REVIEW ARTICLE

LIGHT CURING UNITS - AN INSIGHT

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ABSTRACT

Success of a composite resin restoration is dependent on multiple factors starting with case selection, tooth preparation, and the placement techniques for the restorative material. The clinical success of these light-cured resin composite restorations also hangs on the optimized polymerization of the adhesive and composite resin. At times dentists surmise that activating a light-curing device will reliably and predictably cure the material. However there are important factors that need to be taken into account to ensure the durability of the light curable restorations placed. This review intends to throw light on important factors that needs to be taken into consideration when selecting a light curing devices and specific requirements in employing these devices to polymerize few newly evolved dental materials

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INTRODUCTION

Dental resin composites in clinical practice are basically cured by a process of photo-polymerization. The term polymerization implies that a malleable resin composite converts into an insoluble polymer after it is subjected to light irradiation from a light emanating source.[1] Adequate photo polymerization of the resin is necessary for the long-term success of a composite restoration.[2] Inadequate and improperly cured composite restoration are bound to fail and can bring about associated problems such as recurrent caries due to microleakage, fracture due to reduced strength, sensitivity problems, pulpal damage and poor wear resistance.[3]

Optimized light curing techniques employing the best of the light curing devices plays a crucial role in achieving this objective. Even though it may appear that all curing lights will achieve an adequate result, it has been demonstrated that not all light curing devices are equivalent and many key variables affect the efficiency of the light curing devices. From that view point not all light curing devices available at the disposal of a clinician would provide the desired features in term of curing capabilities.[3]

How to evaluate a light curing unit:

Findings from several studies across the globe suggest that dentist often end up using improper light curing devices and mostly they are unaware of this deficiency of the light curing device in terms of inadequate amount of radiant exposure or improper wavelength to cure their resins.[3] Output of the light and the amount of time the light is turned on towards the resin are two important critical variable in evaluating the efficiency of light cure polymerization.[4] It is a common practice to describe the light output from a light curing device in terms of irradiance due to its ease of observation. Dental radiometers are utilized for this purpose to convince clinicians. Frankly this does not provide complete information on the potential performance of a light curing unit.[5] Light output from light curing units can seldom be accurately measured and never can be completely described by a commercial dental radiometer.[6] The inaccuracy and inefficiency of this method can be attributed to several factors such as variation in the active curing tip diameter, emission spectrum of the light curing unit (LCU), types of filters used in the radiometers.[6]

Depending on the shade and brand of composite used for a conventional 2mm thickness increment the minimum energy requirement to photo polymerize has been reported to be in the range of 6 J/cm^2 to 24 J/cm^2.[7] Importantly the irradiance can be very different at clinically relevant distances away from the light tip when curing dental resins within cavity preparations. Curing lights deliver significantly less irradiance, of often 75% or more, within a cavity preparation in clinical dental practice.[8] Manufacturers' stated irradiance values can give the impression that the clinician is using a powerful curing light, but the fact remains is that significantly less of irradiant energy is actually reaching the surface of the resin composite that the clinician intends to cure.[3]

Beam Profile from the LCU:

The light beam from the curing light unit tip disperses leading to inhomogeneous distribution of light intensity. So when the wand is moved away from the resin surface, the light intensity decreases thereby the amount of curing also decreases. This inhomogeneity can result in non uniform polymerization beneath the light guide tip.[9]

A beam profile demonstrates the locations and radiant intensities on the surface of the light tip from where light is being emitted. For some lights, the light being emitted is uniformly distributed over the entire surface of the light tip, referred to as a "top hat" appearance. While in some light curing units the light is predominantly delivered only at the center of the tip with a rapid fall-off at the edges of the light tip. While in case of few light curing units, the profile appears to be hills and valleys with an inconsistent and uneven light output.[10] Ideally the manufacturer should furnish report about the beam profile of a light curing unit thus enabling the clinician better understanding about the beam characteristic which the surface of the composite resin would receive during photo polymerization. The clinical implications of a beam profile is that if an superimposed overlay of the beam profile were to be placed onto a tooth preparation, it would demonstrate the regions of the preparation that are not receiving adequate radiant exposure to cure a dental resin.[3]

Temperature changes in light curing units:

The light from a LCU can be also a source of heat, which can have biological effects. Hence arbitrarily increasing the exposure time to assure complete polymerization without understanding the effects of heat from the light source can be detrimental. For every 1°C degree rise in temperature the rate of reaction will increase by 1.90 %.[11] It is reported that 1 second after the light is turned on, the conversion rate becomes twice as fast when the initial temperature of the resin based composites (RBC) increases from 22 °C to 35 °C.[12] Composite resins polymerized at an elevated temperature (37°C) build up stress more rapidly than specimens at 23 °C.[13]

