Evaluation of Different Light-Curing Units—Light-Emitting Diodes and Quartz–Tungsten–Halogen-Based Light-Curing Units in Polymerization of Posterior Composite: An In Vitro Study

R. Bansal[1] M. Bansal[1] S. Walia[1] C. Gupta[1] L. Bansal[1] R. Aggarwal[1]

[1]Deparment of Conservative Dentistry and Endodontics, Guru Nanak Dev Dental College and Research Institute, Sunam, Patiala, Punjab, India

Address for correspondence Rajinder Bansal, MDS, Guru Nanak Dev Dental College and Research Institute, Sunam, Patiala 148026, Punjab, India (e-mail: drrajinderbansal@hotmail.com).

Dent J Adv Stud 2018;6:60–64

Abstract

Objective To assess the adequacy of various light-curing units to polymerize the posterior composite resin.

Materials and Methods Specimens were prepared by placing a single increment of posterior composite resin in split cylindrical metallic mold of dimension (6.0 mm in diameter and 5 mm in depth). Polymerization was done by utilizing one quartz-tungsten-halogen and three light-emitting diode light-curing units of different powers. The specimens of composite resin were then mounted on metallic molds utilizing autopolymerizing acrylic resin. After polishing, the complete setting of composite resin material was analyzed using Vickers hardness test.

Results Showed in each group, hardness reduced as we moved from upper to lower surface of composite resin. Furthermore, hardness increased as intensity of light was increased. The maximum hardness was detected when light-emitting diode light-curing unit having intensity of 1,250 mW/cm^2 was utilized and least hardness was detected when halogen lamp having intensity 418 mW/cm^2 was utilized and results were found to be highly significant ($p < 0.01$).

Conclusion It was concluded that increased top and bottom hardness can be accomplished by utilizing the light-curing unit of high intensity.

Keywords
- light-curing units
- metallic molds
- hardness values

Introduction

With each passing day, request of esthetic restoration is picking up momentum which has made esthetic materials like composite resin, the restorative material of choice. Achievement of consistency of composite resin restoration depends upon one main consideration, i.e., level of resin polymerization accomplished during its placement in the prepared tooth. The utilization of curing units in complete curing of resin has become an inseparable component of an advanced dentistry.

For a long time, quartz-tungsten-halogen curing lights (often referred as "halogen curing lamps") had been utilized to initiate the photoinitiator system in the composite resin matrix. In any case, halogen-based light units have a few disadvantages which incorporate overheating of the incandescent lamp, degradation of the internal components after some time which could bring about insufficient ploymerization.[1]

Numerous types of newer visible curing lights are available nowadays. Out of these, new solid-state light-emitting diode (LED) technology is most commonly utilized as it has points of interest of being light weighted, versatile, having longer life expectancy, and so forth.

The present study was attempted to assess the curing effectiveness of most commonly utilized light-curing units of different power outputs on composite resin.

received
October 25, 2018
accepted after revision
September 18, 2018
published online
November 15, 2018

DOI https://doi.org/10.1055/s-0038-1675685
ISSN 2321-1482.

Materials and Methods

1. Light-cured posterior composite resin (SurefilTM, Dentsply)
2. Four light-curing units are as follows:
   a) One tungsten lamp (418 mW/cm^2; Dentsply)
   b) Three LED units of various powers 450 mW/cm^2 (Mectron), 950 mW/cm^2 (Dentsply), 1,250 mW/cm^2 (ColteneWhaldent).

It consists of 80 specimens which were isolated into four groups of 20 each and were labeled as group I, group II, group III, and group IV. In each of these groups, light-curing unit of various intensity was utilized to polymerize the composite resin.

Preparation of the Specimens

STEP 1: While conducting the study, a special two-section split mold having four cylinders of thickness of 5 mm and distance across of 6 mm was set up such that when the split form was opened, the line of split separated the cylinders precisely into two equal parts. The cylinder was opened and shut with the assistance of screws connected to the mold. The mold had a flat top, and on the base surface, it was bolstered by a metal plate (**►Fig. 1**).

