



COMPARATIVE EVALUATION OF THE VICKERS MICRO HARDNESS AND DEPTH OF CURE OF SELECTED DENTAL COMPOSITES - An In vitro study

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ABSTRACT

Aims and objectives: The current invitro study evaluated Vickers microhardness (VH) and depth of cure (DC) of selected dental composite resins polymerized with either a commercial halogen LCU or LED, LCU respectively.

Materials and Methods: Five dental composite resins were selected for measuring VH (Spectrum TPH, Filtek™ P60, Z₁₀₀, Chitra dual cure, Chitra radioopaque light cure). Four resin composites were investigated for depth of cure measurement. The VH of the surface was determined with a microhardness tester (HMV 2000 SHIMADZU) using a Vickers diamond indenter and a 1kg load applied for 20 sec. Depth of cure was measured using the digimatic calipers.

Results: The results were compared statistically using one way ANOVA for VH. All samples showed statistically significant higher VH values for LED LCU except Z₁₀₀ which exhibited no difference. The mean values were taken into consideration for depth of cure. All samples except Z₁₀₀ showed higher mean value for LEDLCU.

Conclusion: In summary VH and DC of samples cured with Halogen LCU and LED LCU exceeded the values required by ISO standards, manufacturers specifications and clinical demands.

KEYWORDS : Blue light emitting diodes, Vickers Hardness, Depth of cure.

Introduction

Composite resins are widely used in dental restorations as they are mercury free, minimally invasive and esthetically pleasing to the patient. Materials and devices to prepare and cure resins have evolved jointly, passing from chemically cured to the modern form of visible light curing.

Composite resins of thickness 2mm requires a power density of at least a minimum of 400mW/cm² and 20 sec for all curing lights. The most common and popular light curing units are quartz tungsten halogen devices(QTH). However they have some limitations such as lamp filter, reflector part degradation, high thermal emission and short life.^{2,3,4} To overcome the inherent problems of halogen lamps solid state LED's have evolved for curing composite resins. These LEDs are compact, cordless, working life time over 10000 hrs, and wavelength peak of around 470µm which corresponds to the absorption maximum of camphoroquinone photosensitizer. They have less degradation in continual usage, show the minimum decrease of power output and a constant intensity.

Different factors can influence curing degree such as filler particles size, filler loading, polymerisation initiator concentration, monomer type, silanecoupling agent, the shade and translucency of material, intensity and distance of the incident light, wavelength of light, irradiation time, design and size of the light guide and increment thickness. An inadequate curing degree affects the chemical and physical properties of the resin composites such as water sorption, discolouration, wear resistance, strength, elution of the possible irritants, toxicity, hardness, marginal breakdown, bond between the tooth gingiva and the restoration⁵ In order to minimise these undesired effects, a composite resin should be cured to a high degree and to an appropriate depth as well.

Surface hardness is defined as the resistance to surface indentation. The hardness of a composite resin is directly related to the conversion rate of polymerisation light, radiation power and the type of material at the tip of the energy source.^{6,7,8,9,10} Direct tests for hardness such as Fourier transform infrared spectroscopy are expensive, complex and time consuming. In contrast indirect tests are inexpensive and easier to conduct.^{11,12,13,14}

Depth of cure(DC) is the depth to which light is able to harden the

material. This is limited to that distance from the top surface of a cylindrical sample where no more resinous material can be scratched off.^{15,16} Studies have found that depth of cure depends on material filler composition, shade, translucency, intensity of the light source and the distance from the curing unit.^{17,18,19,20,21} The quality of polymerization has been one of the most studied since the introduction of composite resins polymerized by light. Thus there is a need for comparing light sources that promote an appropriate conversion of monomer to polymer so that restoration has optimum physical and mechanical properties.

In the present work, we compare the Vickers Microhardness (VN) and depth of cure (DC) of commercial composite resins cured by different light curing units using standardized samples and methods according to the guidelines for reporting.

Materials and methods

The materials used in this study with their composition are given in Table I.