Polymerization of light-activated composite resins causes both an exothermic polymerization reaction and also a temperature rise from the light energy absorbed during irradiation. The heat generated depends on the bulk of material, the irradiance, and the rate at which the RBC polymerizes.[14] Many clinicians advocate either air cooling the tooth during extended light exposure and curing or allowing a cooling period of 2-3 seconds between every 10 second curing.[3]

Light curing device:

Source of light from a light curing unit such as quartz tungsten halogen (QTH) bulb, light emitting diode (LED), or plasma arc (PAC) plays an important role in the irradiance value, and the radiant exposure delivered to the tooth and the RBC being placed. Other variables include exposure time, configuration of the tips/ probes, energy source of the unit and the cooling mechanisms.

It has been observed that conventional and most popularly used QTH units exhibit more light scattering. On the other hand, more light is absorbed by composite resin when LASER light cure units are used.[15] Though the laser lights have better absorption, the devices have limited bandwidth and emit wavelengths closer to the absorption peak of certain photoinitiator in composite resin. Thus, QTH units are more efficient than LASER units for visible light cured composites. Conversely, due to inherent property of coherency of laser beam, there is no loss of power in the distance in laser units which is pronounced in QTH units. Therefore, laser units are preferable in curing composites in accessible areas.[16]

Exposure Time:

Increasing the power density of light curing units can reduce the exposure time required for a given depth while at the meantime increases the rate and degree of cure.[17] As the energy density is a product of intensity multiplied by exposure time, the same energy can be consumed at high or low intensities by modifying the exposure time to maximize the energy efficiency.[18] It has been reported that exposure times longer than those recommended are usually required to optimize the flexural strength for an incremental thickness of composite.[19] An exposure time of 40 secs is considered optimal for all curing light units used for resin based composites.[20]

Lamp output intensity:

Clinical life of a light curing unit mainly depends on the ability to maintain the units output intensity. This usually reduces over a period of time. This reduction can be attributed to alternative heating and cooling of the tip surface, leading to dulling or clouding of the tip due to condensation of vapors from bonding system solvents or moisture. Moreover, the resin composite itself adheres to the tip resulting in scattering of light and reduction in its effectiveness. Therefore, it is important to clean the mirror surface of the tip routinely using alcohol or methyl ethyl ketone solvents to preserve and renew the reflection effectiveness of the light source.[21]

Angulation of light tip:

A light beam creates a circular spot of light when it is held perpendicular to the restoration surface. In order to achieve maximal light intensity at the restoration surface, the wand tip of curing should be held parallel to the restoration surface . When the wand is tipped, the circular shape changes to an ellipse shape and thus there will be decrease in the light intensity as energy would be spread over a greater area. [22]

Distance of curing tip from composite Surface:

Light intensity striking the composite restoration surface is inversely proportional to the distance from the tip of the fiber optic bundle of the curing light to the composite surface.[16] Depth of cure generally decreases as the distance from the tip to the resin increases.[23] Ideally the tip of the light cure should be within 3mm of resin composite to be effective. For darker shades of composites, the increments should be limited to 1mm of thickness.[18]

Photo-initiator used:

Light cure polymerization of dental composites happens or in fact starts due to the presence of a substance called as photo initiator in the composite. Two commonly used photo-initiators used in dental composites are camphorquinone (CQ) and monoacyl phosphine oxide (TPO). CQ is a bright yellow type II photo initiator that absorbs light in the visible spectrum at a wavelength 467nm and in the UV region in the range of approximately 200-300nm.[1] TPO is light yellow type I photoinitiator and absorbs light in the range of approximately 295-390nm.[24] The two photoinitiators may be used either alone or in combination at different concentrations along with their co-initiators.[1] The output of the light cure unit should be in the range which can activate the particular photoinitiator in the composite being used, because all composites do not use the same photoinitiator and not in the same proportions. This mismatch between the unit output and the manufacture choice of photoinitiator can be major clinical issue.

In order to efficiently cure a wide range of composites with different photo initiator such as TPO, manufacturers of light curing units have introduced new polywave light curing unit. Monowave light curing units have LED source that emits output at approximately the same wavelength. The new polywave unit have different LED source combination enabling them to emit light of combination of different wavelength near the camphorquinone range and the 400-410nm range, which is close to the absorption range of TPO. This allows the polywave system to activate the resin composites more efficiently in which newer photo-initiators are been incorporated .

CONCLUSION:

Clinician's knowledge and skill in handling and maneuvering curing units play an important role in polymerization and final outcome of the resin based composite restorations. In order to address the problem associated with curing and to improve the chance of a successful restoration, it is important to understand the curing units along with its properties so that we can use this information to improve the clinicians ability to deliver sufficient light to resin based composites.

