Heat generation with the use of LED curing device

Dr. Shatha Abdullah Salih
Conservative Department,College of Dentistry,
Medical Hawler University

الخلاصة

الغرض من هذه الدراسة المختبرية هو لتقييم تولد الحرارة باستخدام جهاز البلمرة الضوئي (الضوء الباعث للدايود) على السطح الخارجي للسن وكذلك الحرارة المتولدة داخل اللب, ومقارنته بجهاز البلازما ارك والجهاز التقليدي للبلمرة الضوئية.

حفرت حفرة من النوع الخامس على السطح الخدي و اللساني ل (15) سن من الاسنان العلوية المقلوعة من الضواحك, ووزعت الاسنان عشوائيا الى ثلاثة مجاميع حسب طريقة البلمرة:

المجموعة الاولى صلبت بواسطة الجهاز التقليدي للبلمرة الضوئية.

المجموعة الثانية صلبت بواسطة جهاز البلمرة الضوئي (الضوء الباعث للدايود).

المجموعة الثالثة صلبت بواسطة جهاز البلازما ارك.

كل مجموعة تتكون من 5 اسنان (10 حفر) ملئت بالحشوة الراتنجية الضوئية, قبل استخدام الجهاز الضوئي تم استخدام اثنين من المتحسسات الحرارية, احدهما ادخل داخل اللب والاخر ملاصق للسطح الخارجي للسن.

سجلت قرائتين لازدياد الحرارة قبل وبعد البلمرة والاختلاف بين القرائتين سجل خارجيا وداخليا.

اظهر التحليل الاحصائي بان جهاز البلمرة الضوئي (الضوء الباعث للدايود) تسبب في اقل زيادة في الحرارة المتولدة على السطح الخارجي للسن وفي داخل اللب.

Abstract

Objective: The purpose of this in vitro study was to evaluate heat generation with the use of LED curing device externally (on the outer surface of the tooth)& internally (inside the pulp chamber), in compares with plasma arc & conventional curing device

Materials & Methods: On the buccal and palatal surface of fifteen upper extracted premolar teeth a standardized class V cavity was prepared, the teeth were randomly divided into three groups according to the cure mode, group I cured with DentSuply (Conventional cure unit QTH), group II cured with Radii (LED cure unit) and group III cured with Flipe .(Plasma arc cure unit) .

Each group consist of 5teeth (10 cavities), and filled with (micro-hybrid resin composite), before light curing of the composite resin a thermocouple was inserted into the pulp chamber .A second thermocouple was attached on the surface of the tooth; the other end of the thermocouple was connected with an electrical thermometer. Two reading of temperature increasing were measured. Then the difference between the initial and final temperature was recorded externally and internally.
Results: Statistical analysis of the results revealed that the LED light curing unit had the least increase in the temperature with a significant difference (P<0.001) when it was compared with plasma arc curing device externally & internally. In spite of statistically a significant difference between LED & conventional curing device externally (P<0.001) and the lower temperature mean was found with LED internally, no significant difference between LED & conventional curing device internally.
Conclusion :LED light curing unit had the least increase in the temperature at the outer surface of the tooth and inside the pulp chamber.

Introduction

Since restorative resin composites were introduced into dentistry in the mid- 1960, these materials have developed significantly (Obici et al, 2002), they are the most frequently used direct tooth colored restorative materials (Aguiar et al, 2002) and there curing with visible light is the standard method of clinically polymerizing composites (Yap et al, 2001).

However, despite considerable scientific effect, one of the side effects which have to be taken into account is the temperature increase during polymerization (Althoff & Hartung, 2000). Light curing units produce heat during operation (Lony, 2001).

For nearly two decades conventional quartz tungsten-halogen (QTH) curing lights have been the standard equipment used for polymerizing composite resins. However, these lights have a number of inherent limitations such as degradation of the bulb, filter, reflector, and a limited effective lifetime.

In recent years technologies such as the light-emitting diode (LED) and plasma arc curing lights (PAC) have been introduced to the dental profession as alternatives to conventional curing units (Yazici, 2007). Commercial LCUs using light emitting diodes (LEDs) have recently become established on the market (Uhl A et al, 2003). (LED) polymerization of dental restorative materials has become increasingly popular.(Owens & Rodriguez, 2007). LED technology appears to be an effective alternative for curing of light-activated esthetic restorative materials. (Owens & Rodriguez, 2007), even though some aspects of their performance have not been fully investigated. Temperature rise of dental composites during the light-induced polymerization is considered to be a potential hazard for the pulp of the tooth (Uhl A et al, 2003). Therefore, clinicians should be aware of the potential thermal hazard to the pulp which might result from visible-light curing of composite resins (Hannig & Bott, 1999). Since most dentists are familiar with the conventional quartztungsten-halogen (QTH) curing light technique, so they should be cautious when using these alternative sources of light to polymerize resin based composite (Fortin & Vargas, 2000).

