

Comparison of Temperature Changes Through Dentin Discs with Different Thicknesses and Different Distances of Light Curing Tip by Two Different Light Curing Units

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Abstract

Background and Aim: Excessive heat produced while curing of light-activated dental restorations may cause irreversible damage to dental pulp. The Aims of this study were to measure the temperature rise (TR) induced by two different light curing units and to evaluate the relationship between the measured TR in dentin discs of different thicknesses and different distances of light guide tips from dentin disc.

Materials and Methods: In this experimental study, Quartz-Tungsten-Halogen (QTH) (400 $\frac{mW}{cm^2}$) and Light-Emitting Diode (LED) systems (1500 $\frac{mW}{cm^2}$) were used as the curing units. Dentin discs of 0.5, 1.0 and 1.5 mm thicknesses were prepared. Distances of 1, 2 and 3 mm from the tip of the light guide and dentin discs were set. Temperatures were recorded using a digital laser thermometer. Data were statistically analyzed using two-way ANOVA, Duncan and T-test.

Results: Results showed that both dentin thickness and distance between tip of curing units and dentin disks had significant effects on temperature rise in both curing units ($P < 0.001$).

Conclusion: LED produced the highest and the QTH the lowest TR for all tested conditions. Reduced thermal insults were related to increased dentin thickness, increased distance between the light guide tip and dentin, and decreased energy emitted from the light-curing unit.

Key Words: Temperature - Curing lights - Dentin

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Received: 5 Oct 2011

Accepted: 29 April 2012

Journal of Islamic Dental Association of IRAN (JIDAI) / Fall 2012 / 24 / (3)

Introduction

Health of a tooth is indebted with health of the dental pulp as a unique tissue [1]. Surgical and restorative treatments induce thermal, physical and mechanical insults to the dental pulp among which intrapulpal heat buildup is of paramount importance [2]. It appears that there is a critical spectrum for intrapulpal temperature. Studies have shown that intrapulpal temperature increase beyond 5 to 8 degrees centigrade may easily lead to cell death [3,4]. Principal studies by Cohen and

Zach indicated that temperature rise beyond 5.5 degrees centigrade causes irreversible cellular damage [4]. One of the most frequent factors that leads to intrapulpal temperature rise is application of light-curing devices for polymerization of tooth-colored restorative materials. It is reported that intrapulpal temperature rises up to 8 degrees centigrade during light curing a composite restoration. Intrapulpal temperature rise is dependant upon several factors such as type of curing device used, intensity of curing, time, type of curing, filtering

quality of the curing device, distance to the light source, restoration size, presence of temperature barrier layers, thickness, color and composition of the composite used [5-9]. Another important factor is the remaining dentin thickness. Direct temperature rise within the pulp chamber is minimized by the low thermal conductivity of dentin [10]. Also, risk of pulpal damage while using light curing devices with higher output energy is increased [11]. Some light curing devices generate a considerable amount of heat while being used so that the operator cannot keep his/her finger in a 2- to 3-millimeter distance from the tip of the device for 20 seconds [12]. In recent light curing devices which are LED-based, there is usually a high intensity of irradiation which can jeopardize pulpal health. Santini et al stated that the heat generated in pulp chamber by LED devices with 1100 mw/cm^2 was significantly higher than that of QTH devices with 500 mw/cm^2 [11]. Bagis also showed that in comparison of QTH, LED and plasma arch (PAC) devices, in a 1-mm distance the maximal and minimal temperature increase was observed in plasma arch and LED devices, respectively [13]. Dogan also showed that PAC devices induced higher temperature increase in comparison with LED devices in different dentin thicknesses [14].

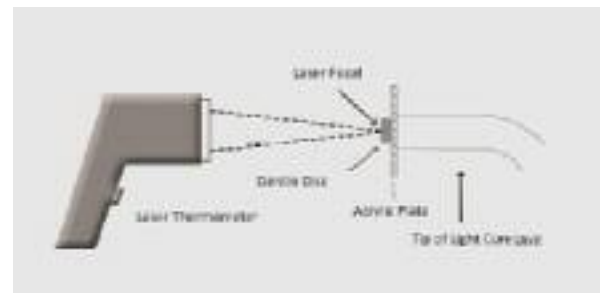
The aim of this investigation was to compare the heat produced by LED and QTH devices and the effect of the remaining dentin thickness in cavities and the distance between the light curing device tip and remaining dentin on the resultant temperature increase.

