Review Article

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Light Curing Unit: Variables Affecting the Composite Restorations

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ABSTRACT

Background: Dental light-curing unit has become an indispensable piece of equipment, in almost every dental office. The recent composites, are dependent to a large extent, on the curing light used for their polymerization and achieving a higher percentage of this conversion. The spectral emission, distance, angulation and uniformity of light beam, radiant emittance and exposure, duration of exposure, affect the properties and longevity of the composite restoration. This article, explains and discusses, the various factors that ought to be considered, for the use and application of the curing light.

Keywords: Light Curing Unit, Light Emitting Diode, Spectral Emission, Radiant Emittance, Radiant Exposure.

INTRODUCTION

Composite restorations have been in use for many decades. The earliest introduced composites in dentistry were self-cure, later light cure composites became prevalent. The latter became immensely popular because of their esthetics, superior properties and ease of use. Strength and other qualities of these restorations depend on the light used for inducing the curing procedure. (1)

Direction and distance of the tip of the light-curing device, the wavelength, bandwidth and intensity of the curing light, irradiation time, colour and thickness of the composite effect the polymerization process. (2) Dental light-curing unit (LCU) has become an indispensable piece of equipment in almost every dental office. (3) This article traces the history and factors of LCU that affect, the quality and longevity of composite restorations.

History of Light curing units:

The first dental-curing light was developed in the 1970s and used ultraviolet light to cure the material. It was discontinued due to drawbacks of ultraviolet (UV) light and limited depth of cure because of shorter wavelengths. (3) A few years later, a curing device that used blue light was introduced. Next curing light with quartz-halogen bulb, possessing longer wavelengths of the visible light spectrum was introduced. These permitted greater penetration and light energy. (3) In1990s focus shifted towards generating, higher intensity to cure faster and deeper. Quartz-tungsten-halogen (QTH) curing lights were the standard for clinical use due to their dependability and satisfactory performance until the late 1990s. Mills and colleagues in 1995, developed light-emitting diodes (LED). (4) In 1998, the plasma arc curing light was introduced, which possessed, high-intensity light, a fluorescent bulb

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containing plasma. [5] The latest LED curing lights, use a single high intensity blue LED with a larger semiconductor crystal, emitting light with an intensity of 1000mW/cm^2 or higher.

Factors for evaluation of Quality of Light:

1. Spectral Emission: To photo cure, sufficient spectral radiant power must fall within the spectral range required to activate the photoinitiator(s) present in the resin. [6] This measurement is necessary because there exist wide ranges in spectral radiant power in the "blue light" output from LCUs, PAC and QTH. Curing peaks between ~405 to ~455 nm.

2. Light beam uniformity: light output from the device shows "hot spots" of very bright light and "cold spots" where very little light comes from the light tip. [7]

3. Distance to target: Light may be emitted at different degrees of beam divergence from the tip end of curing light. As a result, the effect of tip distance on the irradiance received at the target, is not the same, for all lights. The dentist should maintain the closest distance while delivering curing light to the resin surface. [3]

4. Radiance emittance: Total radiant exposure is the result of radiance emittance and exposure time. Increased radiance emittance enhances the degree of cure, with improved physical properties of the composite. Radiant exposure of 16 J/cm^2 provides adequate polymerization of 2 mm thick composite.

Factors for Optimal Composite Restoration:

1. Manufacturer's Instruction: Each bonding and composite system, has its unique procedure, wherein the manufacturer instructions need to be followed for optimal result.

2. Effectiveness of Moisture Control: Isolation of the operating field with a properly placed rubber dam and suction is ideal. [9] Wet bonding is recommended for most adhesive systems. The optimal amount of wetness varies depending upon the adhesive system (etch & rinse or self-etch) used and the primer (acetone or ethanol) in the system. The alternative systems for isolation, like Isolite, Isodry or Optragate, can be used in place of rubber dam. [8]

3. Polymerization Shrinkage: Restorative composites display volumetric shrinkage between 1% to 6%, dependent on formulation and the curing conditions. Resulting in the restorative material pulling away from the tooth, leaving a gap that leads to postoperative sensitivity, marginal staining, recurrent caries, and eventual loss of the restoration. [10] Various methods are advised to overcome this problem, including incremental layering, [11] placement of flowable composite as stress breaker [12] and different light applications (pulse or ramp curing). [13]

4. Size and Location of Restoration: The position of the tooth in the arch and the size of the cavity are other factors in the success of a restoration. Risk of failure in the molar area is twice as high as for premolars, [14] while in lower molars, it is three times that of the upper premolars. Multi-surfaced restorations are also more prone to failure than single surface restorations. For every surface added to the restoration, a 40% increase in the failure rate results. [29]

5. Proper Placement Technique: Incremental placement of the composite is recommended due to a decrease in the "C" factor and the resultant shrinkage stress. With the introduction of the low shrinkage stress composite materials, the bulk filling has become more popular. [12]

