



EVALUATION OF TEMPERATURE CHANGES IN THE PULPAL CHAMBER OF THE PRIMARY TOOTH DURING CURING OF COLORED COMPOMERS

Renkli Kompomerlerin Sertleşmesi Sırasında Süt Dişi Pulpa Odasında Görülen Sıcaklık Değişimlerinin Değerlendirilmesi

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ABSTRACT

Purpose: To investigate the temperature changes in the primary teeth pulp chambers during the curing of different colored compomers

Materials and Methods: Class II cavities were prepared in primary mandibular second molars (n=5). Gold, blue, green, berry, and tooth (control group) colored compomers were tested in two steps (aproximal and occlusal). Measurement of pulp chamber temperature changes during curing was performed with a J type thermocouple. The data including differences between the highest and initial temperature values were recorded and analyzed by two-way ANOVA and Mann-Whitney U tests

Results: There were statistically significant differences temperature changes in groups (p<0.05). Cümle yeniden kurulabilir. Gold colored compomer Demonstrate the highest temperature increase in both proximal and occlusal surfaces. Tooth colored compomer (A2) Demonstrate the lower temperature increase. The temperature increase in aproximal cavities was found higher than the temperature increase in occlusal cavities.

Conclusions: Colored compomer can be an alternative restorative materials in superficial class I and II cavities in primary teeth. Dark coloured compomers should be used in deep cavities.

Running Title: Temperature Changes During Curing of Colored Compomers

Key Words: Colored, Compomer, Temperature rise

ÖZ

Amaç: Farklı renkli kompomerlerin ışıkla sertleşmesi sırasında süt dişi pulpa odasındaki sıcaklık değişikliklerinin araştırılması amaçlanmaktadır.

Materyal ve Metod: İkinci molar süt dişleri Sınıf II kaviteler hazırlandı (n=5). Altın sarısı, mavi, yeşil, mor ve diş rengindeki kompomerler iki aşamada (aproximal ve oklüzal) test edildi. Işıklı sertleşme sırasında meydana gelen pulpa odasındaki sıcaklık değişimi ölçümleri J tipi termokupl ile gerçekleştirilmiştir. En yüksek sıcaklık ve başlangıç sıcaklıkları arasındaki farklar veri olarak kaydedildi ve analizleri iki yönlü-ANOVA ve Mann-Whitney U testi ile yapıldı.

Results: Sıcaklık değişimleri arasında istatistiksel olarak anlamlı farklar vardı (p<0.05). Altın sarısı kompomer, hem aproximal hem de oklüzal yüzeylerde en yüksek sıcaklık artışını gösterdi. Diş rengi (A2) en düşük sıcaklık artışını gösterdi. Aproximal kavitedeki sıcaklık artışı oklüzal kavitedeki artıştan daha yüksek bulunmuştur.

Sonuç: Renkli kompomerler süt dişlerinde sığ sınıf I ve sınıf II kavitelerde alternatif restoratif materyal olabilir.

Kısa başlık: Renkli Kompomerlerin Sertleşmesi Sırasındaki Sıcaklık Değişimleri

Anahtar Kelimeler: Renkli, Kompomer, Sıcaklık artışı

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INTRODUCTION

Compomers (polyacid modified composite resins) are very popular restorative materials in primary dentition.¹ Compomers are a mixture of glass ionomer cements and resin-based composites, containing polyacid modified monomers with fluoride-releasing silicate glasses, resin components, photoinitiators, and stabilizers.² Due to their preservation of dental structure in cavity preparation, relatively low thermal conductivity, fluoride release, continuous progress in the stability of the composition, and an increasing demand of parents to provide esthetic restorations for their children, compomers are well-received.^{1,3} Colored compomer (CC) has been commercialized for use in children's dentistry and to improve their cooperation in dental treatments.⁴

CC is produced by adding glitter particles and coloring pigments to conventional compomers to create different colors (e.g., blue, green, pink, and gold), and the filler content is similar to conventional compomers.⁴ As with conventional compomers, CCs are similar to traditional composites in that their setting reaction includes light-curing. Compomers and CCs contain the light-activated ingredient dimethacrylate. Typically light-initiated camphorquinone with an amine accelerator is sensitive to blue light at 470 nm and 7,8 MK as the initiator.⁵ Different light devices of varying power outputs are used during the curing of compomers. The factors that can affect the temperature changes in the pulp chamber are the light source type, intensity, and activation time.^{4,6} For curing the compomers, the most common type of visible light activation unit uses blue light-emitting diodes (LEDs).⁷ High-intensity LEDs were introduced to reduce the curing time for sufficient polymerization, with 1400 mW/cm² and 395-480 nm for 40 seconds.^{7,8}