Methods and materials

In this interventional experimental study 30 intact human intact caries-free third molars were included. The teeth were stored in 0.2% thymol solution before use. Initially the whole thickness of enamel was removed from the tooth surface using a diamond bur and copious water irrigation. After preparing a relatively smooth surface from the cross section of the tooth crown, each sample was mounted in orthodontic acrylic resin blocks. The samples were randomly divided into three groups

of ten each. Dentin thicknesses of interest were marked on the lateral surface of the acrylic molds (0.5, 1 and 1.5 mm). Teeth were sectioned (Non stop-Bego, Germany) so that the sectioning blade was located perpendicular to the acrylic mold and an even disc was obtained in each section. Tooth sections were measured by a gauge after sectioning. Therefore, 30 discs in different thicknesses i.e., 0.5, 1, and 1.5 mm in diameter ($n=10$ each) were prepared and stored in distilled water. Acrylic plates were prepared to establish a fixed distance between the light cure tip and dentin discs. Temperature changes were measured using a laser digital thermometer (Dostman electronic, China- 485 Scan temp) (fig.1)

Fig 1: Schematic representation of thermal measurement



The complex was assembled in a way that the dentin disc was fix on one side of the acrylic plate and the tip of the light curing device on the other side in predetermined distances of 1 to 3mm. The initial temperature of the dentin discs were equalized with the room temperature (27.0 ± 0.1).

Output intensity of the QTH device (Litex 695 C- Dentamerica, USA) was 400 mw/cm^2 . The samples were cured for 20 minutes. Maximal temperature was recorded. Thermal measurement was performed three times for each section. After light curing, the temperature of each sample was returned to 27 degrees centigrade.

In other experimental groups, the same procedure was followed by using an LED system (Litex 680 A- Dentamerica, USA) with an output intensity of 1500 mw/cm^2 for 20 seconds. Output intensity of each device was measured by a light meter device (LCM 1000 and CM300-1000)

Statistical analysis was carried out using t-, two-way ANOVA and Duncan tests, using SPSS software.

Results

The results of this study is represented as the mean of temperature changes in degrees centigrade. According to the presence of three dentin disc thicknesses (0.5, 1.0, and 1.5 mm) and three light cure tip to dentin disc distances (1, 2, and 3mm) as well as two types of light-cure devices (QTH and LED), a total of 18 different conditions were evaluated using ANOVA test. The results are demonstrated in tables 1 and 2. In order to evaluate the effect of different dentin thicknesses and light cure distances on temperature rise two-way ANOVA and Duncan tests were used.

Table 1: Comparison of mean temperature changes in different light-cure tip distances and various dentin thicknesses using the LED device

| number | SD | mean | thickness | distance |
|--------|------|-------|-----------|----------|
| 10 | 1/46 | 12/38 | 0/5 | 1 |
| 10 | 1/35 | 11/15 | 1 | |
| 10 | 0/87 | 9/53 | 1/5 | |
| 30 | 1/69 | 11/02 | total | |
| 10 | 1/52 | 9/68 | 0/5 | 2 |
| 10 | 0/76 | 9/14 | 1 | |
| 10 | 0/68 | 8/62 | 1/5 | |
| 30 | 1/11 | 9/14 | total | |
| 10 | 0/85 | 9/39 | 0/5 | 3 |
| 10 | 0/59 | 9/06 | 1 | |
| 10 | 0/46 | 7/91 | 1/5 | |
| 30 | 0/9 | 8/78 | total | |
| 30 | 1/86 | 10/48 | 0/5 | total |
| 30 | 1/35 | 9/78 | 1 | |
| 30 | 0/95 | 8/68 | 1/5 | |
| 90 | 1/60 | 9/65 | total | |

The maximum temperature increase was recorded in LED group at a 1-mm distance of the light-cure tip from the 0.5-millimeter-thick dentin disc (12.38

Table 2: Comparison of mean temperature changes in different light-cure tip distances and various dentin thicknesses

| number | SD | mean | thickness | distance |
|--------|------|------|-----------|----------|
| 10 | 0/85 | 7/18 | 0/5 | 1 |
| 10 | 0/77 | 6/96 | 1 | |
| 10 | 0/59 | 6/12 | 1/5 | |
| 30 | 0/86 | 6/75 | total | |
| 10 | 0/79 | 6/31 | 0/5 | 2 |
| 10 | 0/53 | 5/87 | 1 | |
| 10 | 0/36 | 5/00 | 1/5 | |
| 30 | 0/79 | 5/73 | total | |
| 10 | 0/63 | 6/24 | 0/5 | 3 |
| 10 | 0/58 | 5/74 | 1 | |
| 10 | 0/29 | 4/93 | 1/5 | |
| 30 | 0/74 | 5/63 | total | |
| 30 | 0/85 | 6/57 | 0/5 | total |
| 30 | 0/83 | 6/19 | 1 | |
| 30 | 0/69 | 5/35 | 1/5 | |
| 90 | 0/94 | 6/04 | total | |

± 1.46 degrees centigrade). The minimal temperature rise was recorded in the QTH device at a 3-mm distance of the light cure tip from the 1.5-millimeter-thick dentin disc (4.93 ± 0.29 degrees centigrade). The two-way ANOVA test results indicated that both the distance of the light-cure tip and the dentin thickness had significant effects on both QTH and LED devices. ($p < 0.001$) It was observed that the mean temperature increase in certain distances increased with decreases in dentin thicknesses, regardless of the device used. ($p < 0.001$) The LED device induced a significantly more temperature increase than the QTH device regardless of the thickness of the dentin sample and the light cure tip distance. ($p < 0.001$) It was demonstrated that increasing the distance of the light cure device tip with the target dentin sample leads to a significant decrease in temperature rise, regardless of the device used. ($p < 0.001$) There was a statistically significant difference among different dentin thicknesses according to the Duncan test in both light curing devices. There was also a sig-

nificant difference between the 1-millimeter distance of the light cure tip with the other two distances.

