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Research Article / Araştırma Makalesi

Effect of Preheating on Microhardness, Degree of Conversion, and Depth of Cure of Various Bulk-Fill Composites

Ön Isıtmanın Bulk-Fill Kompozitlerin Mikrosertlik, Monomer Dönüşüm Derecesi ve Polimerizasyon Derinliği Üzerine Etkisi

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ABSTRACT

Background: This study aims to evaluate the effect of preheating on microhardness, degree of conversion, and depth of cure of bulk-fill composites (Tetric EvoCeram Bulk-Fill, SonicFill2) and a conventional composite (Tetric EvoCeram).

Methods: Layers of Tetric EvoCeram (2 mm), Tetric EvoCeram Bulk-Fill (4 mm), and SonicFill2 (5 mm) were placed in 4-mm diameter molds and polymerized at room temperature or heated to 55ºC for 10 s with a total number of 60 samples. Then, the top surfaces of the samples were polished. Thirty samples' Vickers microhardness was measured from the top and bottom surfaces. The other 30 samples were pulverized into a fine powder, and the composites' degree of conversion was measured with attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy. Obtained data were analyzed statistically with a significance level of $p<0.05$.

Results: The degree of conversion of Tetric EvoCeram was higher than the minimum rate of clinically acceptable value, which is 55%, but the scores of Tetric EvoCeram Bulk-Fill and SonicFill2 were below the threshold. Preheating increased the degree of conversion of Tetric EvoCeram Bulk-Fill and SonicFill2. In addition, preheating did not affect the depth of cure of SonicFill2 but decreased the rate of Tetric EvoCeram Bulk-Fill.

Conclusion: The results showed that the effect of preheating on the degree of conversion and depth of cure varied according to the material.

Keywords: Preheating, bulk-fill composite, degree of conversion, depth of cure, microhardness.

ÖZ

Amaç: Bu çalışmanın amacı ön ısıtma işleminin bulk-fill kompozitlerin (Tetric EvoCeram Bulk-Fill, SonicFill2) mikrosertlik, monomer dönüşüm derecesi ve polimerizasyon derinliği üzerine etkisini geleneksel bir kompozitle (Tetric EvoCeram) karşılaştırmalı olarak incelemektir.

Gereç ve Yöntemler: Kompozitler oda sıcaklığında veya 55ºC'ye ısıtılarak 4 mm çapında kalıplara Tetric EvoCeram 2 mm, Tetric EvoCeram Bulk-Fill 4 mm ve SonicFill2 5 mm derinliğinde yerleştirilerek LED ışık kaynağıyla 10 sn polimerize edilmişlerdir (n=5). Üst yüzeyleri cilalanan toplam 60 örneğin yarısının üst ve alt yüzeylerinden Vickers sertlik değerleri ölçülmüştür. Örneklerin diğer yarısı toz haline getirilmiş ve attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroskopisi ile monomer dönüşüm dereceleri ölçülmüştür. Elde edilen veriler istatistiksel olarak analiz edilmiştir ($p<0.05$).

Bulgular: Tetric EvoCeram'ın monomer dönüşüm derecesi klinik olarak kabul edilen minumum değer olan %55'den yüksek olup, Tetric EvoCeram Bulk-Fill ve SonicFill2 bu değerin altında kalmıştır. Ön ısıtma işlemi Tetric EvoCeram Bulk-Fill ve SonicFill2'nin monomer dönüşüm derecesini artırmıştır. SonicFill2'nin polimerizasyon derinliği ön ısıtmadan etkilenmezken, ön ısıtma Tetric EvoCeram Bulk-Fill'in polimerizasyon derinliğinde azalmaya neden olmuştur.

Sonuç: Ön ısıtmanın monomer dönüşüm derecesi ve polimerizasyon derinliğine etkisi materyale bağlı olarak değişmektedir.

Anahtar Kelimeler: Ön ısıtma, bulk-fill kompozit, monomer dönüşüm derecesi, polimerizasyon derinliği, mikrosertlik.