Materials and Method

1 - Samples Collection:

Fifteen sound upper premolar teeth freshly extracted for orthodontic purpose were collected and stored in distilled water . then the teeth were scaled by subgingival scaler to remove any calculus on the surface and polished by pumice and rubber cup with contra-angled handpiece at low speed to remove the plaque and debris completely than washed under running water for 30 second .The visual examination of the teeth was done by a magnifying eye lens (x 10) and light from light cure device to check for cracks on the surface of teeth .Fifteen non carious and crack free teeth were selected and stored in distilled water at room temperature.

2 - Teeth preparation:

On the buccal and palatal surface of upper extracted_premolar teeth a standardized class V cavity was prepared, with occlusal margin in enamel and the cervical margin 1mm apical to the cemento-enamel junction at the cervical margin bevelling the enamel would certainly provide for improved retention .However,the danger of reducing or even entirely removing the thin enamel layer argues against the bevel preparation.

Therefore, in accordance with international guide lines a butt-joint finishing line was prepared in the present study for all cavo surface line angles (ADA Protocol guide line 1993)

Cavity dimensions were standardized utilizing a template to trace an out line on both buccal and lingual surface with amesiodistal width and the occlusogingival height of (3mm); the depth of the cavity was 2mm and was calibrated by measuring with a premarked periodontal probe. The cavities were cut using a tungesten carbide fissure bur no.330, in high speed hand piece with proper water cooling.

The cavo surface walls were finished with a stainless steel fissure bur no.53 in the low speed handpiece a new bur for each 5 cavity was used .The preparations were rinsed and dried with a gentle stream air for 20 seconds.

The apices of the roots were removed with a separating disc, and the access through the apex was confirmed by pre-opening the canal through the apex with root canal reamers of size (20-50), root canal and the pulp chamber were excavated.

3 - Sample grouping:

The teeth were randomly divided into three groups according to the cure mode. Each group consist of 5teeth (10 cavities)

1 - Group I: Each cavity filled with (micro-hybrid resin composite) and cured with DentSuply (Conventional cure unit QTH), with constant intensity of approximately 450mw/ cm^2.
2 - Group II: Each cavity filled with (micro-hybrid resin composite) and cured with Radii (LED cure unit), with intensity of 1200mw/ cm^2
3 - Group III: Each cavity filled with (micro-hybrid resin composite) and cured with Flipe. (Plasma arc cure unit) with high intensity of 1340 mw/cm^2

4 - Filling Technique:

Each group filled with (micro-hybrid resin composite) ,of A2 shade, according to its manufacture instruction. By etching all cavity surfaces for 15 seconds with 37.5% phosphoric acid etch , then removed by thoroughly rinsing for 15 seconds and dried lightly, a layer of the bonding was applied to the enamel and dentine surfaces with a light brushing motion and light cured for 20 seconds by conventional curing unit then the placement of the composite resin to the cavity by its applicator ,it was covered with a celluloid strip through which curing of the composite resin according to the three groups.

5 - Temperature measurement:

By using a manikin as a base for each tooth, the teeth were placed into a water bath at 37°c, leaving the crowns and restorations exposed to ambient air. Temperature was measured by a type K thermocouple Before light curing of the composite resin a thermocouple was inserted into the pulp chamber through the apex of the root . A second thermocouple was attached on the surface of the tooth adjacent to the composite resin restoration.

The other end of the thermocouple was connected with an electrical thermometer, which record the temperature after the tooth temperature stabilized; initial temperature was recorded at the two thermocouple location. Another reading was recorded immediately after curing of resin composite, for all samples of the three groups. (Christensen et al, 1999).

Then the difference between the initial and final temperature was recorded in table (1 & 2).

Results

By using two thermocouple (K type) connected with thermometers, the increase of temperature in two locations, internally (inside the pulp chamber) and externally (at the outer surface of the tooth) for all specimens of the three ° C groups, were recorded and they are shown in tab. (1& 2) which show the lowest mean of increasing temperature were recorded externally and internally with group II (LED group), (4.62 ° C , 1.93 ° C) respectively. While the highest mean of increasing temperature were recorded externally and internally with group III (Plasma arc group), (38.54 ° C ,7.9 ° C) respectively.

