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ORIGINAL RESEARCH

A Comparative Evaluation of Curing Depth and Compressive Strength of Dental Composite Cured with Halogen Light Curing Unit and Blue Light Emitting Diode: An *in vitro* Study

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ABSTRACT

Purpose: To evaluate the curing depth and compressive strength of dental composite using halogen light curing unit and light emitting diode light curing unit.

Materials and methods: Eighty cylindrical composite specimens were prepared using posterior composite P_{60}(3M). Forty specimens, out of which 20 samples (group A) cured with halogen light and 20 samples (group B) cured using light emitting diode (LED) light were checked for curing depth according to ISO 4049. Remaining 40 samples out of which 20 samples (group I) cured using halogen light and 20 samples (group II) cured using LED light were checked for compressive strength using Instron universal testing machine.

Results: Twenty samples (group A) cured with halogen light showed better curing depth than 20 samples (group B) cured with LED light. Twenty samples (group I) cured with halogen light showed almost similar results as 20 samples (group II) cured with LED light for compressive strength.

Conclusion: Halogen light commonly used to cure composite resin have greater depth of cure, when compared to LED light, while both the lights produced compressive strength which is almost similar.

Clinical significance: Lower depth of cure with the LED unit, compared to the QTH unit, is associated with different light scattering due to differences in spectral emission. LED technology differs from QTH by the spectral emission that favorably matches the absorption spectrum of camphorquinone.

Keywords: Curing depth, LED curing light, Halogen curing unit, Compressive strength.

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INTRODUCTION

Light activated resin composite restorations have been widely applied in clinical dentistry since its introduction. With the dramatic rise in the use of composite restoratives, there is a rapid increase in the number of light activation units.[1]

The light source first used for curing composite resins was an ultraviolet light (UV).[2] But because of safety concerns about the long-term use of ultraviolet light, visible light curing (VLC) was developed around 1980. The visible light curing units usually use a tungsten halogen light source for polymerization of composite resins and still it is the most popular method of delivering the blue light.[3]

Despite their popularity halogen light curing units has several drawbacks. Halogen bulb generate high heat which degrades the bulbs overtime, quartz tungsten halogen bulbs have effective lifetime of around 100 hours.[4,5,8] QTH light curing units deliver the light with the light intensity of 400 to 900 mW/cm^2.[9]

RW Mills proposed solid state light emitting diode (LED), to overcome the drawbacks of QTH light. LED technology utilizes, Gallium Nitride blue LEDs and produce narrow spectrum of light (400-500 nm) with electroluminescence that falls closely within absorption range of camphorquinone that initiates polymerization of resin monomer.[12,13] While both LED lights and halogen lights are believed capable of curing resin-based composites, some differences are observed in the performance of the

cured resin.[6,7] Moreover, both the composite material and its curing time have a significant association with the resulting degree of polymerization.[10,11] Hence, the purpose of this study was to evaluate the curing depth and compressive strength of dental composite using halogen light and LED light.

MATERIALS AND METHODS

In this study, 80 composite testing specimens were prepared using posterior composite P_{60} (3M). Out of these 80 specimens, 40 cylindrical specimens of 4 mm in diameter and 8 mm in depth were used to measure the depth of cure and remaining 40 cylindrical specimens of 4 mm in diameter and 6 mm in depth were used to check the compressive strength. The composite specimens were prepared by filling the plastic mould with A3 shade of posterior composite P_{60} (3M) and excess was squeezed by placing microscope slides on top and bottom of the mould and then mylar strip was placed on top and bottom surface of the composite specimens and the specimens were light cured from the top surface for 40 seconds with the tip of the light source held close to the composite specimens, 20 specimens were cured with halogen light (group A) for depth of cure (group I) for compressive strength and 20 specimens were cured with LED light (group B) for depth of cure and (group II) for compressive strength. Radiometer was used to check the intensity of the light source before light curing each specimen.

Then all the specimens of groups I and II were kept in water for 72 hours.

TESTING PROCEDURE

To check the Depth of Cure

Depth of cure was analyzed using scrape test (according to ISO 4049). All the specimens of groups A and B were cured from top of the mold. Then the specimens were removed from the mold and the soft uncured part was scraped off from the bottom surface using spoon excavator, and the length was measured using a stainless steel scale.

