10.5005/jp-journals-10015-1148
ORIGINAL RESEARCH

Analysis of the Effect of Dental Chair Light on the Knoop Hardness of Composite Resin While Light Curing with QTH and LED Light Units

Bandish Parekh, Sucheta Sathe, Vivek Hegde

ABSTRACT

Dental chair lights have been known to rapidly polymerize light-cured composites beyond the point of workability. Often in our dental clinics we are advised to switch off the dental chair light while light curing of dental composites. The purpose of this study was to determine whether the dental chair light causes any effect on the degree of polymerization of light cured composites using the quartz tungsten halogen (QTH) and the light emitting diode (LED) light curing units (LCUs). Filtek Z350 composite samples of 2 × 5 mm were prepared in an acrylic mold. Four groups were made having 20 samples each. In group I and II light curing was done using QTH LCU with and without the dental chair light respectively. Similarly in group III and IV LED LCU was used. Microhardness was measured and compared using Knoop's hardness Test. Data was submitted to ANOVA and Tukey's test. Results showed that the average microhardness was significantly higher in group 4 (LED light curing with dental chair light on). Thus, it was concluded that the dental chair light can be left on while using QTH and LED LCU's during light curing of composite material.

Keywords: Composite resin, Dental chair light, Knoop hardness.

How to cite this article: Parekh B, Sathe S, Hegde V. Analysis of the Effect of Dental Chair Light on the Knoop Hardness of Composite Resin While Light Curing with QTH and LED Light Units. World J Dent 2012;3(2):156-160.

Source of support: Nil

Conflict of interest: None declared

INTRODUCTION

Since their introduction in the 1970, light-activated composite resin restorations have been widely applied in clinical dentistry. A dental composite can be considered as a three-dimensional combination of at least two chemically different materials, with an interface separating the components. Basically, they are composed of an organic matrix, fillers (glass, quartz and/or melted silica) and a coupling agent, such as an organic silane, a photoinitiator, such as camphoroquinone and other components, such as inhibitors, opacifiers and color pigments.

To initiate polymerization, light curing is performed with visible light in the blue area range of the electromagnetic spectrum to excite camphoroquinone that possesses an absorption spectrum in the interval between 400 and 500 nm. The most efficient wavelength for polymerization would be 468 to 470 nm.[1]

Quartz tungsten halogen (QTH) and light emitting diodes (LED) light cure units (LCUs) are commonly used light sources for composite polymerization. Despite their popularity, the halogen units present several limitations, such as gradual reduction in energy output over time due to bulb and filter degradation, limited depth of cure and relatively longer exposure time is required.[2] LED LCUs have proved to overcome these shortcomings and are thus preferred over QTH LCUs.[3]

In a dental office, while light curing of resin-based materials, we usually shut the dental chair light. An interference of the blue light due to the yellow dental chair light is suspected for the same, however, its effect on the intensity of the light in any way is still unknown. A reduction in the intensity of the polymerizing light source would retard the degree of conversion of the composite material.[4] The mechanical properties of composite resin are directly influenced by the degree of conversion.[5]

Thus, any attenuation in the intensity of light reaching the surface of composite could decrease the mechanical properties of the polymerized composite structure.

The aim of this study was to determine whether the dental chair light causes any effect on the microhardness of light cured composites using the QTH and the LED LCUs.

MATERIALS AND METHODS

A total number of 80 samples were prepared. A stainless steel split mold was made to accommodate composite disks of 2 mm depth and 5 mm diameter (Fig. 1). A nanocomposite (FiltekZ 350:3M Z350, USA) of shade A2 was used. Using composite instruments (InSci, Equinox) the material was packed into the split mold holding the two parts of the mold together firmly by the thumb and the index finger (Fig. 2).

QTH (QHL Dentsply) and LED (Radii, SDI) LCUs were used to cure the samples. The light intensity of both the curing units was measured with a radiometer (Curing Radiometer, Optilux 501) to ensure consistency in the output. A brand new 55W 12 V light bulb (Philips, India) in the dental chair light unit was used for the study and kept at a distance of 50 cm from the stainless steel mold. Light curing was carried out using QTH and LED LCUs in each sample for 20 seconds.