The pulp has a structure that is affected by physical, chemical, biological and thermal

stimuli. Several factors can affect the temperature increase in the pulp chamber, such as cavity preparation procedures, bleaching, polishing of dental restorations, laser applications, polymerization of light-cured materials.⁹⁻¹¹ Thermal cameras and thermocouples are used to evaluate a temperature increase in the pulp.⁹ Thermal cameras are devices that display images in different colors according to the temperature of the region that the camera focuses on, by sensing the infrared wavelengths caused by thermal energy. Regarding the use of thermal camera, thermocouples are used in evaluating the temperature increase in the pulp chamber as the temperature change on the tooth surfaces is evaluated.^{9,12} The pulpal microcirculation occurring in the pulp plays an important role as a coolant in decreasing the effect of thermal stimuli on the pulpal tissue.¹³ In their study on monkeys, Zach and Cohen¹⁴ found that a temperature increase of 5.5°C in the pulp chamber for 10 seconds led to the loss of vitality on the pulp tissue by 15%.

Many studies have demonstrated the physical, mechanical and biological properties of CCs.¹⁵⁻¹⁸ To date, few studies have been carried out to measure the thermal properties of CCs.^{5,19-20} In this study, we investigated the temperature changes in a microcirculation model in the primary teeth pulp chamber for a class II cavity during the curing of different CCs. The null hypotheses in this study; there is no difference between the pulpal temperature changes during the curing of different CCs.

MATERIALS AND METHODS

The sample size was calculated at a 95% confidence interval and a significance level of 0.05 (type I error), type II error rate was 0.2 and effect size was 1.40, according to the Savas *et al.*²⁰ The analysis indicated that a group sample size was 10 (n=10).

Cavity Preparation

Five extracted, caries-free, primary mandibular

second molars were used in this study. The roots were removed 2 mm beneath the cement-enamel junction. All organic remnants in the pulpal chambers were cleaned using a 5.25% sodium hypochlorite solution. The teeth were prepared as class II cavities. The cavity preparations were performed in two steps; approximal box (only mesial) the occlusal cavity. A small diamond round (1/2 round) bur was used to remove the enamel on the occlusal surface. The diamond fissure bur was used to remove the dentin to a 4 mm depth of the approximal box. The height x width x length dimensions of the cavity were 4 x 3 x 3 (Figure 1). The angles of the walls and floors were slightly rounded. One millimeter of dentin remained between the pulp chamber, the axial wall and pulpal floor, measured with a caliper and assessed radiographically. The prepared teeth were kept in distilled water for protection from dehydration.

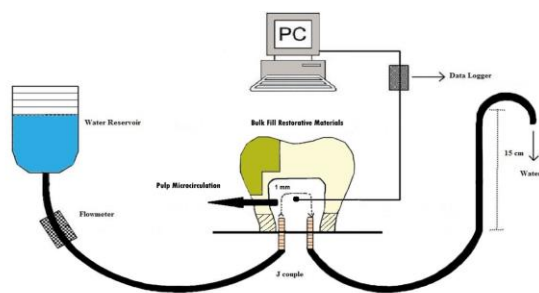


Figure 1. Dimensions of class II cavity in primary tooth

Temperature changes in microcirculation model

A pulpal microcirculation model, that originally designed by Savas *et al.*²⁰ was used. The fluid flow rate of the system was set and kept constant at 1 ml/min using a digital infusion flowmeter (SK-600II infusion pump, SK Medical, Shenzhen, China). Distilled water at room temperature (26°C) was used to simulate blood and the blood pressure in the pulp at 15 cm H₂O (Figure 2). A heat-transfer unit (ILC P/N 213414; Wakefield Engineering, Beverly, MA) was applied to the tip of the thermocouple wire, fixed with light-curing glass ionomer cement (Calcimol LC; Voco GmbH, Cuxhaven, Germany) to maintain contact with the pulp chamber. Therefore, the gap around the thermocouple wire was sealed to prevent leakage from the system (Figure 2).

