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# The effect of Light Emitting Diode and Sandwich technique on Pulp Temperature during Polymerization of Composite resin

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## Abstract

This in vitro study evaluated the effect of glass ionomer liner in limiting temperature rise during composite curing with Light Emitting Diode (LED cure unit) compare it with Conventional visible light-cure lamp.

Twenty sound upper premolar teeth were used & on the buccal and palatal surfaces of them, a standardized class V cavity was prepared, 1mm occlusal to the cemento-enamel junction. Cavity dimensions of occluso-gingival height 1.5mm, mesio-distal width of 3mm. The depth of the cavity was 2mm and was calibrated by measuring with a pre marked periodontal probe. The teeth were randomly divided into four groups according to the cure mode and filling teqnique. Each group consist of 5 teeth (10 cavities); Group I; each cavity filled with 2mm (micro-hybrid resin composite) and cured with Quartz Tungsten Halogen light unit (QTH), Group II; the same as Group I but cured with Light Emitting Diod (LED cure unit), Group III; each cavity filled with glass ionomer lining of 0.5mm and 1.5mm (micro-hybrid resin composite), and cured with Quartz Tungsten Halogen light unit (QTH), & Group IV; each cavity filled with glass ionomer lining of 0.5mm and 1.5mm (micro-hybrid resin composite) but cured with Light Emitting Diod (LED cure unit). Temperature was measured before light curing of the composite resin & immediately after it. Then the Temperature was measured by a type K thermocouple.

The results revealed that there were significant differences between the groups at $p<0.01$ with in favor of the group filled with composite resin & cured with LED with glass ionomer lining.

The use of sandwich restorations with LED curing unit produced lesser temperature degrees toward the pulp space.

## Introduction

Pulp insults can be caused mainly by heat, desiccation, exposure to chemicals and bacterial infection. Effects of different harmful procedures are cumulative[1]. The dental pulp can with stand small temperature changes (from 37° C to 42° C) without any permanent damage; however a temperature rise of 5.5°C in the pulp is the limit that permits the pulp to recover from thermal damage[2].

While others have been reported that a 5.5°C increase in pulp temperature created protein denaturization and irreversible damage in 15% of the human teeth tested[3].

Light curing units used for polymerizing restorative resins produce heat during operation[4]. Regardless of the amount of infrared energy transmitted from the curing source, polymerization of resin composites always results in a temperature increase in the material caused by both the exothermic polymerization and the light energy absorbed during irradiation[5].

Most commercial light curing units (LCUs) for dental applications use conventional halogen bulbs. Commercial LCUs using light emitting diodes (LEDs) have recently become established on the market, 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[6].

Although halogen lights have proven effective and their popularity is evident in dentistry, they have several draw backs. These include, the halogen bulbs have a limited effective life time of about 40-100 hours. The bulb, reflector, and filter deteriorate over time due to the

High heat subjected to them during operation cycles. The fatigues of these components of halogen systems have been proven to decrease the effectiveness over time, leading to inconsistent curing[7], and the clinicians should be a ware of the potential thermal hazard to the pulp which might result from visible-light curing of composites[8].

So when using high-powered LCUs, the issue of temperature increase is of particular interest. This is because the increased energy of these LCUs may also increase the potential of generating injurious temperatures in the pulp — especially when they are used in deep cavities with minimal remaining dentin thickness. Moreover, the concept of total adhesive bonding precludes the use of a protective cement base or cavity lining, which also means a higher potential for thermal injury to the pulp[5].

Therefore one might use of cement bases which are materials essentially serve as a replacement for the protective dentine that had been destroyed by caries and or cavity preparation[2], so in a sandwich restoration the resin composite is replaced in the dentin part of the cavity by another material with lower elastic modulus. The first horizontal layer can be conventional glass ionomer cement. Sandwich restorations with conventional glass ionomer cement were introduced in the early 1990s[9,10]. The aim was to minimize the effects of the resin composite shrinkage. The technique was especially recommended in high-caries-risk patients because of the continuous fluoride release from the glass ionomer cement.

## Materials and Methods

A total of 20 freshly extracted, caries free, human premolars without cracks or previous restorations were selected for the study. Calculi and residual soft tissue were carefully removed, and the teeth were stored at room temperature (23ºC - 27ºC) in distilled water within one month after extraction. Standard Class V cavity preparations (mesiodistal width of 3 mm, occluso-gingival length of 1.5 mm, and a depth of 2 mm were prepared on buccal and lingual surfaces 1mm occlusal to the cemento-enamel junction with a highspeed hand-piece with air-water spray and a #1090 diamond fissure bur (Diatech Dental AG, Heerbrugg Switzerland). New burs were used after every four preparations[11].

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 (15-50), root canal and the pulp chamber were excavated[12].

The teeth were randomly divided into four groups according to the cure mode and filling technique. Each group consists of 5teeth (10 cavities)

1-GroupI each cavity filled with 2mm (micro-hybrid resin composite) and cured with DENTSPLY (Quartz Tungsten Halogen light unit, QTH), with constant intensity of approximately 450mw/ $cm^2$.

2- Group II each cavity filled with 2mm (micro-hybrid resin composite) and cured with Radii (Light Emitting Diod, LED cure unit), with intensity of 1200mw/ $cm^2$.

3-group III. Each cavity filled with glass ionomer lining of 0.5mm (3M ESPE Ketak Molar Easymix, it's application according to the instruction of use) and 1.5mm (micro-hybrid resin composite ) and this was calibrated by measuring with a pre marked periodontal probe and cured with DentSuply (QTH), the same as group I

4-Group IV Each cavity filled with glass ionomer lining of 0.5mm and 1.5mm (micro- hybrid resin composite ) as group III and cured with Radii (LED cure unit), the same as group II.

