Original Article

"A COMPARATIVE STUDY OF DEGREE OF CONVERSION (DOC) OF HYBRID COMPOSITE RESINS WITH NANOCOMPOSITE RESINS WHEN EXPOSED TO VISIBLE LIGHT CURE (VLC) UNIT AND LIGHT EMITTING DIODES (LED): AN IN-VITRO STUDY."

Ruchi Dhir Sharma[1], Jaideep Sharma [2], D. ARUNAGIRI [3]

[1] Senior Lecturer, Department of Conservative Dentistry & Endodontics, ,[2] Senior Lecturer, Department of Conservative Dentistry & Endodontics, Himachal Institute of Dental Sciences, Poanta Sahib, H.P

[3] Principal & HOD, Dr. Bhim Rao Ambedkar Dental College,Patna, Bihar.

Abstract

BACKGROUND: Recent advances in resin adhesives and restorative materials, as well as an increased demand for esthetics, have lead to the introduction of newer resin-based composites like nanocomposites and light curing units like Light Emitting Diodes.

AIM: The present study was conducted to evaluate the effect of conventional Quartz Tungsten Halogen (QTH) curing unit and Blue Light Emitting Diode (LED) on degree of conversion of hybrid composite (Filtek Z250, 3M ESPE) and nanocomposite (Filtek Z350, 3M ESPE) resins.

METHOD: Forty brass molds measuring 6±0.2 mm in length and 4mm in diameter were used. The molds were divided into 4 groups of 10 each and were prepared according to restorative resin and light cure unit used- Hybrid/QTH, Nanocomposites/QTH, Hybrid/LED and Nanocomposites /LED. Degree of Conversion was measured by using Scraping method. The results were analyzed using 'One way-ANOVA and Independent t-tests'.

Results: Maximum degree of conversion was obtained for the Hybrid composites exposed both to LED and QTH. LEDs were found to cause greater degree of conversion than QTH in both the composites.

Key words

Nanocomposites, Hybrid Composites, Quartz Tungsten Halogen (QTH), Light emitting Diode (LED), Degree of Conversion, Depth of Cure.

INTRODUCTION

Recent advances in resin adhesives and restorative materials, as well as an increased demand for esthetics, have stimulated a great increase in the use of resin-based composites. Central to the placement of direct tooth-colored resin restorations is the need for adequate resin polymerization. However, despite the remarkable developments in the technology of the restorative resins, clinical failures of resin restorations are still reported due to polymerization shrinkage and low Depth of Cure of restorative materials which in turn causes degradation, substance loss, bulk fracture, discoloration with marginal staining of restoration. This addresses the need to characterize properties like: (a.) polymeric component - to minimize the deleterious effects of contraction stresses developed during polymerization and (b.) candidate light curing unit- to improve the degree of conversion of restorative resin.1

For this reason, several new materials have been developed with modifications in filler technology, filler distribution, filler loading and alterations in the matrices2 like micro-hybrids, packable composites and more recently, nanocomposites that have been added to the vocabulary of restorative dentistry. The nanocomposites consist of two fillers- nano particles and nano clusters which allow higher filler loading, thereby, exhibiting high strength of hybrids and high polishability.

With ongoing focus to facilitate greater degree of monomer conversion, that in turn enhances physical, mechanical and chemical properties, as well as clinical performance in composite resins3 newer curing units have also been developed like QTH, Light Emitting Diodes (LEDs), Plasma Arc (PAC), or laser curing lights. Though halogen-curing lights have been popular for polymerization, they present certain disadvantages like heat generation that can possibly harm the dental pulp, bulb silvering that reduces the intensity of emitted light, gradual loss of light output and frequent bulb-replacement.4

The introduction of LEDs, based on gallium nitride technology, in 1995 is the latest innovation to address the shortcomings in composite materials and light curing units. LEDs use doped semiconductors for the generation of light and present a spectral bandwidth of 440-500nm. They produce minimal heat. Though manufacturers claim better efficiency of LEDs over halogen curing units, there is little information concerning their efficacy in the dental literature.

Hence, this in-vitro study evaluated depth of cured

Address For Correspondence:

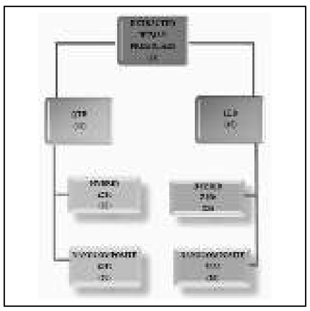
Dr. Ruchi Dhir Sharma, Senior Lecturer, Department of Conservative Dentistry & Endodontics, Himachal Institute of Dental Sciences, Poanta Sahib, H.P.

resin as an estimation of degree of conversion of monomer into polymer in brass molds restored with the microhybrids and nano-composite resins when exposed to QTH curing unit and LEDs.