Discussion

Use of light-activating devices play an integral part in quality of the tooth-colored restorations. Nowadays, most of the manufacturers of the light-curing devices tend to introduce devices with intensities of more than $1000\text{mw}/\text{cm}^2$ to the market to reduce the curing time and increase curing depth. When high-intensity light curing devices are used, a significant temperature increase is observed in comparison with QTH devices. There is also an increased risk of pulpal damage when higher intensity devices are used [11]. In this study, the effect of dentin thicknesses, tip distances and two light cure devices were evaluated on the post-curing temperature increase. It was shown that the temperature rise following use of the LED device was significantly more than that of the QTH device ($p < 0.001$). The range of the temperature changes was between 7.91 and 12.38 degrees centigrade in LED and between 4.93 and 7.18 degrees in the QTH device. Zach and Cohen demonstrated that increasing the pulpal temperature more than 5.5 degrees centigrade could cause pulpal necrosis in 15 % of the cases. Intrapulpal temperature increase up to 11.1 degree centigrade caused 60% and up to 16.6 degrees centigrade, 100% pulpal necrosis [4]. The temperature increase caused by the LED device was beyond the critical 5.5 degrees centigrade in all distance- and thickness- conditions. On the other hand, in the QTH device, only in two out of nine conditions, the temperature increase was lower than the critical 5.5 degrees. According to the more intense output of the LED device ($1500\text{mw}/\text{cm}^2$) compared with that of the QTH device ($400\text{mw}/\text{cm}^2$), higher temperature increase was observed in the LED device. Therefore the risk of pulpal irritation is increased. This was in accordance with the results of Guiraldo et al who reported that the output light intensity and radiation time were the most important factors in temperature rise after curing [15]. Millen and co-

workers also demonstrated that LED device caused an increased temperature rise in comparison with QTH [16]. Durey et al investigated the temperature increase within the dental pulp after use of two LED and one QTH curing devices. They demonstrated that pulpal temperature increase was seen significantly more in LED compared with QTH devices, but there was no significant difference between the two LED systems [17]. On the contrary, Dogan and colleagues reported a higher temperature increase after use of a QTH device in comparison with an LED system. Such incongruence can be attributed to the differences in light intensity of the QTH devices used as well as variances in curing times.

In studies by Santini et al [11] and Yazici et al [18], temperature changes were determined by using thermocouples within the pulp chamber of the teeth with class II cavity preparations. Contrarily, in the current study as well as the work done by Dogan et al [14] dentin discs were prepared which made it possible to evaluate dentin thicknesses precisely. On the other hand, for evaluation of the temperature changes, a laser beam was directed to the dentin surface, without being influenced by environmental temperature.

According to the results of our study, it can be concluded that more intensive remedies must be taken into consideration to protect pulpal tissue from thermal irritation when cavities with the remaining dentin thicknesses of less than 1.5 mm are restored.

It can also be recommended that the light cure tip be placed at a 2 mm distance from the dentin surface in tooth-colored restorations to prevent excessive heat buildup. On the other hand, there is no need to increase the distance of the light cure tip up to 3 mm due to the decrease in depth of polymerization [20].

Soh and Yap evaluated the temperature increase following use of LED and QTH devices at 3- and 6-millimeter distances. At the 3-millimeter distance the temperature rise was recorded to be 4.1-12.9 and 17.4-46.4 degrees centigrade for LED and QTH devices, respectively. They found out that the

temperature rise at a 6-millimeter distance was 2.4-7.5 and 12.7-25.5 degrees centigrade for LED and QTH systems, respectively. The higher temperature increase in the closer distance is in accordance with the results of our investigation [21].

Curing time for both devices were set at 20 seconds. Knezevic and colleagues stated that the most pronounced thermal increase following use of curing devices were seen within the initial 20 seconds of the curing procedure. The thermal changes between 20 and 30 seconds was considered to be between 1-2 degrees and was not significant and there was no thermal changes between 30 to 40 seconds [22].

It must not be overemphasized that the results of this in vitro study cannot be extrapolated to the clinical conditions, because there are a lot of contributing factors that compensate such thermal changes within the pulp chamber, such as pulpal blood flow, presence and flow of the dentinal fluid and periodontal tissues [14].

Conclusion

It can be concluded that the temperature rise following use of LED system is more than that of QTH device in different dentin thicknesses and different light cure tip distances.

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