Fig. 1: Stainless steel mold

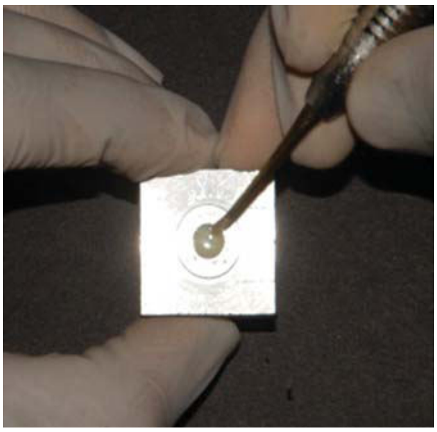

Fig. 2: Packing of composite into the split mold

Fig. 3: Group I QTH light curing without dental chair light

Fig. 4: Group II QTH light curing with dental chair light

Fig. 5: Group III LED light curing without dental chair light

Fig. 6: Group IV LED light curing with dental chair light

The samples were divided into four test groups as follows:

Group I: Light curing was carried out in 20 samples with QTH LCU and keeping the dental chair light switched off (Fig. 3).

Group II: Light curing was carried out in 20 samples with QTH LCU and the dental chair light switched on (Fig. 4).

Group III: Light curing was carried out in 20 samples with LED LCU and keeping the dental chair light switched off (Fig. 5).

Group IV: Light curing was carried out in 20 samples with LED LCU and keeping the dental chair light switched on (Fig. 6).

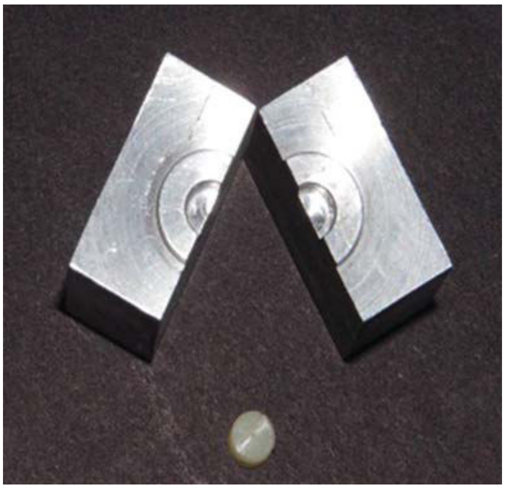

Fig. 7: Retrieval of one sample after splitting the mold

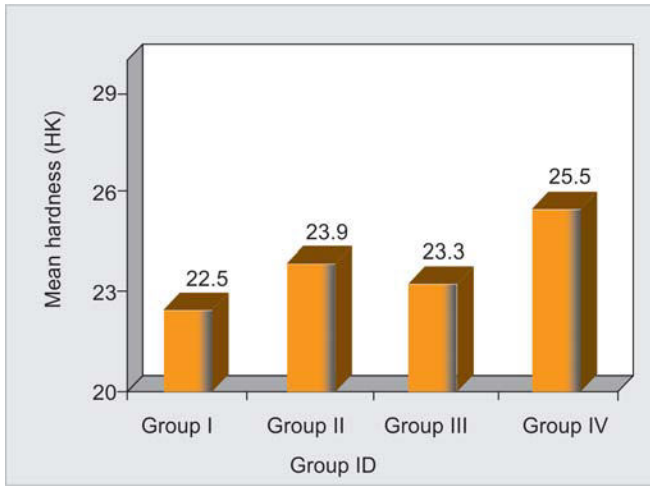

Fig. 8: Comparison of groups

The samples were then retrieved by seperating the split ends of the mold (Fig. 7). The under surface of the samples were then finished with wet 400, 600 and 1,200 grit Al_2O_3 abrasive paper (Carborundum, Saint-Gobain Abrasivos Ltda, Cruz de Rebouças/Igaraçu, PE, Brazil) and then polished with 3 and 1 µm diamond paste (Arotec Ind. Com., Sao Paulo, Brazil) using a polishing cloth.

The samples were then submitted to a microhardness testing machine (HMV-2000, Shimadzu, Japan). Microhardness was measured by means of a Knoop indenter under 25 gm load and 20 seconds dwell time. For depth, the values read referring to the size of the greater diagonal were transformed into knoop hardness number (KHN) and the average of the values was calculated. Data was submitted to two-way ANOVA/Tukey's test with a global significance level of 5%.