Introduction

Despite all the advances in dental composites today, polymerization still has problems. To ensure adequate polymerization, the applied light must penetrate the bottom of the composite, and the monomers in the organic matrix must be converted into polymers at the highest rate. Conventional composites can be applied to the cavity with a layer thickness of up to 2 mm.[1] However, this application takes time, especially in deep cavities. It increases the possibility of incorporating voids and contamination between layer two and bond failures between increments, causing failure in restoration.[3] Bulk-fill composites developed to overcome these problems can be applied to the cavity in 4- or 5-mm layers and reduce these risks.[3-5] For the bulk-fill composites to be polymerized in thicker layers, some applications have been made to increase light transmittance. The first is to increase the size of the inorganic fillers, thereby reducing the surface area between the organic matrix and the fillers. With this application, the material transparency is increased, the scattering of the light applied from the surface decreases as it moves toward the bottom, and a deeper polymerization is provided. Another method is to add a more photosensitive germanium-based photoinitiator, Ivocerin (Ivoclar, Vivadent, Schaan, Liechtenstein) (dibenzoyl germanium derivative), in addition to camphor quinone to the composite structure.[6]

Bulk-fill composites may be low-viscosity (flowable) or high-viscosity, depending on the amount of filler. Low-viscosity bulk-fill composites are more easily placed in the difficult-to-reach areas of the cavity and are better adapted to the cavity walls.[7] However, because the filler is low, its mechanical properties are weak, and chewing surfaces must be covered with conventional composites. Restoration can be completed without needing an additional capping layer with high-viscosity bulk-fill composites[5,6] A sonic activating device is used to make the high-viscosity bulk-fill composites flowable while placing them into the cavity so that they can be inserted into the cavity more easily.[8] In addition, preheating high-viscosity composites reduces the viscosity of the material and facilitates their placement in the cavity.[9]

Inadequate polymerization of composite resins leads to the weakening of the material's physical, mechanical, and biological properties, increasing the amount of residual monomer, adversely affecting pulp tissue, and causing discoloration and failure in restoration.[10,11] The temperature of the composite resins affects the degree of conversion (DC) and the structural properties of the formed polymers. With the increase in temperature, the mobility of the radicals and monomers in the composite increases, and a higher DC is obtained.[12,13] However, some studies have shown no increase in the DC of preheated composites.[9,14-16] Tauböck et al.[17] reported that the DC of preheated high-viscosity bulk-fill and conventional composites increased or remained at the same level, depending on the composite type.

The depth of cure (DOC) refers to the composite thickness of the light-

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cured composite resins where sufficient monomer conversion occurs from top to bottom and can be properly polymerized.[18] DOC is determined by proportioning the bottom surface microhardness value of the composite samples to that of the top surface.[19] In studies evaluating the microhardness of preheated composites, while it was observed that the microhardness value of some composites increased,[14,15,20-23] no change was observed in some of them.[21,24,25] Previous studies show that preheating composite resins results in different properties, such as polymerization efficiency and microhardness of the material, depending on the different types and compositions of composite resins.[9,20,21,23,26-28]

This study examines the effect of preheating two different high-viscosity bulk-fill composites (Tetric EvoCeram Bulk-Fill (Ivoclar/Vivadent, Schaan, Liechtenstein) (TECBF) and SonicFill2 (Kerr Corp. Orange, CA, USA) (SF) on the material's DC, microhardness, and DOC by comparing a conventional composite (Tetric EvoCeram, Ivoclar/Vivadent, Schaan, Liechtenstein) (TEC). The study's first hypothesis is that preheating does not cause a difference in the DC of bulk-fill composites; the second hypothesis is that preheating does not cause a difference in the DOC of bulk-fill composites; the third hypothesis is that there is no difference between conventional composites and bulk-fill composites in terms of DC and DOC.

Material and Methods

Specimen preparation

Two commercially available bulk-fill composites (TECBF and SF) and a conventional composite (TEC, the control group) were the materials under investigation (**Table 1**).

