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A COMPARISON OF POLYMERIZATION BY LIGHT EMITTING DIODE AND HALOGEN BASED LIGHT CURING UNITS ON HYBRID AND NANO COMPOSITES - AN IN VITRO STUDY

Dental Science

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ABSTRACT

AIM: To evaluate the top and bottom hardness of Hybrid and Nano composites polymerized with Halogen based and Light emitting diode light curing unit and Variation in duration of exposure.

MATERIALS AND METHODOLOGY: Sixty Hybrid resin based composite and sixty Nano composite specimens fabricated in 8mm x 2mm stainless steel molds were used for this study. Using two different light curing units: Halogen Based and Light Emitting Diode. The top surface was polymerized for 20/40/60seconds according to the division of each subgroup. The top surfaces were identified with an indelible marker then specimen will be stored in dry lightproof container. Twenty-four hours later indentation were tested using knoop hardness tester of 100gm load and a dwell time of 10sec.The top and bottom surface were checked. Statistical analysis was done using 2-way ANOVA and the interaction effect were tested by scheffe's multiple comparison test ($p<0.001$).

RESULTS AND CONCLUSION: Results showed that the hybrid and nano resin based composite, for all top and botttom hardness, the hybrid producing much higher knoophardness.(for group A,B). The halogen based light curing units produced harder top and bottom resin based composite surface than light emitting diode curing units.(Group A- sub group A, B).From this study we can conclude that the effect of duration for exposure, presents no significant difference with respect to curing units and type of resin based composites in all groups.

KEYWORDS

Hybrid Resin Based Composite, Nano Composite, Halogen Based Light Curing Units, Light Emitting Diode

INTRODUCTION

Resin based composites have currently emerged as the most frequently used esthetic restorative material in dentistry. Methods and devices to cure these resins have also evolved jointly, progressing from chemical cure to modern forms of light curing. [1]

The clinical integrity of resin composite restorations can affected by the curing efficiency of light-cured resin composites and shrinkage stresses induced during polymerization. For this reason, investigation of factors controlling composite photopolymerization reaction is of scientific interest. Apart from the material characteristics, light-curing units significantly influence the polymerization efficiency of light-activated resin composites. The spectral output of the light source, the light intensity emitted, and the curing mode are the most important features associated with the effectiveness of light-curing units.[2]

Quartz-tungsten-halogen (QTH), plasma arc (PAC), Argon laser, and light-emitting diode (LED) are main types of commercially available curing lights. Traditionally, halogen based curing lamps, which use filters to restrict the emitted light to blue region of the spectrum for polymerization have been used to activate the photo initiator system in the composites.[3] The conventional halogen-bulb units emit light intensities up to 400–800 mW cm)[2] . They generate high operating temperature, large quantity of heat, and have a limited effective lifetime of 100 hours.

later Light Emitting Diode (LED) technology has been accepted for dental use, it includes single diode crystals for improved light intensity and illumination coverage specifically for light polymerization. They produce a narrow spectrum of light around 470nm which is ideally suited for composite resin that uses CQ (CamphorQuinone) as photo initiator. The LED have shown to have an effective lifetime of 10,000 h and not to require the use of filters to produce blue light.[4]

In general, total energy—the product of light intensity and exposure time—determines the mechanical properties of the resin composites. If the amount of light reaching the resin composite is reduced, the depth of cure could be decreased.[5]

The surface hardness of dental composites is often used to measure the curing ability of LCUs [6,7] and the depth of cure of resin composites.[8,9] The surface hardness of resin composites correlates with the degree of monomer conversion[6] and is therefore used as an indirect measurement of curing depth in the present study. Knoop hardness measurement is one of the several suitable methods available for the determination of the surface hardness.

Aim of the present Invitro study was to evaluate the top and bottom hardness of hybrid and nano composites polymerized with halogen based and light emitting diode light curing units and also variation in duration of exposure.

MATERIALS AND METHODS:

METHOD OF PREPARATION

Two posterior restorative composites (Filtek Z250, 3M ESPE and CeramX DENTSPLY) of B2 shade and two light curing units (LCUs) were selected for this study. LED (Gnatus), Halogen (Curex).