6. Proximal Box Placement: Bonding failures have been commonly attributed to the gingival margin of Class II composite restorations because of little or no enamel. [15] The discrepancy between etching depth and adhesive infiltration leads to a large area of exposed collagen at the gingival margin. [17]

7. Water content: Increased water content leads to reduced adhesive infiltration and lower monomer/polymer conversion of the adhesive at the gingival margin as compared to the proximal wall. Placement of a glass ionomer as the first layer for these deep margins is recommended. [19]

8. Finishing and Polishing: High-quality finishing and polishing improve both the esthetics and the longevity of composite restorations, whereas rough, poorly polished surfaces contribute to staining, plaque accumulation, gingival irritation, recurrent caries, and discolouration of the restoration. [20]

9. Depth of Cure: Intensity output of curing lights affects cure depth and time needed for complete polymerization of resin composites. [21] It has been proposed that a QTH curing light delivering an irradiance of 400 mw/cm^2 should be used for 60 s to adequately polymerize a 1.5–2-mm-thick increment of resin composite. [25]

10. Shade: Darker shades of composite tend to display a lower degree of conversion. [30]

11. Filler particle size: A most important limiting factor for the depth of cure is light scattering, and it can be minimized by using nano-sized filler particles. [3]

12. The temperature of Composite: Preheating the composite to the oral temperature enhances its properties. [31]

Inadequate light emission by the LCU, results in inadequate polymerization. Nearly 30% of LCUs, have LIOs below 200 mW/cm2. [23] Aging and degradation of the light source, the buildup of scale on the fibre-optic light probe after autoclaving need to be monitored on a regular basis. [25] Regular maintenance of LED/ LCU is extremely important to ensure their adequate and appropriate functioning.

LED radiometers should be used for measuring the output intensity of LED lights. Machines should not be shut off after immediately cyclic curing, and else it results in heating. When the LCU is used for extended curing times, then the tooth should be air-cooled, or the operator should wait at least 2–3 s between every 10 s of light curing. [27]

DISCUSSION

The recent composites are dependent to a large extent, on the curing light used for their polymerization. Amongst the other factors, the most important in developing the optimal properties, of a composite restoration, is the degree of conversion achieved, a result of the exposure to light. In numerous studies, it has been observed that composites, tend to achieve a degree of conversion, nearing 61-65% on the surface, which decreases, with increasing depth of the composite mass. [32] This degree of conversion is generally adequate to achieve satisfactory properties. The curing light used, tends to play an important role, in achieving a higher percentage of this conversion. In recent times, LED's are the most widely used LCUs. The properties of the emitted light play a cardinal role since the photoinitiators become active in a specific band of wavelength. [3] Camphorquinone, the earliest used photoinitiator, has optimal sensitivity at 470 nm. The composites are further affected, by virtue of their shade, translucency, filler particle size and load. Darker shades, display lesser conversion, on the contrary composites with higher translucency, have a higher conversion. [33]

It has been an observation in numerous studies, that filler size has an important role regarding the Degree of Conversion. When the filler particle size, is less than half the wavelength of the employed light, curing is higher. As a consequence, the recently introduced nanofiller particle are advantageous in this regard. [34] For the same composite, if the light is used injudiciously, the result is suboptimal. Towards fulfilling this requirement, the light tip needs to be placed, as near as practically possible without touching the composite surface. [35] Aguiar et al. have found that keeping the tip of the light, within 0.5 mm of the composite surface is adequate. [36] In the same instance, the angulation of the tip should be perpendicular to the composite surface. The distance and the angle tend to affect, the beam profile; hence their proper positioning is an absolute must. In various studies, it has been the observation that light tip has been touching, the surface of the composite or it had been sterilized or disinfected, multiple times. These tend to affect, the quality of the emitted light, resulting in altered radiant emittance. Chong et al. suggested that in order to prevent cross-infection, the use of plastic cover over the light tip should be preferred. [37]

Of late, bulk-fill composites have gained widespread acceptance. These composites are especially prone, to the vagaries of the employed light. Since, these bulk-fill composites, can be used in a thickness of up to 4 mm, the used light becomes all the more important and the property of radiant exposure, assumes greater importance. [38] For composites, a radian.t emittance of 400 mW / cm2 is considered adequate, but not for bulk-fill composites. The latter requires a radiant emittance of at least 1000 mW/ cm2. Ultimately, it comes down to the radiant exposure, wherein radiant emittance and exposure time have to be calibrated, so as to achieve optimal properties of the composite. For a 2mm thick composite restoration, adequate polymerization can be achieved with a radiant exposure of 16 J/ cm2. Keeping all these considerations, in proper and controlled interplay, produces a composite restoration that can withstand, the vagaries of the oral environment and can last more than 10-12 years.

Conclusion: LED is the preferred LCUs. Light tip, should be covered with plastic sleeves and placed at a perpendicular, as near to the composite surface as possible, without touching. For a 2mm thick composite restoration, adequate polymerization can be achieved with a radiant exposure of 16 J/ cm2. Bulk fill composites should be exposed to a radiant emittance of at least 1000 mW/cm2.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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