To set up the specimens, the mold was split open with the assistance of screws and Mylar strip was placed between two parts of cylinder. Screws were then again fixed to accomplish a complete cylinder. Composite resin was completely stuffed into each half of cylinder with the assistance of Teflon covered instrument (**►Fig. 2**).

STEP 2: The resin was then cured with the assistance of light-curing unit of 418mW/cm^2 force by positioning the tip of the light guide onto the top surface of the composite material which was secured by a Mylar strip (Golden Matrix Strips). Curing of the posterior composite resin was done for 40 seconds as prescribed by the manufacturer.

STEP 3: After curing, the split mold was opened with the assistance of screws and two comparative semicircular halves of resin were acquired. Identification marks were set on the resin cylinder to separate between the top and base surface of resin.

Group I: It consisted of 20 specimens where polymerization of the posterior composite resin (Surefil) was done with the strength of 418 mW/cm2 of qartz–tungsten–halogen-based light unit.

Group II: The methodology attempted for this group was like that of group I except from that the polymerization was finished with the assistance of LED-based light-curing unit having intensity of 450 mW/cm^2. A total of 20 specimens were thus prepared as for group I.

Group III: The polymerization was completed with the assistance of LED-based light-curing unit of power 950 mW/cm^2. A total of 20 samples were also prepared as for group I and II.

Group IV: A total of 20 samples were also prepared in this group similar to above groups with the exception that the polymerization was finished with the assistance of LED-based light relieving unit having output strength of 1,250 mW/cm^2.

Mounting of the specimens: Eighty samples thus obtained from all the four groups were then stored in dry for 24 hours. After storage, the semicircular equivalent halves of resin specimen were then mounted in hollow metallic molds with the assistance of self-cure acrylic resin such that the semiround resin got embedded in the acrylic resin and flat surface showed up at the top of the mold. Before mounting the specimens, separating medium was applied to the inward surface of the hollow metallic mold to encourage the easy expulsion of acrylic blocks with the embedded resin specimens. The acrylic blocks with embedded specimens were then expelled from the metallic molds after setting of acrylic resin (**►Fig. 3**).

Polishing of the specimens: The flat surface of composite specimens embedded in acrylic resin was then grounded gently with the assistance of automated polishing unit followed by hand polishing with various grits of fine emery papers. The final polishing was then performed with automated polishing unit. After polishing, hardness was estimated with microhardness scale testing machine (**►Fig. 4**).

Fig. 1 Materials and equipment used in the study.

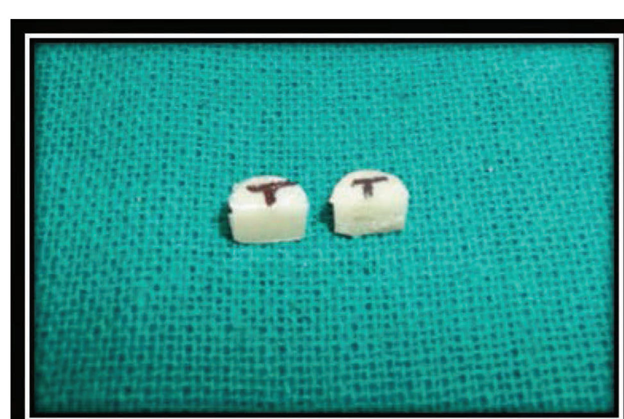

Fig. 2 Posterior composite resin samples.

Results and Analysis

Discussion

The expanding interest for esthetic restorations and dread of mercury harmfulness has driven composite resins to supplant dental amalgam in the restorative dentistry (►Figs. 5, 6).

