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Curing of posterior dental composites - A surface microhardness study

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ABSTRACT

Background: Adequate cure of the photo activated polymer and sufficient light intensity is important for optimal mechanical properties, polymerization and strength of the composite material. This study establishes the relationship between the light intensities produced by 2 different light curing systems - a Light emitting diode (LED) and a Halogen light curing system, the distance of the curing tip to the composite and its effect on the surface microhardness changes at various depths of 2 dental composite systems. Methodology: Ten samples each of 2 posterior composite materials were prepared at 2 depths using customized moulds and cured at 0mm and 2mm distance from the light source. The Knoop hardness number of the top and bottom surfaces of the blocks were assessed following their respective treatments and subjected to statistical analysis using the paired and unpaired T test ($p<0.01$). Conclusions: Proximity of light source to the photo-activated material influenced the surface hardness of the light activated restorative material. LED produced superior surface hardness than the halogen light curing system, though significant variations weren't observed.

KEYWORDS

Dental composite;
Light emitting diode;
Halogen light curing systems;
Microhardness;
Curing.

INTRODUCTION

An important milestone in the history of modern restorative dentistry is the development of light-cured composite resins for direct procedures[1]. They are most widely preferred for advantages such as esthetics, improved physical properties and operator's control over the working time[2]. Improvements in the mechanical properties of composite resin and in the light curing devices used to polymerize them have permitted their use with greater reliability than was the case few years ago[3].

Adequate polymerization is a crucial factor in obtaining optimal physical performance to improve the clinical durability of resin composite materials[4]. However, there are several variables affecting the amount of light energy delivered to the top and bottom surfaces of a resin composite restoration. These include the design and size of the light guide, distance of the light guide tip from the resin composite, power intensity, exposure duration, shade and opacity of the resin composite, increment thickness and material composition[5].

The first light emitting diode (LED) light curing units were introduced marketing in 2001 as an alternative to the conventional halogen lamps. LEDs are highly efficient light sources that produce light within a narrow spectral range. Overtime only little degradation of light output is observed and they do not produce heat. LED units feature very narrow spectral ranges and are, therefore, highly efficient light sources[6]. Operating around 470 nm, with a bandwidth of about 20 nm, blue LEDs have all the spectral purity for highly efficient curing of resin composites[7]. Some studies have demonstrated good performance of these units in terms of an adequate depth of cure and flexural strength[8,9]. This study aimed to compare and establish a relation between the curing light intensities produced by a conventional light source and an LED, the distance of the curing tip and its effect on the surface microhardness changes at various depths of 2 newer composite systems.

MATERIALS AND METHODS

Eighty cylindrical specimens each of Microhybrid resin composite Z100 (3M-ESPE Dental products) and Posterior composite Solare P (GC Corp., Tokyo, Japan) were prepared in customized acrylic ring molds. The circumferential internal diameter of the resin restorative specimens was 8mm, while the depths were prepared at 2 mm and 4mm. The mold cavity was randomly filled in a single increment and polymerized according to the manufacturer's instructions at 0mm and 2mm distance from the light source.

Two polymerization modes were used as follows:

Conventional - using an XL 3000 halogen curing light (3M-ESPE, Grafenau, Germany) at an intensity of 300 mW/cm^2 measured by a photometer.

LED - using an Elipar Freelight (3M-ESPE, Grafenau, Germany) at an intensity of 360 mW/cm^2.

Each specimen was removed from its mold and stored in a lightproof container at 37°C with a relative humidity of 95% (± 5) for 24 hours. 10 samples each were studied in the 2mm and 4mm groups respectively of both the restorative materials. The samples were then washed and the microhardness on the bottom and top of each specimen was tested using a Knoop hardness tester [Clemex, Model MMT-X7, Matsuzawa Co. Ltd, Japan] at the National Institute of Technology, Mangalore, India. A 25gf load was applied through the indenter with a dwell time of 10 seconds. Five measurements were taken at the approximate center of the specimen as was done by Price et al. (2002)[5]. Ethical approval and protocol authorization for the study was provided by the Institutional committee for ethics and research, affiliated to the Rajiv Gandhi University of Health Sciences, Bangalore, India.

Statistical analysis

The results were assessed using the Statistical Package for Social Sciences (SPSS) version 17.00 and MS-Excel. The student's paired sample T-test compared the mean surface microhardness between the top and bottom surfaces of the same block in a group. The student's T-test for independent samples compared the differences in microhardness between the samples cured with conventional and LED light systems. $p<0.01$ was considered significant.