Table 1. Composites used in the study

Material	Manufacturer, batch no.	Curing time	Type (shade, max. layer thickness)	Resin Composition (Filler wt/vol%)	Filler Size
Tetric EvoCeram (TEC) (control group)	Ivoclar Vivadent, Schaan, Liechtenstein, U23115	10 s	Conventional sculptable, (A2, 2 mm)	Resin matrix: Bis-GMA, Bis-EMA, UDMA Filler: Barium glass, YbF3, mixed oxide, PPF (75-76%/53-55%)	0,04-3μm
Tetric EvoCeram Bulk Fill (TECBF)	Ivoclar Vivadent Schaan, Liechtenstein, U17294	10 s	Sculptable full-depth bulk-fill/ no capping layer required (IVA, 4 mm)	Resin matrix: Bis-GMA, Bis-EMA, UDMA Filler: Barium glass, YbF3, mixed oxide, PPF (76-77% /53-54%)	0,04-3μm
SonicFill 2 (SF)	Kerr Corp. Orange, CA, USA, 6038935	10 s	Sonic-activated flowable and sculptable full-depth bulk-fill/ no capping layer required (A2, 5 mm)	Resin matrix:Bis-GMA, TEGDMA, Bis-EMA, Bis-EMA SR-541 / Filler: Glass, SiO2, oxide, PPF zirkonium silicate (81,5%/65,9%)	4μm

Bis-GMA, Bisphenol-A glycidyl methacrylate; TEGDMA, Triethyleneglycol dimethacrylate; UDMA, Urethane dimethacrylate; Bis-EMA, Ethoxylated Bisphenol A dimethacrylate; PPF, prepolymerized fillers; YbF3, ytterbium trifluoride.

The main hypothesis of the research was to compare two independent groups. Similar studies that can be used in the sample size calculation were examined, and the highest sample size calculation based on the statistical method according to hypotheses was used. This study calculated the sample size at the 95% confidence level using the "G-Power 3.1.9.2" program. As a result of the analysis, α=0.05, the standardized effect size from the study in which three independent groups were compared: 23 (81.07±14.08, 101.42±11.71, 150 .28±10.23) was calculated as 0.9211, and with theoretical power of 0.80, the minimum sample size was calculated as 15. Thus, a minimum sample size of 5 per group was calculated.

Specimens with a diameter of 4 mm were prepared with Delrin molds. The sample thickness was 2 mm for TEC, 4 mm for TECBF, and 5 mm for SF, adhering to the maximum thickness recommended by the manufacturer. There were 60 composite specimens; 30 were preheated, and 30 were polymerized at room temperature (23±1°C). The preheated groups were heated to 55±1°C by keeping the Ena Heat Composite Heating Conditioner/CHC3 ((Micerium S.p.A, Italy) heating device in T2 mode for 20 min after the device reached 55±1°C. Composite materials were placed in a Delrin mold, which was placed on a glass slide. They were covered with transparent tape (Mylar Strip; SS White, Philadelphia, PA, USA) and 1-mm-thick microscope glass, and excess material was removed by hand pressing. Afterward, the composites were polymerized for 10 s according to the manufacturer's recommendation with a light-emitted diode (LED) light-curing unit (Demi Plus, Kerr Corp. Orange, CA, USA) with periodic level shifting (PLS) technology, which provides a light intensity varying between 1100–1330 mW/cm2 at a wavelength of 450–470 nm during the application. The preheated composites were removed from the heating device and placed in the cavity, and polymerization was achieved within 1 minute. The specimens were kept in a dark, dry environment at 37°C for 24 h to complete the polymerization reactions and randomly divided into two groups to prepare for measuring DC and Vickers microhardness.

Measurement of the degree of conversion

The DCs of composite specimens (n=5) were determined by Fourier transform infrared (FTIR) spectroscopy (Shimadzu IR Prestige[21], Shimadzu Co. Japan) equipped with an attenuated total reflectance (ATR) apparatus. First, a small amount of unpolymerized restorative materials was placed on the device's ATR crystal, and then FTIR analysis was performed. The cured material was pulverized into a fine powder. Three measurements were made of each specimen. Each specimen was measured with 16 scans at a resolution of 4 cm-1 within a wavelength spectrum of 4000–600 cm^{-1}. Peak heights at 1637 cm^{-1} (aliphatic carbon double bonds) and 1608 cm^{-1} (aromatic carbon double bonds) were measured using the baseline method with the software Origin 8.6 (Origin Lab Corporation, Northampton, USA).