Since their introduction, the composite resins have experienced constant modifications, going from chemically cured resins to light-cured composite gum. Today visible light activated composite resin have completely supplanted the UV (ultra violet) light cured composite as a result of its favorable circumstances, for example, bring down danger of harm to the patient and operator's wellbeing and more polymerization depth.[2] Most dental composite gum utilize camphorquinone, which has greatest absorption in the blue range of visible light spectrum.[3]

In this study, a special two section split metal mold as recommended by Backer et al was prepared.[4] The depth of cylinder was kept 5 mm due to the manufacturer's claim that the experimental composite resin material Surefill (Dentsply) can be cured upto a depth of 5 mm (Surefil, technical manual).[6] The metal molds were prepared over the propylene and Teflon molds as Yearn (1985) suggested that the metal mold corresponds nearly to cavities in extracted teeth.[7]

Rueggeberg and Craig RG (1988) revealed that microhardness test is more sensitive than other usually utilized methods to measure level of polymerization after 24 hours. After polishing the samples, the microhardness was measured with the assistance of hardness testing machine

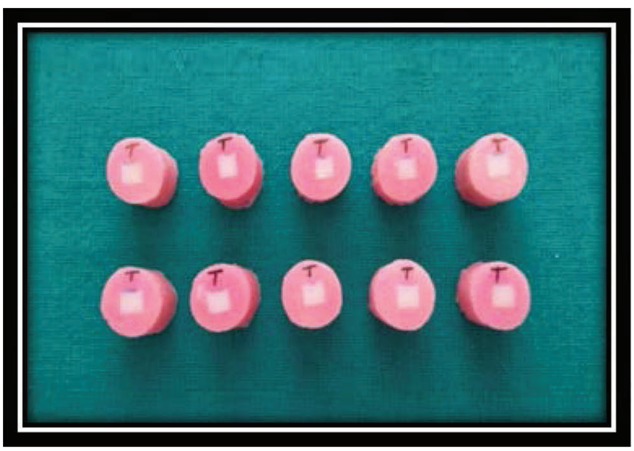

Fig. 3 Acrylic blocks with embedded composite resin samples.

Fig. 4 Indentations obtained on resin surface (see red arrow) at ×100.