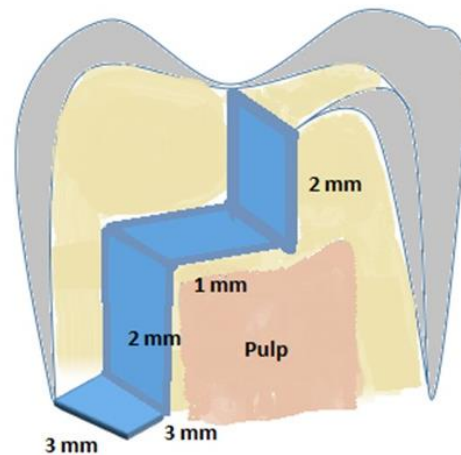


Figure 2. Schematic diagram of the measurement of intrapulpal temperature changes

Four different colors of Twinky Star (Voco, Cuxhaven, Germany) gold, blue, green, and berry compomers, as well as tooth-colored compomer (A2, DyractXtra, Densply) (control group) were tested in this study. The different compomers (gold, green, blue, berry, and tooth-colored) were applied to the cavity in two steps. According to the manufacturers, the tooth colored compomer was cured for 20 s and the CCs for 40 s. In the first step, a compomer was applied to the proximal cavity and cured with an LED curing unit (EliparFreelight, 3M ESPE, US) (Figure 2). In the second step, a compomer was applied to the occlusal cavity and cured. A 2 mm layer of compomer was placed on the floor of the proximal box. Acid etching or dentin bonding were not used before putting the compomers in the cavity. Two small notches were made at the edge of the proximal step and occlusal surface to remove the cured compomers from the tooth surface easily.

One tooth (n=1) was used for each group randomly and 10 measurements were done for each teeth (n=10). During curing, the temperature was measured with a thermocouple connected to a data logger (XR440-M Pocket Logger, Pace Scientific, NC, USA) to record the temperature increase values from the pulp chamber during curing. The collected results in graphic form were monitored in real time and transferred to a computer. Later, the difference between the first and highest temperature values

(Δt) was calculated. The recorded data were analyzed by two-way ANOVA and Mann-Whitney U tests. A Kruskal Wallis analysis was used to conduct multiple comparisons of the groups to determine their differences.

RESULTS

The mean pulp temperature increase values and the standard deviations are shown in Table 1. The two-way ANOVA indicated that both the tested groups ($p = 0.05$) and the proximal and occlusal cavities ($p=0.010$) significantly influenced the intrapulpal temperature. The highest temperature increase values in aproximal surface were recorded in the gold-colored group (7,71°C), followed by the berry (6,84°C), blue (6,08°C), and green (5,94°C) colored groups, and lastly the tooth colored-control group (3,26°C). The highest temperature increase values in occlusal surface were recorded in gold-colored group (5,79°C), followed by the blue (4,16°C), green (3,92°C), and berry (5,94°C), and tooth colored groups (2,34).

Table 1. Mean values and standart deviations of mean temperature changes of the groups

Groups	Aproximal Surface Mean \pm SD	Occlusal Surface Mean \pm SD
Gold	7.71 \pm 1.30 ^{a,*}	5.79 \pm 1.01 ^{a,**}
Green	5.94 \pm 1.40 ^{b,*}	4.02 \pm 1.08 ^{b,**}
Berry	6.84 \pm 1.47 ^{b,*}	3.92 \pm 1.26 ^{b,**}
Blue	6.08 \pm 0.78 ^{b,*}	4.16 \pm 0.56 ^{b,**}
Tooth Colored (Control Group)	3.26 \pm 0.77 ^{c,*}	2.34 \pm 0.89 ^{c,*}
P	0.001	0.001

Different uppercase letters in each column indicate differences within the tested materials ($p < 0.05$)

Different stars in each row indicate differences within the tested materials ($p < 0.05$)

The lowest temperature increase values were recorded in the tooth-colored compomers. No significant differences in the temperature rise were observed for the berry, blue and green-colored groups ($p > 0.05$). The Kruskal Wallis analysis revealed significant differences in the proximal and occlusal cavity applications ($p < 0.05$), as shown in Table 1. The temperature increases were higher in the aproximal cavity compared to occlusal cavity

during polymerization for all compomer groups.

DISCUSSION

Compomers are widely used in pediatric dentistry and CCs.⁵ Even though CCs have similar contents with conventional compomers except color pigments and glitter particles. The temperature in the pulp chamber during the curing of CCs is not well known. There is no study in the literature regarding CCs that include thermal changes in primary dentition. The purpose of this study was to compare the temperature changes in the microcirculation model in primary teeth pulp chambers in class II cavities during the curing of different CCs.