MATERIALS AND METHODS

The composite resins used in the study included microhybrids (Filtek Z250, 3M ESPE) and nanocomposites (Filtek Z350, 3M ESPE). The light cure units used in the study were- QTH: CU 100 A (Q-LUX) and LED: LITEXTM 695 (DENTAMERICA). The light intensities of both the curing units were comparable (CU-100A: 540mW/cm2; LITEX TM 695: 508mW/cm2).

The Degree of Conversion was evaluated according to the procedure defined by the 'International Standard Organization for Standardization 4049: 2000 (E) 5, for resin – based filling materials. Forty cylindrical brass molds were prepared. Each cylinder had 4mm of internal diameter and 6mm of length. All the molds were measured for accuracy using a 'mm scale' and were standardized to ± 0.2 mm. All the molds were divided into 4 experimental groups of 10 samples each as in Figure 1.



Group wise, each mold was filled with respective composite resin with the help of Teflon coated composite filling instrument, while stabilizing the bottom surface of mold on a glass slab.
Another transparent glass slab was placed on the top surface of the filled mold to extrude any extra resin out of the mold. After removal of the glass slab, a mylar strip was placed on the top surface of the mold. While keeping the tip of respective curing unit on the upper surface of mylar strip, the specimen was cured for recommended time (as per the manufacturer's instructions). Any soft (unpolymerized) composite resin was scraped off from the bottom surface with the help of Teflon coated cement carrier.

The measurement of Degree of Conversion was carried out with the help of Digital Micrometer' and the Digital Callipers', readings were taken for each sample. The digital micrometer measured the highest point of unevenly scraped material and Digital Callipers measured the deepest point of unevenly scraped material.

STATISTICAL ANALYSIS.

Souce of Support: Nill, **Conflict of Interest:** None declared

The statistical analysis for the Degree of Conversion in Hybrid composite resins and Nanocomposite resins on exposure to QTH and LED was analyzed using One- way ANOVA followed by Independent t-tests.

ONE-WAY ANOVA

$$N = n_1 + n_2 + \ldots + n_k \quad and \quad \bar{x}_{.} = \frac{\sum_{j=1}^{k} n_j \bar{x}_j}{N}$$

$$SS_{total} = SS_{ss} = \sum_{j=1}^{k} \sum_{i=1}^{n_j} (x_{ij} - \bar{x}_{.})^2 = \sum_{j=1}^{k} \sum_{i=1}^{n_j} x_{ij}^2 - \frac{\left(\sum_{j=1}^{k} \sum_{i=1}^{n_j} x_{ij}\right)^2}{N}$$

$$SS_{treat} = \sum_{j=1}^{k} n_j (\bar{x}_j - \bar{x})^2$$

INDEPENDENT t-TEST

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2 + s_2^2}{N}}}$$

RESULTS:

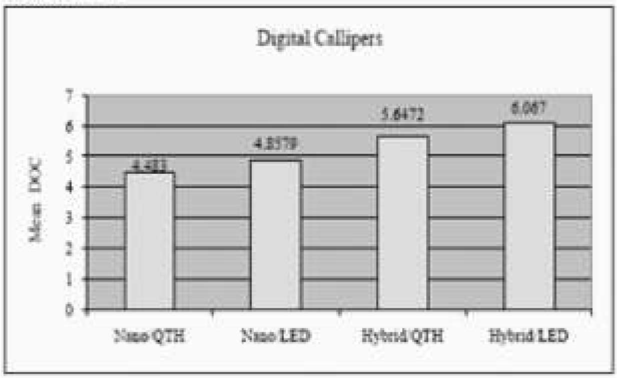
Table 1 and Graph 1 shows the Degree of Conversion measured by Digital Vernier Callipers in each sample in all the experimental groups. It showed that Hybrid Composite showed significantly greater Degree of Conversion ($p < 0.05$) than Nanocomposite on exposure to QTH and LED.
Comparing the means, Degree of Conversion for experimental groups was observed in the following order-

Hybrid Composite exposed to LED > Hybrid Composite exposed to QTH > Nanocomposite exposed to LED > Nanocomposite exposed to QTH.
Table 2 and Graph 2 show the Degree of Conversion measured by Digital Micrometer in each sample in all the experimental groups. Table 3 and Graph 3 show the Mean Values for Degree of Conversion measured by 'Digital Micrometer and Digital Vernier Callipers' in each sample in all the experimental groups.
Both micromeater readings and 'mean of Micrometer and Digital Caliper readings' showed that statistically, HYBRID COMPOSITE showed significantly greater Degree of Conversion ($p < 0.05$) than Nanocomposite on exposure to QTH and LED. Statistically, there was no significant difference in Degree of Conversion for Hybrid Composite exposed to QTH and LED. However, significant difference was observed for LED and QTH curing units in polymerizing Nanocomposites with LED causing greater degree of conversion than QTH. Hence, both micromeater readings and 'mean of Micrometer and Digital Caliper readings' showed that Degree of Conversion was observed in following order-
Hybrid Composite exposed to LED = Hybrid Composite exposed to QTH > NanoComposite exposed to LED > NanoComposite exposed to QTH.
Hence, it can be concluded that Hybrid composites when exposed to LED exhibited greater Degree of Conversion than nanocomposites.