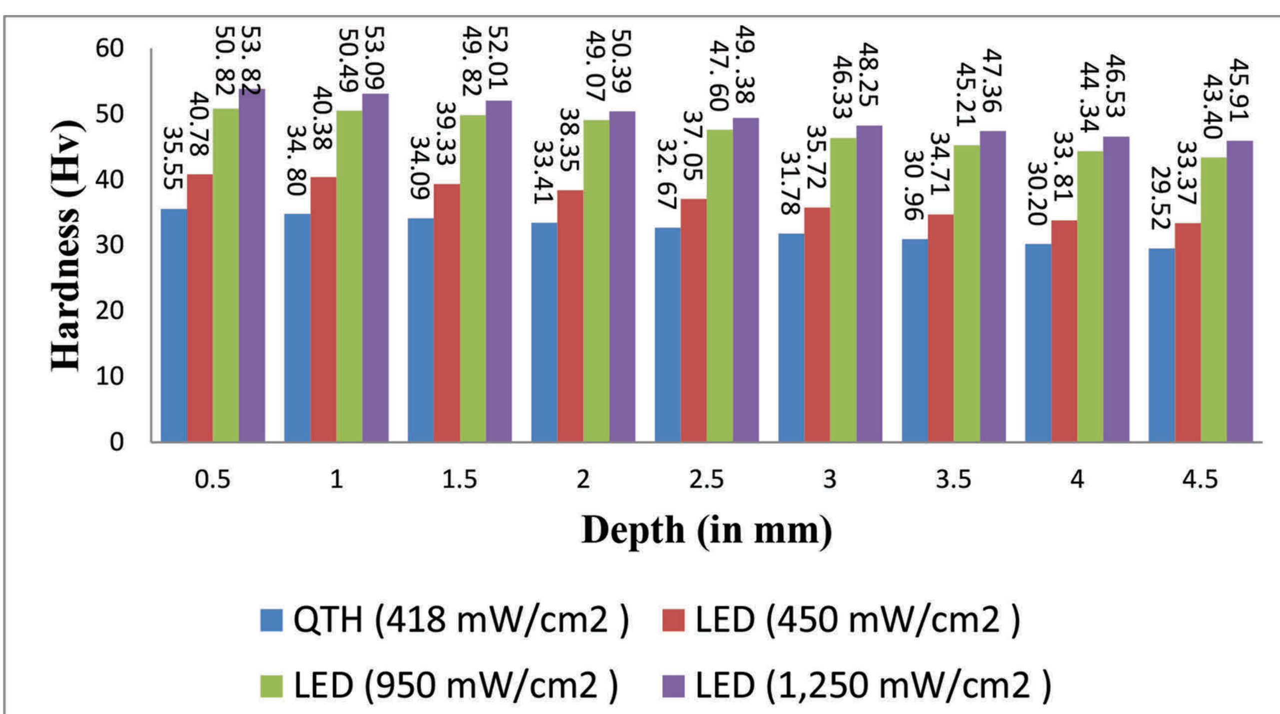

Fig. 5 Bar diagram showing mean Vickers hardness (Hv) achieved at various levels of depth when different light-curing units were used to polymerize posterior composite resin. LED, light-emitting diode; QTH, quartz-tungsten-halogen.

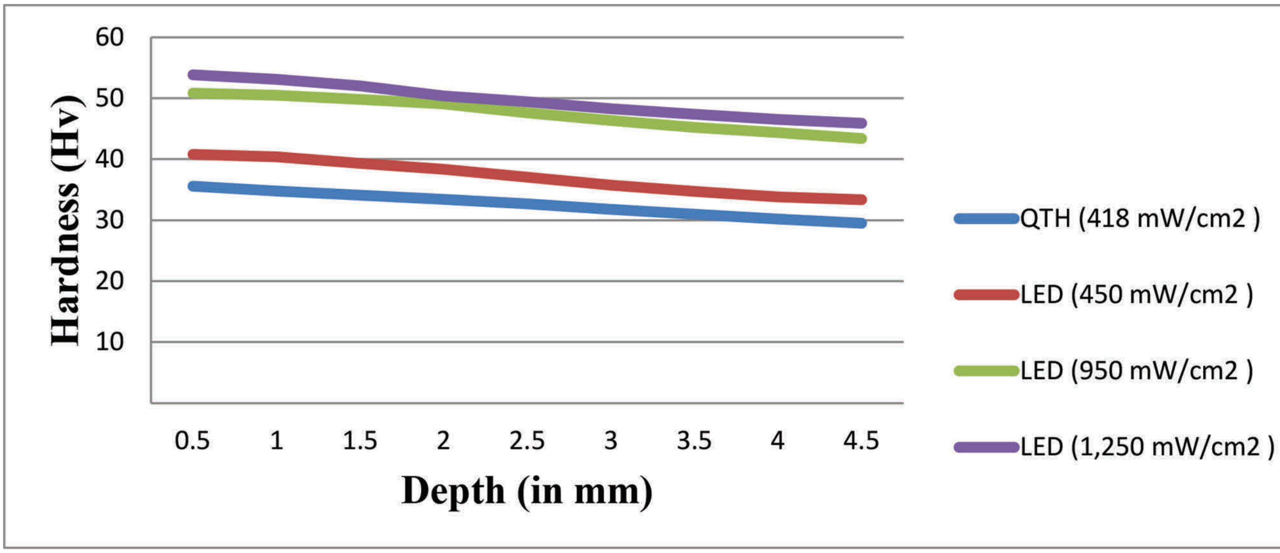

Fig. 6 Line diagram showing mean Vickers hardness (Hv) achieved at various levels of depth when different light-curing units were used to polymerize posterior composite resin. LED, light-emitting diode; QTH, quartz-tungsten-halogen.

(Mitutoyo, Japan). To obtain indentations, a load of 50 grams for 10 seconds was applied. De Araújo et al[8] proposed that a load of 50 grams for 10 seconds is adequate to acquire hardness.[8] Results showed that when exposure time was kept constant, hardness increased as intensity of light-curing unit increased. Sobrinho et al[9] demonstrated similar findings when light intensity was increased, hardness increased regardless of exposure time.[10]

Mills et al[15] additionally obtained similar outcomes that when the exposure time was kept steady and power of light was increased, hardness increased.

