Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

Effect of Quartz-tungsten-halogen and Light-emitting Diode-curing Units on the Depth of Cure and Flexural Strength of a Nanohybrid Composite Resin: An *In Vitro* Study

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Abstract

Introduction: Over the years, the demand for esthetic dentistry has grown dramatically and there has been a rapid development of new adhesive restorative materials with nanotechnology that can restore the color and characteristics of natural tooth. To polymerize these materials, light-curing dental materials extensively used are quartz-tungsten-halogen (QTH) and light-emitting diode (LED)-curing units. Literature search revealed that depth of cure and flexural strength are the most important properties of composite resin materials, relevant to the clinical technique of incremental packing and curing.

Purpose: The objectives of the present study were to evaluate and compare the depth of cure and flexural strength of a nanohybrid composite resin.

Materials and Methods: Two light-curing units were selected for this study: QTH (Bonart, Unicorn) and LED (Ivoclar Vivadent, Bluephase® N). The depth of cure was evaluated with scraping technique using digital caliper and flexural strength was evaluated using universal testing machine with a crosshead speed of 1 mm/min.

Results: Descriptive statistics was employed to measure the mean and standard deviation of the depth of cure and flexural strength. Unpaired *"t"*-test was used to compare the study variables. Statistical significance was fixed at ≤0.05 and LED-curing unit showed significantly greater depth of cure and flexural strength when compared to QTH curing unit.

Conclusion: Curing effectiveness of resin composite is dependent on the light-curing unit.

Key words: Depth of cure, Flexural strength, Light-emitting diode, Nanohybrid composite resin, Quartz-tungsten-halogen

INTRODUCTION

Resin-based composites, now used worldwide in dentistry due to their esthetic quality and good physical properties, are either chemically activated or light activated or combination of both.[1,2]

The most usual light-curing units (LCUs) used for composite resin polymerization are the quartz-tungsten-halogen (QTH) light and light-emitting diode (LED) LCU.[3]

The physicomechanical properties of composite resin include compressive strength, tensile strength, elastic modulus, thermal expansion, microhardness, flexural strength, surface roughness, depth of cure, and curing

Access this article online

IJSS
www.ijss-sn.com

Month of Submission : 12-2018
Month of Peer Review : 01-2019
Month of Acceptance : 01-2019
Month of Publishing : 02-2019

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Table 1: Comparison between QTH and LED for the depth of cure of a nanohybrid composite resin

Groups	Number of samples	Mean depth of cure (mm)±SD	Mean difference	*t* value	*P* value
Group IA	15	5.55±0.29	−1.09	−11.385	0.001*
Group IB	15	6.64±0.21			

QTH: Quartz-tungsten-halogen, LED: Light-emitting diode, SD: Standard deviation

Table 2: Comparison between QTH and LED for flexural strength of a nanohybrid composite resin

Groups	Number of samples	Mean flexural strength (mm)±SD	*t*-value	*P* value
Group II A	15	126.6700±45.05821	−2.582	0.019
Group II B	15	173.6580±35.81040		

QTH: Quartz-tungsten-halogen, LED: Light emitting diode, SD: Standard deviation

shrinkage.[4-6] Literature search revealed that depth of cure and flexural strength are the most important properties of composite resin materials, relevant to the clinical technique of incremental packing and curing.

However, little is understood about the interaction of these new light sources with composite resins and how they influence the depth of cure and flexural strength.[7] Therefore, the aim of this *in vitro* study was to evaluate and compare the depth of cure and flexural strength of a nanohybrid composite resin polymerized using QTH and LED-curing units.

MATERIALS AND METHODS

The present *in vitro* study was conducted at the dental institute. Ethical clearance was obtained from BVDUMC and H, Sangli.

Experimental Design

The factors under the study were two LCUs (QTH and LED) and a nano-hybrid composite resin (Filtek™ Z250XT, 3M ESPE). The experimental units consisted of 30 resin composite molds for depth of cure assigned to two groups ($n = 15$) and 30 resin composite molds for flexural strength assigned to two groups ($n = 15$). Mean values from scraping technique and universal testing machine were analyzed by Unpaired "*t*"-test for the depth of cure and flexural strength, respectively.

Assessment of Depth of Cure

A cylindrical split Teflon mold measuring 5 mm in diameter and 8 mm in height was placed on a glass slide and approximated using a jig (cylindrical rubber and screw). Black paper was placed between the glass slide and the mold to prevent reflection of the light during activation. Nanohybrid composite resin (Filtek™ Z250XT, 3M ESPE) was placed into the Teflon mold in a bulk increment to obtain resin mold of 8 mm in height. A transparent mylar strip was then placed on the resin mold, and a translucent cover slip covered it.