Compo- site materials	Chitra dual cure	Spectrum TPH	Z ₁₀₀	Filtek™ P ₆₀	Chitra RLC
Manufact urer	SCTIMST, India	Dentsply, Germany	3M Dental products, USA	3M Dental products, USA	SCTIMST, India
Type	Hybrid	Hybrid	Hybrid	Hybrid	Hybrid
Shade	A ₁	B ₁	A _{3.5}	A ₃	A ₂
Filler particle size (µm)	.5 - 7	0.04 - 5	0.01 - 3.5	0.19 - 3.3	0.5- 7
Recomme nded curing time (sec)	40	20	40	20	40
Filler loading	70 Vol. %	57 Vol. %	66 Vol. %	61 Vol. %	70 Vol. %
CQ absorptio n within (400 - 500) nm	Yes	Yes	Yes	Yes	Yes

The tests were carried out at the Dental products laboratory, biomedical technology wing, SCTIMST (Sree Chitra Tirunal institute for medical science and technology).

Twelve specimens were prepared from each composite resin, out of which six were cured by Halogen LCU and the other half by LED LCU. The units used were (Prolite, Dentsply) and (Elipar freelight, 3M ESPE). Composite resins were packed into a silicone spray coated stainless steel mould. Both the ends of the moulds were covered with cellophane sheets and compressed between two steel plates. The samples were then exposed to light sources for 20sec, (Spectrum TPH, Filtek P⁶⁰) and 40 sec (Z₁₀₀, Chithra RLC). After curing the two faces of the samples were ground flat using 240 grit or finer silicon carbide paper and water. The samples were then taken out carefully from the mould and subsequently stored in distilled water in an incubator at 37±1°C for 24±0.5hr before testing. Specimens were then placed in the Vicker's Microhardness tester (HVM2000 SHIMADZU). The instrument was adjusted to deliver a load of 1kg for 20 sec. The VHN was calculated from the measurement of the areas of the diamond imprint. The sample preparation for depth of cure assessment were similar except that it was cured on one side only and there were only 3 samples for each LCU. The thickness of the cured sample was then measured using the digimatic calipers.

Results

Statistical hypothesis was formulated and tested with the help of one way ANOVA tests. The mean value and standard deviations were calculated from six best and consistent values for Vickers microhardness. The depth of cure values were only three in number and hence the mean was taken into consideration. The results are represented in Table 2 and Table 3.

Table 2: VICKERS HARDNESS

Sl. No	Material	Halogen LCU		LED LCU	
		Mean	Standard deviation	Mean	Standard deviation
1.	Chitra dual cure	60.5	0.59	63.40	2.75
2.	Spectrum TPH	54.5	0.71	59.8	0.5
3.	Z ₁₀₀	103	1.86	104	1.26
4.	Filtek P 60	73.2	6.23	84.9	0.85
5.	Chitra RLC	48	1.54	49.8	0.10

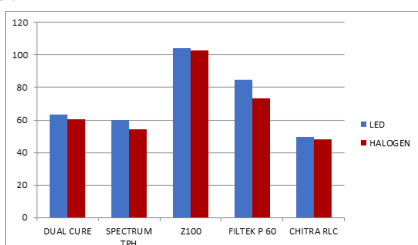
Table 3: DEPTH OF CURE (mm)

Sl. No	Material	Halogen LCU (Mean)	LED LCU (Mean)
1.	Spectrum TPH	4.43	4.90
2.	Z ₁₀₀	4.71	4.37
3.	Filtek P 60	4.01	4.03
4.	Chitra RLC	4.99	5.21

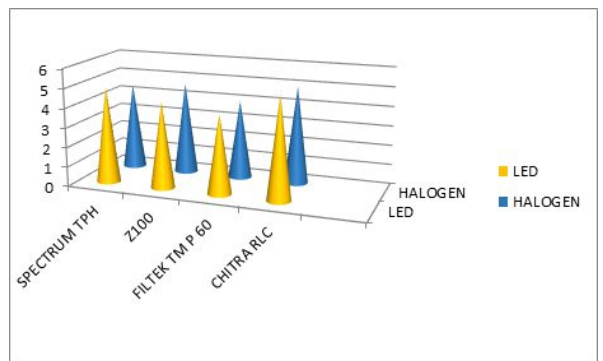
There were statistically significant difference in VH for Chitra dual cure and spectrum TPH for LED LCU (p=0.029 and 3.62x10⁻⁸ resp). Filtek TM P⁶⁰ and Chitra RLC had statistically significant difference for halogen LCU (p= 0.001 and 0.015). Z₁₀₀ showed no statistically significant difference.