The hardness continued to diminish from top to bottom surface of resin, for all light-curing units utilized, showing that the level of polymerization is not uniform throughout the bulk of the material. Ideally hardness of bottom surface ought to be equivalent to hardness of the top surface; however, it is never accomplished because that light intensity diminishes as it goes through the material. Therefore, it is critical to know the level of polymerization which can be considered as satisfactory. Pilo et al (1999)[11] recommended the satisfactory level of polymerization ought to be considered where the bottom hardness value is proportionate to 80% of the surface hardness.[12] When LED light-curing unit of power 1,250 mW/cm^2 (group IV) was utilized to polymerize posterior composite resin, maximum hardness (53.82 Hv and 45.91 Hv) was seen at depth of 0.5 and 4.5 mm, respectively.

Friedman[13] prescribed that the lessening in hardness at the bottom can be compensated by increasing the light intensity. This clarifies the increased hardness at the bottom surface when posterior composite resin was polymerized by LED of force 1,250 mW/cm.[14] Fan PL et al (2002)[10]and Caughman WF (1994)[14] have exhibited that irradiance estimations of no less than 300 mW/cm2 were imperative to adequately cure a composite resin.[12]

Conclusion

From the results of the study, it may be concluded that increased top and bottom hardness can be accomplished by utilizing the light-curing unit of high intensity. However, one ought to know about the potential thermal danger to the pulp with expanded intensity.

Conflict of Interest
None declared.

References

1 Kurachi C, Tuboy AM, Magalhães DV, Bagnato VS. Hardness evaluation of a dental composite polymerized with experimental LED-based devices. Dent Mater 2001;17(4):309–315
2 Correr AB, Sinhoreti MAC, Sobrinho LC, Tango RN, Schneider LF, Consani S. Effect of the increase of energy density on Knoop hardness of dental composites light-cured by conventional QTH, LED and xenon plasma arc. Braz Dent J 2005;16(3):218–224
3 Krämer N, Lohbauer U, García-Godoy F, Frankenberger R. Light curing of resin-based composites in the LED era. Am J Dent 2008;21(3):135–142
4 Backer DJ, Dermaut L, Bruynooghe W. The depth of polymerization of visible-light cured composite resin. Quintessence Int 1985;10:693–701
5 Rueggeberg FA, Craig RG. Correlation of parameters used to estimate monomer conversion in a light-cured composite. J Dent Res 1988;67(6):932-937
6 Surefil TM: high density posterior restorative, technical manual. Available from http://docplayer.fr/53563572-Surefil-high-density-posterior-restorative-directions-for-use-english.html; accessed on October 8, 2018
7 Yearn JA. Factors affecting cure of visible light activated composites. Int Dent J 1985;35(3):218–225
8 de Araújo CS, Schein MT, Zanchi CH, Rodrigues SA Jr, Demarco FF. Composite resin microhardness: the influence of light curing method, composite shade, and depth of cure. J Contemp Dent Pract 2008;9(4):43–50

9 Sobrinho LC, de Lima AA, Consani S, Sinhoreti MAC, Knowles JC. Influence of curing tip distance on composite Knoop hardness values. Braz Dent J 2000;11(1):11–17
10 Fan PL, Schumacher RM, Azzolin K, Geary R, Eichmiller FC. Curing-light intensity and depth of cure of resin-based composites tested according to international standards. J Am Dent Assoc 2002;133(4):429–434, quiz 491–493
11 Pilo R, Oelgiesser D, Cardash HS. A survey of output intensity and potential for depth of cure among light-curing units in clinical use. J Dent 1999;27(3):235–241
12 Neo JC, Denehy GE, Boyer DB. Effects of polymerization techniques on uniformity of cure of large-diameter, photo-initiated composite resin restorations. J Am Dent Assoc 1986;113(6):905–909
13 Friedman J. Care and maintenance of dental curing lights. Dent Today 1991;10(1):40–41
14 Caughman WF, Rueggeberg FA, Curtis JW Jr. Clinical guidelines for photocuring restorative resins. J Am Dent Assoc 1995;126(9):1280–1282, 1284, 1286
15 Mills RW, Uhl A. Jandt KD. Optical power outputs, spectra and dental composite depths of cure, obtained with blue light emitting diode (LED) and halogen light curing units (LCUs). Br Dent J 2002;193(8):459-463