Al-Qudah *et al.*²³ measured the temperature rise during the curing of resin-containing dental materials, flowable, packable, or conventional composites, compomers, and resin modified glass ionomers (RMGICs) with a thermal camera. The maximum temperature rise was observed in flowable composites, and minimum temperatures were observed in compomers and packable composites. Tosun *et al.*²⁴ compared the temperature rise under caries-affected and caries-unaffected primary tooth dentin during the curing of compomer and composite resin materials. As a result of the study, it was reported that there was no difference between the resin materials because both materials had high filler ratios (Compoglass F 77% and Aelite LS 84%). Kahvecioglu *et al.*²⁵ measured the thermal changes during the setting and curing of a glass carbomer, resin modified glass ionomer, and compomer in primary teeth. No difference in temperature increase was observed between compomer and RMGIC in occlusal cavities in primary teeth. The resin content (type, filler ratio, and size), color, monomer type, and ratio are important factors affecting temperature increase.⁵

The twinkly star CC contains Bis-GMA, diurethanedimethacrylate, TEGDMA, carboxylic acid modified methacrylate (TCB), silicon

dioxide, and camphoroquinone. Twinky star has filler Barium aluminum fluoro borosilicate glass with dioxide particles and glimmer with a content of 77.8% w/w; 60.8 v/v, and a particle size of 0.4-3 μm .^{18,20} Tooth colored compomer, Dyract Extra, contains Bis-GMA, urethane dimethacrylate (UDMA), TEGDMA, TCB and has filler 73% w/w; 47 v/v with particle size 0,8 μm . All tested compomers showed different temperature rises compared to tooth colored compomer, and the null hypothesis was rejected.²⁰ Despite the similar content in the filling materials, this difference in the temperature increase during the curing of compomers can be explained by the glitter effects.

Based on a study by Hwang *et al.*¹⁵, the distribution of light transmission can be affected by glittering; the gold color was noted to have a lower light transmission rate than the other colors (blue, green, pink, silver, orange, lemon, and tooth colored). Vandembulcke *et al.*¹⁹ reported that blue, green, and tooth CCs had greater curing depths (DoC) than other colors, and the gold color had the least DoC compared with the other colors. In the present study, the highest and lowest temperature increases were obtained in the gold (7.71°C) and tooth colored (3.26°C) compomers. The results of this study are partly consistent with those of the previous study; the blue and green CCs exhibited similar light transmissions. However, in relation to the highest light transmission in different CCs, there was no consensus in the literature.^{5,15,19} The studies showed that the transmission of light for the gold color was the least, and had a seemingly higher light absorption.^{15,19,26} The higher light absorption led to an increase in temperature during curing of the compomers with low light transmission.

Many factors of temperature changes in pulp can be connected with the contents of dental restorative materials, type of light curing unit (LCU), light intensity of the LCU, exposure time to LCU, and thickness of the remaining

dentin.^{6,9,11} Different curing units (halogens, plasma arcs, and LEDs) were preferred to cure the composite resins and compomers.^{10,16} Contemporary LCUs are more commonly used than other light sources in restorative dentistry and have many benefits. For instance, they are resistant to overheating, have longer lifetimes, generate less heat, and their light output reduces minimally in time.²² In this study, same light-emitting diode was used to cure all samples so that the temperature increase of the compomers would not be affected by LCU factor.

Conventional compomers are widely used for class I and II cavities in anterior, and III, IV, and V cavities in posterior teeth. In deep cavities, the vitality of pulp tissue can be affected by thermal changes, especially in class II cavities. In this study, temperature increase in approximal cavities was higher than the occlusal cavities in in CCs, except for tooth-colored compomer. Only the gold colored compomer was higher than the critical point of 5.5°C, reported by Zach and Cohen.¹⁴ Blue and green exhibited similar temperature changes in approximal and occlusal cavities. The difference between the occlusal and approximal cavities may be explained by the orientation and number of dentine tubules in primary teeth. The number of dentine tubules increase when moving from the occlusal towards the approximal wall and dentine tubules run oblique and parallel to the axial walls.²⁷

There were some limitations of this present study; firstly, only one type light curing unit was used. Secondly, glitter particles in CCs were not evaluated. The temperature rise may be affected by the size and amount (per gram) of glitter particles. Thirdly, the temperature changes may be affected by the initial temperature in the pulp circulation model. The difference between the highest and initial temperature may be lower when the temperature in the pulp is close to body temperature.

CONCLUSION

Glitter particles include irregular shapes and sizes in CCs that increase the temperature rise in primary teeth. The use of darker shades of compomers may be advisable, especially in deep cavities.

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