation through a variety of sophisticated feedback system. The typical output from these types of lights was near 2000mW/cm2, and was broad banded: from 380 to 500 nm, with a naturally occurring peak near 460 nm, where CQ has its optimal absorption[7]. High energy output and short curing time. High conversion rate and high depth of cure. These devices are bulky and expensive. Heat production should be controlled and hence filters and ventilating fans must be used[6].

Fig 2: Plasma arc curing light

The argon-ion laser

They have the highest intensity and emit at a single wavelength (fig 3). Lamps currently emit 490nm. They do not require filters and require shorter exposure time. Because a laser is a narrow beam of coherent light, no loss of power over distance occurs. the curing tip is small and the curing depth is limited. they have a narrow spectrum and are expensive[6]. "Pulsed argon laser" may be a solution for the shrinkage problem. Pulsing or periodic interruption of the beam can be precisely control Light Emitting Diode in nanoseconds. The theory is that interruption of the beam allows the target material to cool between laser pulses, thus preventing overheating.[1]

Fig 3: Argon ion laser

LED LAMPS

Using a solid-state, electronic process, these light sources emit radiation only in the blue part of the visible spectrum between 440 and 48-nm, and they do not require filters[1]. LEDS require low wattage, can be battery powered, generate no heat and are quiet because a cooling fan is not needed (fig 4)

First generation LED were first introduced to the commercial market at the end of 2000. They used silicon carbide having a power output of 7muW per LED. dental manufacturers incorporated new 1-W chips into curing lights, developing what is referred to as the "second generation" LED lights. Chip manufacturers were now fabricating chips specifically within the wavelength requirements for dentistry, and labelling them as "dental LED blue". they were built on gallium nitride technology and had a power output of 3mW.they were considered to be more efficient in curing composites. They are cordless, light weight, small and battery powered. They do not require filters because they emit light at wavelengths from 400-500nm photoabsoption range of CQ. Thus there is high energy performance of the LCU. they show a constant effectiveness without any drop in intensity with time. There is no heat generation, thus no cooling fan needed[6][7].

In order to enable polymerization of restorative materials utilizing more than only CQ as initiator, curing light manufacturers resorted to providing LED chip sets that emitted more than one wavelength, the 3rd generation LED lamps. by combining the output from two wavelengths, light was provided at wavelengths that were effective for not only CQ, but for the alternative set of initiators as well, creating the equivalent of a "broad banded LED" curing light[7].

Fig 4: LED curing light

RADIOMETERS

With wide ranging claims of curing light performance touted by manufacturers, it becomes of great importance to be able to distinguish the true operating characteristics of curing lights so that valid evaluation of those claims can be made[7]. The recently marketed hand held radiometers serve as a means to objectively measure the performance of these units instead of depending on unreliable subjective parameters. Manufacturers of some dental radiometers imply a direct relationship between intensity readings and depth of cure. The light meter windows of curing radiometers may have a small aperture for taking peak power density measurements or a large aperture for averaging the power from the entire light guide area. Aperture size is dependent upon the manufacturer's design[8].

According to the manufacturers of the curing and heat radiometers, two independant criteria dictate whether to repair or replace the curing light, a reading of <200mW per cm2 by the curing curing radiometer, or a reading of >50mW per cm2 by the heat radiometer. Dental radiometers are claimed to measure the output of visible light curing units within a range of 400-525 nm[9].

Heat development

In recent years, LED LCU have shorter curing times and increased polymerisation, but has an increased temperature and concerns have been raised about increasing risk for pulp and tissue damage in patients. If the temperature of the pulpal tissue increases more than 5.5 degrees, the tissue will start to coagulate, causing irreversible damage.

Decreased curing time may reduce the risk for soft and pulpal tissue damage but can have a negative effect on the degree of conversion. In addition, several other possibilities have been discussed to reduce overheating when using LED LCU such as using external cooling from an airflow, polymerization at intermittent intervals, and placing gauze under the rubber dam to reduce heating the soft tissues under the rubber dam[10].

Tip Distance

The light-curing times recommended by dental manufacturers are based on placing the tip end of the curing light as close as possible to the surface of the resin, but in clinical situations, this positioning is often difficult or impossible to achieve [11]. When the distance is greater than 2 mm, the light dispersion of the light curing unit increases, and it becomes difficult to obtain effective polymeriz ation. Clinically, deficient polymerization can happen in deeper Class I and Class II cavities, due to the dispersion of light energy that occurs because of the distance between the light curing tip and the first resin composite increment[2].

When it comes to photocuring lamps, one important topic is power density, i.e., how much light is emitted in a given area. Power density can also be referred to as irradiance or light intensity and is expressed as mW/cm2. This parameter will determine the amount of energy received by the composite, and ultimately, if the composite will be sufficiently cured or not[5]. It has been reported that a minimum power density of 300 to 400 mW/cm2 is required to adequately cure a 1.5- to 2-mm increment of resin composite in the manufacturers' recommended curing time[12]

LIGHT CURING TECHNIQUES

Soft start technique: initial low rate of polymerization extends the time available for stress relaxation before reaching the gel point. In this technique, curing begins with a low intensity and finishes with a high intensity. The approach allows for a slow initial rate of polymerisation and a high initial level of stress relaxation during the early stages, and it ends at the maximum intensity once the gel point has been reached. This drives the curing reaction to the highest possible conversion only after much of the stress has been relieved. Various light curing units automatically provide soft start exposure sequences. Soft start technique is divided into three techniques:

Ramped: During exposure, intensity is gradually increased or "ramped up". This ramping consists of either stepwise, linear, or exponential modes. The intensity is increased with time either by bringing the light towards the tooth from a distance curing through a cusp, or using a LCU designed to increase in intensity.

Delayed curing: the restoration is initially incompletely cured at low intensity. The clinician then sculpts and contours the resin to the correct occlusion and later applies a second exposure for the final cure. This delay allows substantial stress relaxation to take place. The longer the time period available for relaxation, the lower the residual stress. This method also helps in finishing of composite restorations

Pulse curing: a series of exposure pulses is used, each separated by a dark interval. An initial exposure of up to 1J/cm2 is considered to be most efficient in reducing shrinkage stresses. Another important parameter is the delay time between the irradiances. During the dark period, polymerisation reaction occurs at a reduced rate. Greatest reduction of polymerisation is achieved with a delay of 3-5 mins[6].

CONCLUSION

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. Both the curing light and the curing method help in achieving this success. Various light curing units belonging to different generations are available commercially. The new generation systems have a high power density, high light intensity, and shortened exposure time. The knowledge of these light curing units, their advantages and disadvantages, also the methods of curing, can improve the quality and quantity of the resin based restorations.

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