A total of 30 samples were prepared and divided into two groups:

- Group IA - 15 samples were cured with QTH LCU (Bonart, Unicorn).
- Group IB - 15 samples were cured with LED LCU (Ivoclar Vivadent, Bluephase® N).

All the samples were cured for the given time as per manufacturer's instructions. The depth of cure was checked using Digital Caliper 150 mm (6´´) (precision measuring) after scraping (scraping technique, according to ISO 4049) the uncured composite resin using spoon excavator from the bottom surface until the resistance was felt.

Assessment of Flexural Strength

A Teflon mold measuring 25 mm in length, 2 mm in breadth, and 4 mm in height was placed on a glass slide. Black paper was placed between the glass slide and the mold to prevent the reflection of light during activation. Nanohybrid composite resin (Filtek™Z250 XT, 3M ESPE) was placed into the teflon mold in a bulk increment. A transparent mylar strip was then placed on the resin mold and a translucent cover slip covered it.

A total of 30 samples were prepared and divided into two groups.

- Group IIA - 15 samples were cured with QTH LCU.
- Group IIB - 15 samples were cured with LED LCU.

All the samples were cured for the given time as per manufacture's instructions. Curing was performed at three points (center, right end, and left end) of the resin mold for all the samples. After being light activated, the samples were stored individually in a lightproof container for 1 week at 37°C. Then, the samples were checked for flexural strength under Universal Testing Machine (ACME, INDIA. MODEL: UNITEST. Crosshead Speed 1 mm/min).

RESULTS

The results obtained for comparison between quartz-tungsten halogen and light emitting diode curing units for depth of cure and flexural strength are as summarized in [Table 1and 2].

Depth of cure was significantly higher for light emitting diode curing unit as compared to quartz-tungsten halogen curing unit with a p value of 0.001 [Table 1]. Similarly, flexural strength was also significantly higher for light emitting diode curing unit as compared to quartz-tungsten halogen curing unit with a p value of 0.019 [Table 2].

DISCUSSION

The popularity of tooth-colored restorations has promoted the use of light-activated resin composites, and since then, many light sources are introduced to the dental market for polymerizing light-cured restorative materials.[1,8]

The depth of cure and flexural strength is considered essential physical properties of composite resin materials, relevant to the clinical technique of incremental packing and curing.[3] In the present study, curing effectiveness was measured using indirect scraping method and flexural strength was measured under universal testing machine. A load was increased gradually from "0" until maximum/fracture load was obtained under 3-point Bend Test Jig with a crosshead speed of 1 mm/min.

Nanohybrid composite resin was used in this study. It has been established that the properties of composite resins are dependent on the material composition.[9,10] In general, the monomer constituents affect the degree of conversion, viscosity, surface tension, and contact angle, and it also influences the flexural strength of composite resin.[9] The filler characteristics affect the mechanical properties of the resin composites and it has been shown that a correlation exists between filler content and mechanical properties.[8,11]

The better depth of cure of composite resin by LED LCU can be ascertained by the fact that spectral output falls conveniently within the absorption spectrum of camphorquinone (CQ), conversion of electrical energy into light more efficiently, operation for thousands of hours with a constant light output and spectra, etc.[3] LED LCU has an emission spectrum similar to the absorption spectrum of CQ photoinitiator. This spectral homogeneity allows complete usage of the emitted light by LED LCU, which otherwise does not happen with halogen light.[8] Thus, the better flexural strength of resin composite by LED LCU can also be ascertained by the fact that the convolution of the absorption spectrum of the CQ photoinitiator present in these composites matches the emission spectrum of the LED LCU.

CONCLUSION

LED-curing unit showed greater depth of cure and flexural strength compared to QTH-curing unit.

The results obtained from this *in vitro* study may vary from the clinical outcome. Hence, further long-term clinical studies should be carried out utilizing different dimensions, materials, modes of curing units, and exposure durations to evaluate the efficiency of LCU.

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How to cite this article: Shah AD, Kamat SB, Hugar SI, Nanjannawar GS, Patil PD. Effect of Quartz-tungsten-halogen and Light-emitting Diode-curing Units on the Depth of Cure and Flexural Strength of a Nanohybrid Composite Resin: An *In Vitro* Study. Int J Sci Stud 2019;6(11):75-77.

Source of Support: Nil, **Conflict of Interest:** None declared.