Investigation of Compressive Strength

A compressive load was applied with a universal load-testing machine (UTM Instron Make Model 1011) to the composite samples at a cross head speed of 10 mm/minute. The specimens were kept with one end of the composite sample facing the compressing machine and load applied on that in vertical direction. The testing apparatus was connected to a calibrated drive chart, which plotted load against displacement curve during the testing procedure.

RESULTS

Evaluation of the Depth of Cure between the Two Lights

Table 1: Mean and standard deviation of each group for depth of cure

Light	*n*	*Mean*	*Standard deviation*
Halogen light	20	3.4000	0.20519
LED light	20	3.2100	0.21306

Table 2: Comparison among groups using student's t-test

Comparison of groups	*Test of significance*	*Remarks*
Group A *vs* group B	5.66900 p = 0.001	Very highly significant

Student's t-test revealed that, when comparing group A (halogen light) with group B (LED light), it was found to be statistically very highly significant (p = 0.001) as shown in Table 1.

Evaluation of the Compressive Strength between the Two Lights

Table 3: Mean and standard deviation of each group for compressive strength

Light	*n*	*Mean*	*Standard deviation*
Halogen light	20	344.5650 MPa	9.52057
LED light	20	312.1400 MPa	8.02197

Table 4: Comparison among groups using student's t-test

Comparison of groups	*Test of significance*	*Remarks*
Group I *vs* group II	0.87100 p = 0.389	Not significant

Student's t-test revealed that when comparing group I (halogen light) with group II (LED light), it was found to be statistically not significant (p = 0.389) as shown in Table 4.

DISCUSSION

Polymerization of composite is initiated and sustained, when the curing light intensity is sufficient to maintain camphorquinone, its excited or triplet state.[11,14] Thus, photopolymerization depends on both the intensity of irradiation and its duration. With the development of contemporary photocuring units, the clinician has great control over the duration of light exposure to which the restoration is subjected.[16,17] The clinician should choose a light source with adequate curing power and test its output periodically to ensure that it has maintained proper intensity.[18,19,25]

Conventional curing light use a halogen lamp to generate a white light, which is then filtered so that only blue light in the 400 to 500 nanometer range is emitted from the tip.[20,21]

Lowering light intensity is said to reduce the rate at which free radicals are formed and the rate at which polymerization occurs.[23,24,31]

LEDs use junctions of doped semiconductors (p-n junctions) for the generation of light.[26] Under proper forward biased condition, electrons and holes recombine at the LEDs p-n junction leading the gallium nitride LEDs to emit blue light.[27-30] A small polymer lens in front of the p-n junction partially collimates the light.[32,33] The spectral output of gallium nitride blue LEDs fall conveniently within the absorption spectrum of the camphorquinone photoinitiator (400-500 nm) present in light activated dental materials so that no filters are required in LED LCUs.[34-36]

Several factors influence the degree of polymerization and depth of cure of composite resins. These include light intensity, exposure duration, a composite resins transmission coefficient, the refractive indices of the filler and matrix, particle type, size and loading, opacity and shade.[22,37-39] William J Dunn (2002)[15] showed that Halogen light curing units produces harder surfaces for resin-based composites than LED curing units. This is due to the decreased light output of LED for resin-based composite polymerization.[40-42]

The total irradiance of the Halogen light curing unit (LCU) is 2.2 times larger than the irradiance of the LED LCU.[43] It is therefore expected that the physical properties of composites cured with the halogen LCU is superior to those cured with the LED LCU. A prerequisite to apply this relationship to two LCUs with different light intensities is that the curing times and other parameters like material, spectrum of emitted light and tip diameter are kept constant.[8]

The use of a low intensity light source for photo-polymerization based on LED technology provides equivalent final degree conversion with possible flow of the resin composite, similar to when QTH technology is used.[44] At the same time, the lower temperature rise in the sample and the more favorable development of shrinkage kinetics compared to the higher intensities of halogen light may aid in maintaining marginal adaptation, while avoiding possible thermal injury.[45]

Knoop hardness testing showed that the new generation of LED have enough power to cure composites in the same time as LCUs. The composite material and curing time have a significant association with the degree of polymerization.[46]

CONCLUSION

According to the finding and within the limitations of this study, it can be concluded that composite specimens cured with halogen LCU produced significantly greater depth of cure compared to composite specimens cured with LED light curing unit. There was no statistically significant difference in compressive strength between composite specimens cured with halogen light curing and composite specimens cured with LED curing unit.

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