RESULTS

Microhardness changes at 0mm & 2mm curing distance

The surface microhardnes of the posterior composite restorative materials were assessed at the top and bottom surfaces following light polymerization. The Microhybrid resin composite Z100 was noted to have superior microhardness values when compared to Solare P. However, both the restorative materials showed a similar pattern of decreased hardness at the bottom surface as the depth of the block increased (TABLE 1 & 2). At 0mm and 2mm distance of the light source to the restorative specimen, the paired samples T Test showed a high statistical significance ($p<0.001$) with all the experimented groups that compared the top to bottom surfaces, indicating that sufficient polymerization of resin composite in deep cavities is essential to maximize the hardness and compressive strength of restorative materials (TABLE 1 & 2).

Comparison between LED and halogen light cure

The efficacy of the 2 light curing systems on poste-

TABLE 1 : Surface microhardness changes (SMH) of restorative specimens at 0mm light polymerization

Restorative specimens	LED		Halogen Light	
	Top	Bottom	Top	Bottom
Solare P (2mm)	40.3 (±3.24)	30.9 (±3.38)	38.1 (±2.132)	32.6 (±2.98)
Solare P (4mm)	40.8 (±3.084)	20.8 (±4.315)	36.56 (±1.39)	24.8 (±4.05)
Z100 (2mm)	73.05 (±4.067)	59.16 (±2.53)	68.76 (±1.91)	61.9 (±1.59)
Z100 (4mm)	73.2 (±3.691)	47.1 (±5.094)	68.33 (±1.9)	41.22 (±6.39)

[Mean SMH (± SD); n = 10]; The surface microhardness changes of restorative materials at 2mm and 4mm depths were assessed by comparing the mean values from their respective top and bottom surfaces. (p<0.001)

TABLE 2 : Surface microhardness (SMH) changes of restorative specimens at 2mm light polymerization

Restorative specimens	LED		Halogen Light	
	Top	Bottom	Top	Bottom
Solare P (2mm)	37.5 (±4.321)	23.6 (±3.13)	34.4 (±3.751)	20.3 (±3.743)
Solare P (4mm)	37.1 (±3.421)	12 (±7.213)	35.2 (±4.054)	10.3 (±3.781)
Z100 (2mm)	67.83 (±3.15)	54.6 (±4.76)	64.7 (±3.321)	49.8 (±2.37)
Z100 (4mm)	67.4 (±2.171)	34.6 (±5.012)	64.6 (±2.316)	30.5 (±1.972)

[Mean SMH (± SD); n = 10]; The surface microhardness changes of restorative materials at 2mm and 4mm depths were assessed by comparing the mean values from their respective top and bottom surfaces. (p<0.001)

rior composites were also assessed based on their surface microhardness changes. Though the LED system produced better mean SMH values over halogen light curing systems, the independent sample student's T test showed a low statistical significance (p<.05). The comparison of surface microhardness between the top to bottom surface of the 2mm and 4mm restorative specimens cured using both LED and halogen light system was however, not statistically significant. This result gave an impression that the surface hardness of the restorative resin was directly related to the depth of cure and the distance of the light source to the restorative material. At increasing depths of the restoration, bulk curing can result in fracture, whatever is the light source for polymerization.

DISCUSSION

Adequate curing of a resin-based composite is paramount to its clinical performance. The photoinitiator used in most composites is activated by light in the 400 to 515-nm wavelength, with 470 nm being the wavelength of peak absorption for the most commonly used photoinitiator (Cook, 1986)[10]. To be effective, a curing light must have sufficient energy in the 400- to 515-nm range to effectively activate the mass or increment of composite being irradiated. The light also must be capable of generating sufficient energy density, or intensity, to cure through the entire thickness of the mass or increment. Many researchers have measured the intensities of curing lights using radiometers, many of which were designed for dental office use[11]. The depth of cure of resin-based composites decreases with decreasing intensity of the curing light[12]. In this study, though the surface hardness values of both the restorative materials faired higher when cured with LED, the values weren't statistically significant (p<.07) when compared to those cured with the conventional halogen light source.

The performance of biomaterials is most frequently evaluated using laboratory tests[13]. One such parameter is surface microhardness that evaluates material surface resistance to plastic deformation by penetration. By means of this test, an indirect measurement of the degree of conversion can be estimated as well. Top and bottom surface hardness of materials are still a matter of concern. Some studies have shown significant differences between top and bottom surface hardness[14]. However, there are studies revealing no differences, indicating sufficient energy penetration through the material[15,16]. Hence, this method was incorporated in this study to evaluate the influence of light curing time and polymerization mode on the hardness of top and bottom surfaces of resin composite in a clinical situation, when the light curing tip was at 0mm depth from the resin composite during use.