RESULTS

The average values of groups I, II and III were not significantly different from each other. Average microhardness was significantly higher in group 4 (LED light curing with dental chair light on) as compared to the other groups (Table 1) (Fig. 8).

Table 1: Comparison of groups

Groups	*Hardness (HK) mean*
Group I (QTH)	22.5 (1.3)
Group II (QTH + chair light)	23.9 (1.5)
Group III (LED)	23.3 (2.5)
Group IV (LED + chair light)	25.5 (2.1)

DISCUSSION

It is estimated that 280 mW/cm^2 is the minimal intensity necessary to adequately polymerize a 2-millimeter-thick increment of universal shade composite.[6] Composite increments should be no greater than 2 mm to provide homogeneous hardness following sufficient photo-activation.[7-9] Hence, the stainless steel mold was thus made of 2 mm depth. Knoops hardness was tested on the lower surface of the composite samples. The interference of light was thus, calculated with respect to the maximal permissible depth.

According to the manufacturers recommendations, the composite resin samples were light cured for 20 seconds each. QTH and LED LCUs are most widely used light cure units. QTH LCUs produce a broad wavelength spectrum and thus need a filter to reduce output of undesired wavelengths. This helps in delivering light in the 410 to 500 nm region of the visible spectrum. Halogen light bulbs generate light when electrical energy heats a small tungsten filament to extremely high temperatures which are responsible for QTH light bulb or filter deterioration. As a result, the power density is decreased thereby reducing the lifetime of the unit to 30 to 50 hours. On the other hand, LED LCUs produce a narrow band of wavelength, specifically chosen to excite the camphoroquinone, and last for thousands of hours because they convert electricity into light more efficiently, producing less heat.[10]

The effectiveness of composite polymerization can be evaluated by direct and indirect methods. The direct methods that determine the degree of conversion of a composite material are fourier transformed infrared spectroscopy (FTIR) and Raman spectroscopy.[11,12] Among the most used indirect methods are the hardness tests.[13] According to certain studies, microhardness is a more reliable method to

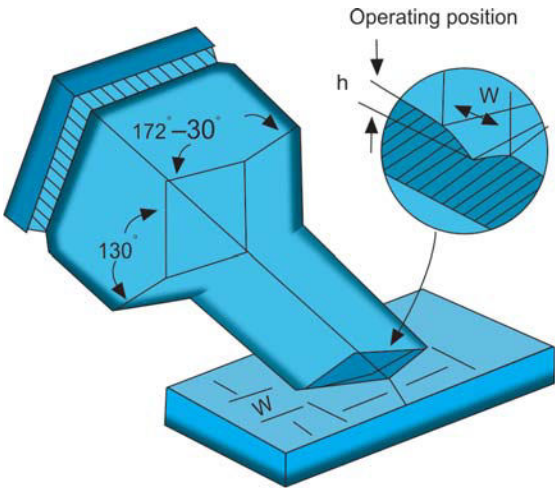

Fig. 9: Knoop hardness test

study degree of conversion.[14-16] This is because spectroscopy is sensitive to changes in the first stages of curing whereas microhardness is more sensitive for detecting small changes after the network is cross linked.[17]

Knoop's indenters are frequently used in studies concerning dental composite samples measuring the microhardness.[18] It provides a good parameter to measure microhardness in a light-curing composite.[3] A pyramidal diamond point is pressed into the polished surface of the test material with a known force, for a specified dwell time, and the resulting indentation is measured using a microscope. The geometry of this indenter is an extended pyramid with the length to width ratio being 7:1 and respective face angles are 172 degrees for the long edge and 130 degrees for the short edge (Fig. 9). The depth of the indentation can be approximated as 1/30 of the long dimension.