N	QTH	LED	Plasma
1	1.4 °C	1.9 °C	7 °C
2	0.8 °C	2.2 °C	7.3 °C
3	2.3 °C	0.5 °C	8 °C
4	2.3 °C	0.4 °C	7.5 °C
5	2.1 °C	2.1 °C	11 °C
6	1.1 °C	1.8 °C	6.9 °C
7	2.5 °C	2 °C	8.4 °C
8	2.2 °C	0.8 °C	10.2 °C
9	2.6 °C	1.1 °C	6.2 °C
10	2 °C	1.5 °C	6.5 °C
M*	1.72 °C	1.43 °C	7.9 °C

*M: Mean

Table 1: The increase in temperature internally

N	QTH	LED	Plasma
1	13.8 C	3.3 C	38 C
2	13.1C	4.2 C	40 C
3	14.5 C	5.3 C	38.8 C
4	13.2 C	4.8 c	37.2 C
5	15.2 C	5.1 C	40.4 C
6	14.1 C	5.3 C	38.5 C
7	15.8 C	4.4 C	36.5 C
8	14.3 C	3.3 C	40.6 C
9	13.6 C	5.2 C	39.1 C
10	16 C	5.3 C	36.3 C
M*	14.36 C	4.62 C	38.54 C

Table 2: The increase in temperature externally

The results of t test between group II & I revealed that there was a significant difference ($P<0.001$) between the groups and the mean increasing of temperature externally, but not significant internally as it is shown in table (3). While significant differences were noted between LED and Plasma arc group (II & III) externally & internally are shown in table (4).

Group		N	Mean	SD	DF	T	P
Ext.	QTH (I)	10	14.36	1.021	18	-23.79466204	<0.001 S
	LED(II)	10	4.62	0.795			
Int.	QTH (I)	10	1.93	0.614	18	-1.72494	0..1 N.S
	LED II)	10	1.43	0.679			

Pvalue <0.001= Significant (S), Pvalue >0.05= not Significant (N.S)

Table 3: t- test for temperature measurements externally & internally for group I & II

Group		N	Mean	SD	DF	T	P
Ext.	LED (II)	10	4.62	0.795	18	- 61,7237	<0.001
	Plasma(III)	10	38.54	1.545			
Int.	LED (II)	10	1.43	o.679	18	-11.92324325	<0.001
	Plasma(III)	10	7.9	1.575			

*DF = degree of freedom

Table 4: t- test for temperature measurements externally & internally for group II & III

The bar chart shows that the lowest increase in temperature was with LED group externally & internally as it is demonstrated in fig. (1 & 2) respectively

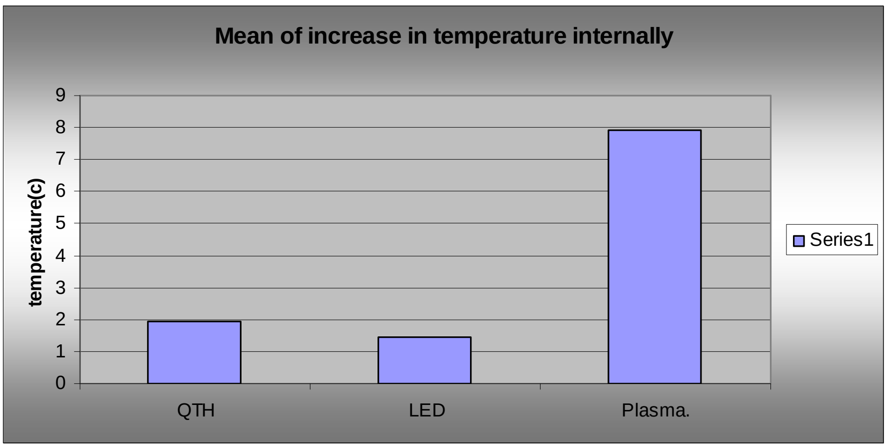

Fig. 1: Peak temperature increase of the three groups internally

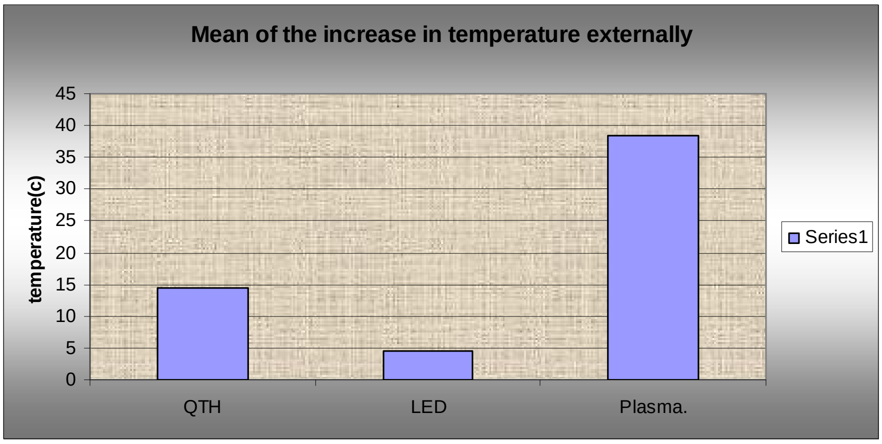

Fig. 2: Bar chart Peak temperature increase of the three groups externally.