Several researchers over the years have experimented on detecting a suitable method for polymerization, an efficient light curing device, and have also attempted to determine if adequate polymerization of the restorative material occurred under specific conditions[11]. Adequate polymerization is a crucial factor in obtaining the optimal physical performance of resin composite materials[4]. In the current study, the top surface of the restorative specimens presented with improved Knoop hardness values in comparison to the bottom surface, after an exposure for 30 sec and were statistically significant ($p<0.05$). In general, both the restorative materials showed a significant decrease in microhardness with the increase of the depth of cure, and this drop was particularly evident at depths higher than 2 mm from the light source. This feature would definitely compromise the clinical efficacy of posterior composites. A possible explanation for such a performance would be that the polymerization of composite materials rely exclusively upon light activation and thus require maximum proximity to the light source[17]. In addition to this, light-cured composite resins require optimal light intensity, sufficient irradiation time and a maximal thickness to allow the appropriate penetration of light throughout the restorative material is placed in cavity preparation[17].

Using the method described in the present study, the results showed that the time recommended by the manufacturers of light curing devices and resin composites was insufficient for optimum polymerization, mainly on the bottom surface of standardized specimens. The resin composite on the bottom surface disperses the light of the light curing unit. As a result, when the light passes through the bulk of the composite, the light intensity is reduced due to the scattering of light by filler particles and the resin matrix[15]. The results of the present study showed the top surface had higher hardness values than the bottom surface in all experimental conditions. On the top surface, the light intensity is usually sufficient for adequate polymerization[14].

The LED mode produced better SMH values over the conventional mode on the top surface of both the restorative specimens. On the bottom surface, the LED mode did not differ statistically from the conventional mode. The LED has a narrow spectral range with a peak around 470 nm which matches the optimum absorption wavelength for the activation of the Camphorquinone (CQ) photoinitiator[18,19]. While the LED mode usually presents a lower intensity than the other light curing modes, it provides a favorable degree of conversion due to the high degree of overlap within the absorption spectrum of CQ[20].

The current experiment thus highlights that the proximity of light source to the photo-activated material will enhance the surface hardness of the light activated restorative material. It also suggests an in-vitro method for dentists to clinically perform and establish the depth of cure of resin-based composites and periodically verify its consistency in regard to the depth of cure. This would ensure longevity and better fracture toughness of restorative materials in an in-vivo situation.

REFERENCES

[1] J.W.McLean, J.W.Nicholson, A.D.Wilson; Quintessence Int., **25**, 587-589 **(1994)**.

[2] J.R.David, O.M.Gomes, J.C.Gomes, S.D.Loguercio, A.Reis; J.Oral.Sci., **49**, 19-24 **(2007)**.

[3] S.F.Rosenstiel, M.F.Land, B.J.Crispin; J.Prosthet.Dent., **80**, 280-301 **(1998)**.

[4] Y.H.Kwon, T.Y.Kwon, J.L Ong, K.H Kim; J.Prosthet.Dent., **88**, 396-401 **(2002)**.

[5] R.B.Price, T.Derand, R.W.Lonev, P.Andreou; Am.J.Dent., **15**, 47-53 **(2002)**.

[6] C.Besnault, J.P.Attal; Am.J.Dent., **16**, 186-190 **(2003)**.

[7] Jr.F.Garcia-Godody, A.Garcia-Godoy, F.Garcia-Godoy, Composite hardness ratio: Effect of different LED curing systems.IADR/AADR/CADR 82nd General Session; March 10-13 **(2004)**.

[8] K.D.Jandt, R.W.Mills, G.B.Blackwell, S.H Ashworth; Dent Mater., **16**, 41-47 **(2000)**.

[9] D.L Leonard, D.G.Charlton, H.R.Roberts, T.J.Hilton, A.Zionic; Oper.Dent., **26**, 176-180 **(2001)**.

[10] W.D.Cook; Biomaterials **7**, 449-454 **(1986)**.

[11] F.E.Martin; J.Dent., **26**, 239-243 **(1996)**.

[12] A.C.Shortall, E.Harrington; Eur.J.Prosthodont.Restor.Dent., **4**, 71-76 **(1996)**.

[13] E.K.Hansen, E.Asmussen; Acta.Odontol.Scand., **55**, 162-166 **(1997)**.

[14] J.P.Standlee, A.Caputo, S.N.Hokama; Can.Dent.Assoc., **16**, 25-28 **(1988)**.

[15] J.De Backer, L.Dermaut; Quintessence Int., **17**, 635-641 **(1986)**.

[16] J.P.DeWald, J.L.Ferracane; J.Dent.Res., **66**, 727-730 **(1987)**.

[17] M.L.Swartz, R.W.Phillips, B.Rhodes; J.Am.Dent.Assoc., **106**, 634-637 **(1983)**.

[18] S.Suzuki, K.F.Leinfelder, K.Kawai, Y.Tsuchitani; Am.J.Dent., **8**, 173-178 **(1995)**.

[19] M.S.Soh, A.U.Yap, K.S.Siow; Oper.Dent., **28**, 371-377 **(2003)**.

[20] F.A.Rueggeberg, W.F.Caughman, J.W.Curtis Jr., H.C.Davis; Am.J.Dent., **6**, 91-95 **(1993)**.