The restorative materials were placed using a single increment since the depths for the composite resin were less than 2 mm. The LCU's were placed to the buccal or lingual surfaces at close range (0-1 mm)[11].

*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.

The other end of the thermocouple was connected with an electrical thermometer , which record the temperature after the tooth temperature stabilized[12], initial temperature was recorded. Another reading was recorded immediately after curing of resin for all samples of the four groups. Then the differences between the initial and final temperature were recorded

## Results

The increase of temperature inside the pulp chamber for all specimens of the four groups, were recorded and they are shown in ( table1) which show the lowest mean of increasing temperature were recorded with group IV (glass ionomer + micro-hybrid resin composite + LED group (0.63 °C ).

While the highest mean of increasing temperature were recorded with group I (micro-hybrid resin composite + QTH group), (1.93 °C).

In spite of group I had the higher mean value which was (1.93 °C), it is less than 5.5 °C.

The descriptive statistics for the results with the means & standard deviations had been presented in ( table2).

By using one-sample t-test, there was significant differences between the groups at $p<0.01$ with in favor of the group IV over the other groups, (table 3).

The results of t test between group I &II, I &III revealed that there was no significant difference, but the significance present when we use LED with the presence of glass ionomer as are shown in (tab.4 & tab.5)

Bar chart revealed that the lowest mean of increasing temperature with group IV.

## Discussion

The results revealed that the sandwich technique and the use of LED curing device had the least temperature rise effect on pulp.

According to Zach and Cohen, a temperature rise of 5.5°C in the pulp is the limit that permits the pulp to recover from thermal damage.

In the current study, temperature changes were measured during the operation of a high-powered LED LCU.

The peak values registered during the curing of all the tested samples were lower than this previously reported critical value. This below-critical-value temperature rise could be attributed to a prominent feature of this high-powered LED LCU, in that LEDs convert electricity into light more efficiently and there was basically no infrared light transmission to the tooth — and hence no excessive heat was produced[5,13]

In addition, “the guiding principle that dictates the efficiency of a photo-polymerization reaction is how much light energy is absorbed by the photo-initiator in the system. The efficiency of a photo-polymerizing device can be described by the total energy concept[14]. This means that while light intensity is important, the more important factor is how much of the emitted light effectively matches the absorption spectrum of the photo-initiator (Camphorquinone). The highest probability of light absorption is at.

the peak maximum of 465 nm. Light at this wavelength is much more likely to start a photo-polymerization reaction and, therefore, is more efficient than light at all other wavelengths, resulting in lesser temperature degrees & heat generation”.

The glass ionomer cement had well-known mechanical & adhesive properties that might isolate the pulp perfectly under the composite fillings from the oral nvironment plus the curing light thermal harmful insults & this was confirmed by many previous studies[15,16,17].

The results from our experiments showed that temperature rise during LED curing light irradiation of resin-based composites generally is less than that recorded when quartz tungsten-halogen curing lights are used, but statistically there was no significance and this is also agree with Dickens et al 2006.

Considering the record of safe use for quartz-tungsten-halogen curing lights over the past two decades, we would expect a similar level of safety for LED curing lights and the same precautions necessary for eye Protection[18].

## Conclusions

Under the circumstances of this study, the following conclusions;

-The use of sandwich restorations with Light Emitting Diod curing unit produced lesser temperature degrees toward the pulp space.

-Inspite of Quartz Tungsten Halogen light curing unit had the higher mean value, it is below the critical value of temperature rise.

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| Descriptive Statistics | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **N** | **Range** | **Minimum** | **Maximum** | **Mean** | | **Std. Deviation** | **Variance** |
| | **Statistic** | **Statistic** | **Statistic** | **Statistic** | **Statistic** | **Std. Error** | **Statistic** | **Statistic** |
| **Group I** | 10 | 1.80 | .80 | 2.60 | 1.9300 | .19439 | .61473 | .378 |
| **Group II** | 10 | 1.80 | .40 | 2.20 | 1.4300 | .21502 | .67995 | .462 |
| **Group III** | 10 | 1.20 | 1.20 | 2.40 | 1.8300 | .13503 | .42701 | .182 |
| **Group IV** | 10 | 1.60 | .00 | 1.60 | .6300 | .17954 | .56774 | .322 |

| **One-Sample Test** | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | **95% Confidence Interval of the Difference** | |
| | | | | | **Lower** | **Upper** |
| **Group I** | 9.928 | 9 | .000 | 1.93000 | 1.4903 | 2.3697 |
| **Group II** | 6.651 | 9 | .000 | 1.43000 | .9436 | 1.9164 |
| **Group III** | 13.552 | 9 | .000 | 1.83000 | 1.5245 | 2.1355 |
| **Group IV** | 3.509 | 9 | .007 | .63000 | .2239 | 1.0361 |

| P | T | DF | SD | Mean | N | group | |
|---|---|---|---|---|---|---|---|
| | | | 0.614 | 1.93 | 10 | **Group I** | |
| | | | 0.679 | 1.43 | 10 | **Group II** | |
| | | | 0.427 | 1.83 | 10 | **Group III** | |
| | | | 0.567 | o.63 | 10 | **Group IV** | |

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

| P | T | DF | SD | Mean | N | group | |
|---|---|---|---|---|---|---|---|
| | | | 0.614 | 1.93 | 10 | **Group I** | |
| | | | 0.427 | 1.83 | 10 | **Group III** | |
| | | | 0.679 | 1.43 | 10 | **Group II** | |
| | | | 0.567 | o.63 | 10 | **Group IV** | |

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

Fig.1: Bar chart showing the groups