The formula calculated the degree of conversion:

DC% = 100- [(AD/BC) x 100]

A: Absorption values of C=C groups at 1637 cm^{-1} in polymerized samples

B: Absorption values of aromatic groups at 1608 cm^{-1} in polymerized samples

C: Absorption values of C=C groups at 1637 cm^{-1} of unpolymerized samples

D: Absorption values of aromatic groups at 1608 cm^{-1} in unpolymerized samples

Microhardness and depth of cure measurement

For the microhardness test, the top surfaces of the specimens (n=5) were polished with four different grains of soflex polishing discs (Optidisc, Kerr Corp. Orange, CA, USA) containing aluminum oxide particles for 10 s at low speed. Microhardness measurements were made with a Vickers microhardness device (Innovatest, Maastricht, Nederland). A constant load of 300 g was applied to the top and bottom surfaces of the specimens for 15 seconds, and three tracks were created on each surface, approximately 1 mm apart. Microhardness values were determined by taking the average of three values from each surface. The DOC was determined by dividing the bottom surface's Vickers microhardness value by the top surface's value.

Statistical analysis

The NCSS 2007 (Number Cruncher Statistical System) program (Kaysville, Utah, USA) was used for statistical analysis. The conformity of the data to the normal distribution was evaluated with the Shapiro-Wilks test, and it was determined that the parameters were suitable for the normal distribution. The Student's t-test was used for the pairwise comparison of quantitative data. A one-way ANOVA test was used to compare normally distributed groups of three or more, and the Bonferroni correction was applied in pairwise comparisons. A value of $p<0.05$ was used in all tests.

Results

The DC of TEC was above 55% at both temperatures, while the bulk-fill composites remained below this ratio. The DOC of all composites remained below 80%. **Table 2** compares the DC, top and bottom surface Vickers microhardness, and DOC of the polymerized composites at different temperatures. DC of TEC is significantly higher than bulk-fill composites ($p<0.01$). The top surface Vickers hardness of the bulk-fill composites was significantly higher than that of TEC at both temperatures ($p<0.01$), and there was no significant difference between the bottom surface microhardness of the preheated

composites (p>0.05).

Table 2. Comparison of degree of conversion (DC%), top and bottom surface microhardness [VH (top), VH (bottom)], and depth of cure (DOC%) of composites polymerized at different temperatures

Tests	DC (%) mean±SD*		VH (top) mean±SD*		VH (bottom) mean±SD*		DOC (%) mean±SD*	
Temperature	Room Temperature (23±1°C)	Preheating (55°C)	Room Temperature (23±1°C)	Preheating (55°C)	Room Temperature (23±1°C)	Preheating (55°C)	Room Temperature (23±1°C)	Preheating (55°C)
TEC (control)	70,17±2,64^{a}	71,93±0,85^{a}	60,82±2,15^{a}	56,07±6,26^{a}	32,58±3,14^{a}	31,99±7,83^{a}	53,40±5,32^{a}	56,60±8,88^{a}
TECBF	34,15±2,50^{b}	42,19±1,76^{b}	72,71±2,99^{b}	73,45±8,38^{b}	39,39±1,69^{b}	32,37±2,23^{a}	54,20±3,11^{a}	44,60±5,77^{bc}
SF	32,42±2,36^{b}	38,55±3,58^{b}	72,93±1,04^{b}	75,33±1,69^{b}	39,34±2,37^{b}	37,35±3,65^{a}	54,00±3,67^{a}	49,80±5,22^{ac}

*Different letters in the columns indicate that there is a statistically significant difference. One-way ANOVA Test (p<0.05), Post Hoc: Bonferroni Test (p<0.01). *SD: standard deviation*

Table 3 shows the comparison of the effect of preheating each composite on the DC, Vickers hardness of the top and bottom surfaces, and DOC. Preheating did not cause significant changes in the DC, top and bottom surface microhardness, and DOC of TEC (p>0.05). The DC of the preheated bulk-fill composites was significantly higher than that of the unpreheated group (p<0.05). Preheating caused a decrease in the bottom surface microhardness and DOC of TECBF (p<0.05).