Two curing regimens were examined using these curing units as detailed in the **Table. 1.**

Table 1: Two curing regimens were examined using these curing units

Light-curing units	Type	Tip (mm)	Energy consumption	Power density (mW/cm3)
Curex	Halogen	8	80w	900

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Gnatus	LED	8	3.6w	150

60 Hybrid resin based composite (Filtek Z250 3M ESPE) and 60 Nano composite specimens fabricated (CeramX, Dentsply), in 8mm x 2mm stainless steel molds were taken for study. Using two different light curing units:

1] Halogen Based
2] Light Emitting Diode

To prepare each specimen, the inner wall of the mold was coated with petroleum jelly to facilitate easy removal of composite after curing. The composite was placed into the mold using plastic filling instrument confined between two opposing acetate strips. The mold along with composite were placed on clear polyester sheet on a flat glass slab, covered with another clear polyester strip supported by a thin, clear cover glass to ensure the sample is flat. The top surface was polymerized for 20/40/60seconds according to the division of each subgroup as shown in **table 2**.

The top surface was identified with an indelible marker, and after polymerization the clear polyester strips were removed and flash material was cut out using a Bard Parker blade no. 15 following which the samples were retrieved from the mold.

Then specimens were stored in dry lightproof container. Twenty-four hours later indentation were tested using knoop hardness tester of 100gm load and a dwell time of 10 second. The top and bottom surface was measured. To ascertain the percentage of depth cure, the bottom surface hardness values were divided by top surface hardness values and multiplied the result by 100.

Data was analyzed using SPSS (Statistical Package for Social Sciences) for Windows release 11.5 (SPSS, Chicago, IL, USA). Two-way ANOVA was used to find the differences between the groups. The interaction effects were tested by scheffe's multiple comparison test.

Table 2: The top surface will be polymerized for 20/40/60seconds according to the division of each subgroup.

	Group	
Subgroup	Group-I Halogen	Group-II–Light Emitting Diode (LED)
Subgroup A - Hybrid resin	Division 1 - 20sec Division 2 - 40sec Division 3 - 60sec	Division 1 - 20sec Division 2 - 40sec Division 3 - 60sec
Sub group B – Nano resin	Division 1 - 20sec Division 2 - 40sec Division 3 - 60sec	Division 1 - 20sec Division 2 - 40sec Division 3 - 60sec

RESULTS:

COMPARISON BETWEEN MATERIAL :

Overall results showed that the hybrid and nano resin based composite,for all top and bottom hardness, the hybrid producing much higher knoop hardness. (table 3 and graph 1).

COMPARISON BETWEEN LIGHT CURING UNITS :

Overall results showed that the halogen based light curing units producing harder top and bottom resin based composite surface than light emitting diode curing units. (table 4 and graph 2).

The main effect of duration for exposure, presents no significant difference with respect to curing units and type of resin based composites.

Table 3: Knoop hardness mean and standard deviation values by surface and groups.

Side	Group	Summary	Halogen	LED	Total
Top	Hybrid	Means	29.5180	22.514	23.516
		Std.Dev.	4.4787	2.3296	3.0686
	Nano	Means	24.2480	20.518	23.883
		Std.Dev.	2.9664	1.4599	4.9956
Bottom	Hybrid	Means	23.3705	19.469	19.919
		Std.Dev.	4.7484	2.2984	3.5902
	Nano	Means	20.7480	13.870	13.809
		Std.Dev.	3.4757	2.2581	2.8568
Ratio	Hybrid	Means	90.2383	78.531	84.384
		Std.Dev.	2.7668	6.9464	7.8980
	Nano	Means	70.8788	48.210	59.5444
		Std.Dev.	5.6407	9.0037	13.6659

Graph 1: Comparison of halogen and Led groups with respect to composites (% of ratio between bottom and top surfacte values)

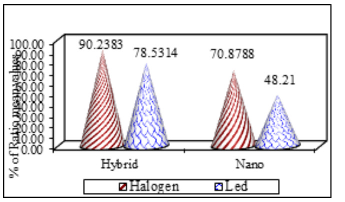
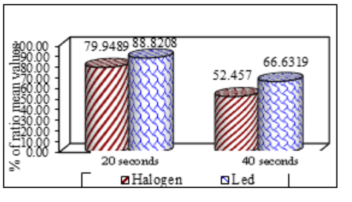


Table 4: Knoop hardness mean and standard deviation values by surface and duration.