Spectrum TPH and FiltekTMP⁶⁰, Chitra RLC give higher DC mean values for LED LCU than Halogen LCU. Z₁₀₀ gave higher mean values for Halogen LCU.

Fig. 1 COMPARISON OF VMH USING LED AND HALOGEN LIGHT SOURCES.



COMPARISON OF DEPTH OF CURE USING LED AND HALOGEN LIGHT SOURCES.



Discussion

A recent series of papers and communication proposes and demonstrates the use of LED, LCU s as alternative source for curing resins.^{22,23,24,25} In this study the curing performance of LED unit was matched against that of a high power halogen unit. Hardness values are an useful indicator of the degree of conversion. Uhl et al²⁶ showed that the degree of polymerisation of composite resins can better be evaluated with knoop or vickers hardness than with the depth of cure tests. Another important consideration related to degree of resin polymerisation is the light intensity delivered by the curing unit. The ISO recommended intensity is 300 mW/cm².²⁷

Hardness evaluation is a widely used test to examine composite curing, which is simple accurate and available. it is especially related to restorative materials that are exposed to high masticatory forces predisposing them to brittle fractures. A material is considered to be hard if it strongly resists indentation by a hard material such as diamond. The resin composite used in this study contains camphoroquinone as the photo initiator and generally such resin composites can be cured efficiently using LED units.^{28,29,30} 95% of the light emitted by a blue LED is within the wavelength range 450- 500 as opposed to 56% for halogen units. All materials tested except Z₁₀₀ gave statistically significant higher values for LED units. Only Z₁₀₀ did not express any difference between the two lights. The highest hardness was noted with Z₁₀₀. Chitra RLC recorded the lowest values (104,48). In this study although the differences in irradiation were large only small differences in Vickers hardness were found which indicates that composite resin properties were equally affected by both LCU. However other parameters like higher irradiance, curing time, influence of curing tips and distance of curing tips definitely requires correlation to microhardness.

Depth of cure still remains a challenge in the application of direct composite resin. The depth of polymerisation is of vital importance not only in order to achieve optimum properties but also to ensure that clinical properties do not arise due to partially polymerised material in the base of the cavity.^{31,32} Depth of cure and shrinkage stresses of dental composites affect the marginal integrity of the restoration. For this reason of investigation of the depth of cure is of scientific interest.

RW Mills et al²⁵ studied the depth of cure of two shades of spectrum TPH cured by both LED and Halogen units. They observed that LED LCU achieved a greater to or equal depth of cure when compared to the commenced Halogen LCU. The results were found to be in agreement with this study. The present study reveals a result in which Elpar free light gave a greater depth of cure (Spectrum TPH) than Prolite. All materials except Z₁₀₀ recorded higher depth of cure values for halogen unit. The greatest depth of cure was recorded with Chitra RLC (5.21, LED) while FiltekTMP₆₀ gave the lowest values (4.01, halogen).

Moreover when depth increases, light intensity decreases from refraction and light absorbance. Since in this study, the composites responded differently to each curing light and at different depths, it

is better to investigate their specific characteristics further by other light curing devices.

All materials polymerized with either the Halogen LCU or LED LCU in the present study fulfill the properties required by ISO 4049. In most cases the values required by the standards were exceeded by both LCU. In the present study, the irradiance of the Elipar free light is 400mW/cm² while that of the Prolite is greater than 300 mW/cm². The rate of polymerization increases only 1.44 lines when the intensity is doubled. A pre requisite to the application of this relationship of the two LCU with different light intensity is that the curing times and all other parameter (material, spectrum of emitted light, tip diameter etc) are kept constant. In the current study these prerequisites are only partially satisfied.

Conclusion

This study evaluated and measured both vickers hardness and depth of cure of selected resin composites. Both the light curing units used in the present study provided resin composites with minimum requirements set by ISO 4049. Clinical studies overtime are necessary to evaluate resin based composites cured by LEDs. However the tested advantages coupled with the data presented in the study provide strong justification the continue the development of blue LED LCUs for dentistry.

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