TABLE 1

S.No.	Nano/QTH	Nano/LED	Hybrid/QTH	Hybrid/LED
1	4.38	4.71	6	6
2	4.61	4.48	5.89	6.01
3	4.8	4.62	5.99	6.1
4	4.84	5.369	6.002	6
5	4.42	5.21	5.62	6.26
6	4.7	4.58	5.64	6.1
7	4.45	5.08	5.12	6
8	4.08	5.22	5.78	6.1
9	4.14	4.81	5.88	6
10	4.41	4.5	4.55	6.1
Mean	**4.483**	**4.8579**	**5.6472**	**6.067**
S. Dev	**0.2565173**	**0.3324216**	**0.469187**	**0.08354**

GRAPH 1

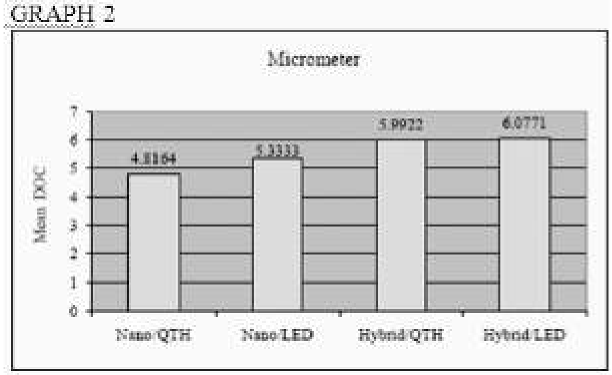


Degree Of Conversion Measured By Digital Vernier Callipers In Each Sample In All The Experimental Groups.

TABLE 2

S.No.	Nano/QTH	Nano/LED	Hybrid/QTH	Hybrid/LED
1	4.569	5.323	6.038	6.023
2	4.696	5.392	5.974	6.123
3	4.841	4.647	6.12	6.112
4	4.844	5.02	6.023	6.003
5	4.555	5.242	6.113	6.124
6	5.118	5.712	6.013	6.133
7	4.839	5.649	5.898	6.004
8	4.996	5.713	5.883	6.134
9	4.71	5.468	6.11	6.001
10	4.996	5.167	5.75	6.114
Mean	**4.8164**	**5.3333**	**5.9922**	**6.0771**

GRAPH 2

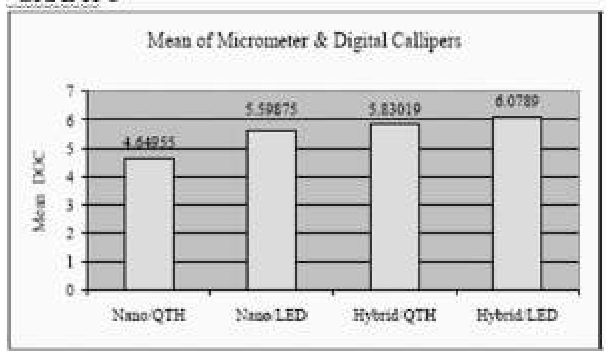


DEGREE OF CONVERSION MEASURED BY DIGITAL MICROMETER IN EACH SAMPLE IN ALL THE EXPERIMENTAL GROUPS.

TABLE 3

S.No.	Nano/QTH	Nano/LED	Hybrid/QTH	Hybrid/LED
1	4.4745	5.016	6.019	6.0115
2	4.648	4.936	5.932	6.066
3	4.8205	9.267	6.055	6.106
4	4.842	5.1945	6.0125	6.001
5	4.4875	5.226	5.9165	6.262
6	4.909	5.146	5.826	6.116
7	4.648	5.364	5.509	6.002
8	4.538	5.866	5.8315	6.117
9	4.425	5.139	6.0454	6.0005
10	4.703	4.833	5.155	6.107
Mean	**4.64955**	**5.59875**	**5.83019**	**6.0789**
S.Dev	**0.168723**	**1.319365**	**0.287251**	**0.082136**

GRAPH 3



MEAN VALUES FOR DEGREE OF CONVERSION MEASURED BY DIGITAL VERNIER CALLIPERS & MICROMETER IN EACH SAMPLE IN ALL THE EXPERIMENTAL GROUPS

DISCUSSION:

Degree of Conversion is defined as the percentage of carbon double bonds converted to single bonds during the polymerization reaction.6 Measurement of the degree of conversion on material is the most sensitive indicator of depth of cure7. In the present study, Scraping Method was chosen because it was simple to perform, reproducible and extensively used by other researchers.8 The Degree of Conversion was evaluated according to the procedure defined by the 'International Standard Organization for Standardization 4049: 2000 (E)' for resin – based filling materials.9

Opaque moulds are used to avoid transmission of light from mould to the composite material. Brass molds were used for the study because they were easily available and satisfied the criteria for mould being opaque.7 After curing, the specimens were evaluated for degree of conversion using micrometer as per ISO Specification 4049: 1988.7 The depth of cure is greater at center than at the edge indicating non-uniform depth of cure of restorative resin across the area of the mould. Scraping pattern of uncured material from the bottom of the mould in our study is in accordance with this observation. Hence, in order to obtain reproducible and comparative results, measurements should always be taken in the center of the mould with the help of micrometer.7 However, in order to obtain exact degree of conversion in all the samples in all the groups, readings for degree of conversion were also taken with the help of Digital Callipers.

Micrometer and mean of Micrometer and Digital Vernier Callipers readings indicated higher degree of polymerization in hybrid composites as compared to nanocomposites on exposure to both the light cure units which is again attributed to increased microgap formations in nanocomposites due to higher filler loading. Also, smaller sized particles in nanocomposites cause scattering of light and decrease it's absorption, thereby, reducing the overall polymerization of material.9 Comparing the curing units, statistically no significant difference was observed for LED and QTH curing units in polymerizing Hybrid Composites. However, regarding nanocomposites, LEDs were found to produce greater degree of conversion than QTH. Such a result can be attributed to narrow spectrum of LEDs which is more close to the absorption spectrum of photoinitiator (Camphorquinone) present in nanocomposite. However, Vernier Calliper readings suggested that LEDs caused greater degree of conversion than QTH in both the composites. Hence, it can be concluded that LED LCUs were as effective as/or more effective than a halogen LCU for polymerization of the composite. It is in accordance with the studies carried out by other researchers.10, 11

CONCLUSION

Within the limitations of this study, it can be concluded that Hybrid composites exhibited greater degree of conversion than Nanocomposite resins which can be attributed to higher filler load and decreased particle size of Nanocomposites. LEDs were found to cause greater degree of conversion than QTH in both the composites which can be attributed to its narrow emission spectrum.

BIBLIOGRAPHY

1. G. Eliades, D.C. Watts, T. Eliades. Dental hard tissues and bonding, Springer Publications, New York 2005; 1st edn.; 123-149.
2. Manhart J, Garcia – Godoy F and Hickel R. Direct posterior restorations : clinical results and new developments; Dent Clin N. Am 2002; 46 :303-339.
3. Luis Eduardo Silva Soares; Rick Rocha; Airton Abrahao Martin; Antonio L. B. Pinheiro; Marcelo Zampieri. Monomer conversion of composite dental resins photoactivated by a halogen lamp and a LED: a FT – Raman Spectroscopy study. Quim. Nova 2005; 28 (2): 229-32.
4. Sarret David C. LED Curing lights; ADA Professional Product Reviews. ADA Fall 2006; 1 (2): 1-5.
5. Kim M. Wiggins, Martin Hartung, Olaf Althoff, Christine Wastian and Sumita B Mitra. Curing performance of a new-generation Light – Emitting Diode dental curing unit. J. Am Dent Assoc 2004; 135 (10) 1471-1479.
6. De Wald J.P, Ferracane J.L. A comparison of four modes of evaluating Depth of Cure of light-activated composites. J Dent Res 1987; 66 (3) : 727-73.
7. Harrington E, Wilson H.J. Depth of cure of radiation-activated materials- effect of mould material and cavity size. J Dent 1993; 21: 305-311.
8. Lui J.L, Chan C.L, Yap K.T. Depth of polymerization of a new nanocomposite according to different exposure times and shades. Annal Dent Univ Malaya 2006; 13: 6-11.
9. William J Dunn, Anneke C. Bush A comparison of polymerization by Light Emitting Diode and Halogen-based light curing units. J. Am. Dent Assoc 2002; 133: 335-341.
10. Attar N, Korkmaz Y. Effect of two Light-Emitting Diodes (Led) and one Halogen curing light on the microleakage of Class V flowable composite restorations. J Contemp Dent Pract 2007; 8 (2): 80-88.
11. Campregher UB, Samuel SMW, Fortes CBB, Medina ADDC, Collares FMC, Oliari FA. Effectiveness of Second-Generation Light –Emitting Diode (LED) Light Curing Units. J Contemp Dent Pract 2007; 8(2): 35-42.

Souce of Support: Nill, **Conflict of Interest:** None declared