Side	Duration	Summary	Halogen	Led	Total
Top	20sec	Means	26.713	20.319	23.5
		Std.Dev.	0.8092	1.461	3.06
	40 sec	Means	25.230	22.53	23.8
		Std.Dev.	5.0173	4.505	4.99
Bottom	20 sec	Means	23.513	16.32	19.9
		Std.Dev.	1.3477	0.464	3.59
	40 sec	Means	23.030	11.58	13.8
		Std.Dev.	0.4771	0.518	2.85
Ratio	20 sec	Means	88.948	79.82	84.3
		Std.Dev.	8.4674	3.862	7.89
	40 sec	Means	66.457	52.63	59.5
		Std.Dev.	13.321	10.00	13.6

Graph 2: Comparison of halogen and Led groups with respect to duration (% of ratio between bottom and top surface values)



DISCUSSION

The ability of LCUs (Light Curing Units) to deliver enough light at appropriate absorption maximums for the respective photo initiators systems in resin-based composites is crucial to optimize the physical properties of light-activated dental materials.[10] Inadequate polymerisation of resin based composites has been associated with inferior physical properties, retention failures, higher solubility and adverse pulpal response to unpolymerised monomers.[11]

Visible light activated resin systems use a diketone absorber to create free radicals that initiate polymerization. Most dental photo initiator system use camphoroquinone as the diketone absorber with the absorption maximum in the blue region of the visible light spectrum at a wavelength of 400 to 500nm.[10]

The effectiveness of composite cure may be assessed directly or indirectly. Direct methods such as Fourier Transform Infrared spectroscopy (FTIR) and Laser Raman spectroscopy assess the true degree of monomer conversion. These methods are not viable for routine use as they are complex, expensive and time-consuming.[11] Indirect methods include scraping and hardness testing. The scraping method has shown to overestimate the depth of cure.[12,13]

Hence in this study, surface hardness measurement has been used to assess the depth of cure as it has been shown to be a better indicator of the degree of conversion. A good correlation between KHN and FTIR has also been reported. A digital micro hardness tester (Indentec, Zwick Roell) was employed due to its relative simplicity and reproducibility.

The knoop hardness test is an accurate indirect method of evaluating polymerization depth.[1] This study revealed significant difference in knoop hardness values for composite type and type of LCU used to polymerize 2-mm thick specimens of resin based composites, the resin-based composites did not adequately polymerize with LED Light curing units as evaluated in this study. According to the criterion that the bottom surface should be atleast 80% as hard as the top surface. The only LCU to exceed 80% is the halogen based (curex) light curing unit.

In this study, the variation of duration for exposure, does not significant differ with respect to curing units and type of resin based composites. As it is better to cure according to the manufactures recommendation.

Overall results of the study showed that the hybrid and nano resin based composite,for all top and bottom hardness, the hybrid producing much higher knoop hardness. This is in agreement with findings of other investigators (phillips,1991 :sturdevant,1995). It is believed that larger particle size and the higher loading percent of the hybrid composite resin compared to that of the nano contributes to this increase in polymerization.

However, the effectiveness of cure cannot be assessed by top surface hardness alone, as this does not predict the hardness at the bottom surface of the restoration [12]. Studies have shown that as light passes through the bulk of restorative material, its intensity is greatly decreased due to light absorption and scattering, thus decreasing the potential to cure. Hence the bottom surface hardness will be affected more than the top surface. Therefore it is important to evaluate the bottom surface hardness also.[14]

Results of this study showed that the halogen based light curing units produces harder top and bottom resin based composite surface compared to light emitting diode curing units ($p< .0001$).

Hofmannet al in 2002 have shown that LED light units with relatively low irradiance of narrow spectral range presented low power output, may result insufficently cured composites and therefore, inferior mechanical properties of the restoration. [15]

Few studies revealed significant difference among LED light curing units to cure the top and botttom surface of a 2mm thick composite specimen. All LEDs tested produced a lower surface hardness than did the Optilux 501 halogen light. [16]

When clinically considered that poorly polymerised resin can lead to undesirable consequences such as gap formation,marginal leakage,recurrent caries,adverse pulpal effects,and ultimate failure of the restoration.[11,17] Bottom hardness greatly influences the long term prognosis of a restoration.[18]

CONCLUSION:

This in vitro comparison study concluded that **:**

- The halogen based light curing units produces significantly harder top and bottom resin based composite surfaces then the LED light curing units.
- When compared with resin based composites, hybrid produced more harder surface then nano composite, regardless of light curing units.
- Effect of duration for exposure in this study presents no significant difference with respect to curing units and type of resin based composites.

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