Discussion

Because of the risk of thermal damage to the pulp, the temperature rise induced by light-curing units should not be too high.

This study compared the temperature increase in a pulp chamber and on the external tooth surface as a result of using various light-curing units during resin composite polymerization, the lowest temperature rise was observed with light emitting diode and this is because Light-emitting diode (LED) light-curing units are solid-state semiconductor devices that produce a more narrow spectral range that is closer to the absorption spectrum of camphorquinone photoinitiators used in composite resins to facilitate polymerization. So these units generate minimal heat, and no fan is required (Yazici, 2007).

LED (light emitting diode) curing units have the main part of their irradiation in the blue range and have been reported to generate less heat than QTH curing units (Erik & Anne, 2005).

WHILE Plasma Arc Curing (PAC) Lights Manufacturers have focused on reducing the resin curing time by using units with high power density. These units use a high frequency electrical field to generate plasma energy that is transformed into a mixture of ions, electrons, and molecules (Yazici, 2007). So, increased temperatures can arise from application of very intense visible light energy to a substrate as with the use of the PAC unit.

The massage number of photons interacts with the molecules of substrate, which must absorb some of this energy, this absorbed energy result in increased molecular vibration and the generation of heat (Rueggeberg, 1999).

The negative heat generation with LED curing lights agreed with Owens BM & Rodriguez KH,2007, Yazici AR, et al. 2006 & Uhl A et al. 2003.

Conclusion

* The three light curing units caused an increase in temperature inside the pulp chamber and at the outer surface of the tooth.
* LED light curing unit significantly decreased the temperature at the outer surface of the tooth when it was compared with QTH & Plasma arc curing units.
* LED light curing unit significantly decreased the temperature inside the pulp chamber of the tooth when it was compared with Plasma arc curing units.
* In spite of statistically no significant difference between LED & QTH inside the pulp chamber of the tooth the lower temperature mean was found with LED.

References

1 - A.D.A. Protocol Guidelines for Dentin and Enamel Adhesive Materials (1993): Council on Dental Materials. Chicago, USA.

2 - Aguiar, F.H.B.; Santos, A.J.S.; Geoppo, F.C. and Lovadino, J.R. (2002). Quantitative evaluation of marginal leakage 0f two resin composite restorations using two filling techniques .Operative Dentistry 27: 475-479 .45

3 - Althoff Olaf and Hartung Martin (2000). Advances in light curing. American Journal of Dentistry Vol.13 .24

4 - Christensen, R.P.; Palmer, T. and Ploger, P. (1999): Resin Polymerization problems- are they caused by resin cyring lights, resin formulation, or both?Compendium of Continuing Education in dentistry 20(supplement 25)12-54.

5 - Erik Asmussen & Anne Peutzfeldt (2005). Polymerization contraction of resin composite vs. energy and power density of light-cure. European Journal of Oral Sciences 113:5, 417–421.

6 - Fortin & Vargas (2000). Polymerization of resin based composite. JADA (131):295-296.

7 - Hanning, M. & Bott, B. (1999). In-vitro pulp chamber temperature rise during composite resin polymerization with various light curing source. Dent.Marer. Jul; 15(4):275-81.

8 - Loney, R.W. & Price, R.B.T. (2001). Temperature transmission of high-output light-curing units through dentin .Operative Dentistry 26:516-520.18

9 - Obici, A.C. ; Sinhoreti, M.A.C. ; Goes, M.F. de. ; Consani, S. & Sobrinho, L.C. (2002). effect of photo-activation method on polymerization shrinkage of restorative composites .Operative Dentistry27:192-198 .88

10 - Owens, B.M. & Rodriguez, K.H. (2007). Radiometric and spectrophotometric analysis of third generation light – emitting diod (LED) light – curing units. J Contemp Dent. Pract. Feb 1;8 (2):43-51

11 - Rueggeberg, F. (1999). Contemporary issues in photocuring. Compend. Contin. Educ. Dent. Suppl. 20;4-15.
12 - Uhl, A. ; Mills, R.W. & Jandt, K.D. (2003). Polymerization and light-induced heat of dental composites cured with LED and halogen technology. Biomaterials. May;24(10):1809-20
13 - Yap, A.U.J. ; Ng, S.C. & Siow, K.S. (2001). Soft-start polymerization:Influence on effectiveness of cure and post-gel shrinkage .operative Dentistry 26:260-266 .29
14 - Yazici, A.R. (2007). The Knoop Hardness of a Composite Resin Polymerized with Different Curing Lights and Different Modes The Journal of Contemporary Dental Practice, Volume 8, No. 2, February 1.
15 - Yazici, A.R. ; Muftu, A. ; Kugel, G. & Perry, R.D. (2006). Comparison of temperature changes in the pulp chamber induced by various light curing units, in vitro. Oper Dent. Mar- Apr;31(2):261-5.