The Knoop hardness HK or KHN is then given by the formula:

$$HK = \frac{\text{Load (kgf)}}{\text{Impression area (mm}^2\text{)}} = \frac{P}{C_p L^2}$$

L = Length of indentation along its long axis
C_p = Correction factor related to the shape of the indenter, ideally 0.070279
P = Load

CONCLUSION

Within the limitations of this study, the following conclusions are made:

1. QTH light curing with dental chair light (group II) and LED light curing with dental chiar light (group IV) showed statistically higher microhardness value as compared to QTH light curing without dental chair light (group I) and LED light curing without dental chair light (group III) respectively.
2. Dental chair light may be switched on while light curing using QTH and LED LCUs for better mechanical properties of composite restoration.
3. Dental chair light seems to be capable of initiating polymerization in composite resin and is advised to be switched off when being packed or molded.

REFERENCES

1. Nomoto R. Effect of light wavelength on polymerization of light-cured resins. Dent Mater J 1997;16:60-73.
2. Nomoto R, Uchida K, Hirasawa T. Effect of light intensity on polymerization of light cured composite resins. Dent Mater J 1994;13:198-205.
3. Price RB, Felix CA, Andreou P. Knoop hardness of ten resin composites irradiated with high-power LED and quartz-tungsten-halogen lights. Biomaterials 2005;26:2631-41.
4. McCabe JF, Carrick TE. Output from visible-light activation units and depth of cure of light-activated composites. J Dent Res Nov 1989;68(11):1534-39.
5. Ferracane JL. Correlation between hardness and degree of conversion during the setting reaction of unfilled dental restorative resins. Dent Mater 1985;1:11-14.
6. Rueggeberg FA, Caughman WF, Curtis JW Jr. Effect of light intensity and exposure duration on cure of resin composites. Oper Dent 1994;19(1):26-32.
7. Davidson CL. Resisting the curing contraction with adhesive composites. J Prosthet Dent 1986;55:446-47.
8. Lutz F, Krejci I, Barbakow F. Quality and durability of marginal adaptation in bonded composite restorations. Dent Mater 1991;7(2):107-13.
9. Rueggeberg FA, Ergle JW, Mettenburg DJ. Polymerization depths of contemporary light-curing units using microhardness. J Esthet Dent 2000;1(6):340-49.
10. Burgess JO, Walker RS, Porche CJ, Rappold AJ. Light curing—an update. Compend Contin Educ Dent 2002;23:889-906.
11. DeWald JP, Ferracane JL. A comparison of four modes of evaluating depth of cure of light-activated composites. J Dent Res 1987;66:727-30.
12. Luis C Mendesa, Andrea D, Tedescob, Mauro S Mirandab. Determination of degree of conversion as function of depth of a photo-initiated dental restoration composite. Polymer Testing June 2005;24(4):418-22.
13. Park SH, Krejci I, Lutz F. Microhardness of resin composites polymerized by plasma arc or conventional visible light curing. Oper Dent 2002;27:30-37.
14. Alaçam T, Uzun Ö, Kivanç BH, Yoldas O, Görgül G, Tinaz C. Microhardness of packable composites used as posts condensed with different methods. J Endod 2004;30:51-53.
15. Watts DC, Am OM, Combe EC. Surface hardness development in light-cured composites. Dent Mater 1987;3:265-69.
16. Yap AU. Effectiveness of polymerization in composite restoratives claiming bulk placement: Impact of cavity depth and exposure time. Oper Dent 2000;25:113-20.
17. Santos GB, Medeiros IS, Fellows CE, Muench A, Braga RR. Composite depth of cure obtained with QTH and LED units assessed by microhardness and micro Raman spectroscopy. Oper Dent Jan-Feb 2007;32(1):79-83.

18. DeWald JP, Ferracane JL. A comparison of four modes of evaluating depth of cure of light-activated composites. J Dent Res 1987;66:727-30.

ABOUT THE AUTHORS

Bandish Parekh (Corresponding Author)

Postgraduate Student (3rd year), Department of Conservative Dentistry and Endodontics, MA Rangoonwala College of Dental Sciences and Research Centre, Pune, Maharashtra, India, e-mail: bandish@gmail.com

Sucheta Sathe

Professor, Department of Conservative Dentistry and Endodontics MA Rangoonwala College of Dental Sciences and Research Centre Pune, Maharashtra, India

Vivek Hegde

Professor and Head, Department of Conservative Dentistry and Endodontics, MA Rangoonwala College of Dental Sciences and Research Centre, Pune, Maharashtra, India