REFERENCES

1. Kamoun, E. A., Winkel, A., Eisenburger, M., & Menzel, H. (2014). Carboxylated camphorquinone as visible-light photoinitiator for biomedical application: Synthesis,characterization, and application. Arabian Journal of Chemistry .
2. Ferracane J, Watts DC, Barghi N, et al. Effective use of dental curing lights: a guide for the dental practitioner. ADA Professional Product Review. 2013;8(2):2-12.
3. Strassler HE, Price RB. Understanding light curing, Part I. Delivering predictable and successful restorations. Dentistry today. 2014 May;33(5):114-6.
4. Price RB, Strassler HE, Price HL, et al. The effectiveness of using a patient simulator

to teach light-curing skills. J Am Dent Assoc. 2014;145:32-43.

5. Shortall AC, Harrington E, Wilson HJ. Light curing unit effectiveness assessed by dental radiometers. J Dent. 1995;23:227-232.

6. Leonard DL, Charlton DG, Hilton TJ. 1999. Effect of curing-tip diameter on the accuracy of dental radiometers. Oper Dent 24(1):31–37.

7. Ferracane J, Watts DC, Barghi N, et al. Effective use of dental curing lights: a guide for the dental practitioner. ADA Professional Product Review. 2013;8(2):2-12.

8. Rueggeberg FA, Jordan D. Light tip distance and cure of resin composite. J Dent Res. 1992;71(special issue A). Abstract 661.

9. Arikawa H, Kanie T, Fujii K, Takahashi H, Ban S. Effect of inhomogeneity of light from light curing units on the surface hardness of composite resin. Dental materials journal. 2008;27(1):21-8.

10. Strassler HE. Successful light curing—not as easy as it looks. Oral Health. 2013;103:18-27

11. Hiemenz PC, Lodge T. 2007. Polymer chemistry. Boca Raton (FL): CRC Press

12. Price RB, Labrie D, Whalen JM, Felix CM. 2011. Effect of distance on irradiance and beam homogeneity from 4 light-emitting diode curing units. J Can Dent Assoc 77:b9.

13. Watts DC, Alnazzawi A. 2014. Temperature-dependent polymerization shrinkage stress kinetics of resin-composites. Dent Mater 30(6):654–660.

14. Bouillaguet S, Caillot G, Forchelet J, Cattani-Lorente M, Wataha JC, Krejci I. 2005. Thermal risks from LED- and high-intensity QTH-curing units during polymerization of dental resins. J Biomed Mater Res B Appl Biomater 72(2):260–267.

15. Oberholzer TG, Makofane ME, du Preez IC, et al. Modern high powered LED curing lights and their effect on pulp chamber temperature of bulk and incrementally cured composite resin. Eur J Prosthodont Restor Dent. 2012;20:50-55.

16. Emami N, Sjödahl M, Söderholm KJ. How filler properties, filler fraction, sample thickness and light source affect light attenuation in particulate filled resin composites. Dental Materials. 2005 Aug 1;21(8):721-30.

17. Bayne SC Thompson JY Taylor DF.Dental materials.In:Robertson TM,Heymann HO,Ritter AV, eds. Sturdvent's Art and Science of Operative Dentistry 4th ed.St.Louis, MO:Mosby;2002:134-234

18. Resin composite restorative materials.In:Powers JM, Sakaguchi RL,eds.Craigs's Restorative Dental Materials. 12th ed.St.Louis MO; 2007:189-182

19. Malhotra N, Kundabala M. Light-curing considerations for resin-based composite materials: a review. Part II. CompendContinEduc Dent. 2010;31(8):584-8.

20. Rueggeberg FA, Cole MA, Looney SW, Vickers A, Swift EJ. Comparison of manufacturer-recommended exposure durations with those determined using biaxial flexure strength and scraped composite thickness among a variety of light-curing units. Journal of Esthetic and Restorative Dentistry. 2009 Feb;21(1):43-61.

21. Antonson SA, Antonson DE, Hardigan PC. Should my new curing light be an LED?. Operative Dentistry. 2008 Jul;33(4):400-7.

22. Williams PT, Johnson LN. Composite resin restoratives revisited. Journal (Canadian Dental Association). 1993 Jun;59(6):538

23. Dunne SM, Millar BJ. Effect of distance from curing light tip to restoration surface on depth of cure of composite resin. Primary Dental Care. 2008 Oct 1;15(4):147-52.

24. Michaud, P.-L., Price, R., Labrie, D., Rueggeberg, F., & Sullivan, B. (2014).Localised irradiance distribution found in dental light curing units. Journal of Dentistry ,129-139.