Table 3. Comparison of the effects of preheating each composite on the degree of conversion (DC), top and bottom surface microhardness [VH (top), VH (bottom)], and depth of cure (DOC%)

Tests	DC (%) mean±SD*		VH (top) mean±SD*		VH (bottom) mean±SD*		DOC (%) mean±SD*	
Temperature	Room Temperature (23±1°C)	Preheating (55°C)	Room Temperature (23±1°C)	Preheating (55°C)	Room Temperature (23±1°C)	Preheating (55°C)	Room Temperature (23±1°C)	Preheating (55°C)
TEC (control)	70,17±2,64^{a}	71,93±0,85^{a}	60,82±2,15^{a}	56,07±6,26^{a}	32,58±3,14^{a}	31,99±7,83^{a}	53,40±5,32^{a}	56,60±8,88^{a}
TECBF	34,15±2,50^{a}	42,19±1,76^{b}	72,71±2,99^{a}	73,45±8,38^{a}	39,39±1,69^{a}	32,37±2,23^{b}	54,20±3,11^{a}	44,60±5,77^{b}
SF	32,42±2,36^{a}	38,55±3,58^{b}	72,93±1,04^{a}	75,33±1,69^{b}	39,34±2,37^{a}	37,35±3,65^{a}	54,00±3,67^{a}	49,80±5,22^{a}

*Different letters in the rows for each test indicate a statistically significant difference. Student's t-test (p<0.05). *SD: standard deviation*

Discussion

The application of preheating to the bulk-fill composites evaluated in the study caused a significant difference in the DC. Therefore, the first hypothesis of the study was rejected. The effect of preheating on DOC varied according to the materials. Since preheating caused a decrease in DOC of TECBF and did not cause a significant difference in SF, the second hypothesis was accepted as partial. DC of TEC was significantly higher than bulk-fill composites. The DOC of preheated TEC was higher than TECBF, and there was no significant difference between TEC and SF. Therefore, the third hypothesis was also accepted as partial.

FTIR spectrometry, one of the direct methods used to determine the DC of composite resins, is accepted as a reliable and powerful analysis technique for quantitatively measuring the polymerization reactions of dental materials.[29] The Vickers microhardness test, one of the indirect methods, is the preferred method for determining the microhardness and DOC because the values obtained by this method are reliable, it does not cause deterioration on the surface of the samples, and the tests are repeatable.[30,31] Performing these tests together provides a comprehensive evaluation of the polymerization efficiency. The DC provides information about the material's biocompatibility by determining the amount of unreacted monomer, and the microhardness values provide information about the durability of the composite resin.[2] Therefore, both tests were performed together in this study.

As a result of the polymerization of composite resins, the carbon-carbon double bonds in the monomers in their structure are opened and transformed into polymer chains with single bonds. The DC of Bis-GMA-based composites varies between 43% and 78%.[29,32] Although there is no consensus on the minimal DC requirements for a successful restoration, it has been reported that it should be at least 55%.[5]

In this study, the DC of the control group TEC, polymerized at room temperature or after preheating, was above 55%, the lowest clinically accepted value. The DCs of TECBF and SF were below this value. Thus, the DC of TEC is significantly higher than TECBF and SF. This study applied 10 s of light to the composite resins according to the manufacturer's recommendation. The only difference in the content of TEC and TECBF is the Ivocerin added to TECBF so that it can polymerize in a thicker layer. However, the DC of TECBF below 55% may have been due to insufficient 10-s curing. In the literature, Ilie et al.[33] determined the DC of TECBF to be less than 55%. Miletic et al.[34] also reported that 10 s of time was insufficient for high-viscosity bulk-fill composites to achieve adequate polymerization. However, Zorzin et al.[4] found that TECBF and Tarle et al.[2] reported that TEC and TECBF reached a DC of over 55%. The difference in the results of these studies might be due to the different experimental conditions.

While the preheating application did not cause a significant change in the DC of the control group TEC, it caused an increase in the DC of TECBF and SF. The DC of SDR (Dentsply) flowable bulk-fill composite preheated to 54°C[12], and of fiber-reinforced EverX Posterior (GC) bulk-fill composite heated to 55°C [35] was found to be higher than the group applied at room temperature. Erhardt et al.[16] showed no difference in the DC of the preheated Filtek BulkFill (3M ESPE). The DC of TEC was 70.17±2.64% and 71.93%±0.85% in the groups that were not preheated and preheated, respectively. It is seen that preheating causes a difference in the DC, but not at a significant level. It is seen that the ratios obtained for TEC under both experimental conditions are at an acceptable level for Bis-GMA-based composite resins.[29,32] The polymerization is a self-limiting reaction, so preheating may not have significantly affected the conversion of more monomers to polymers. Tauböck et al.[17], similarly to our results, found that TEC was not significantly affected by preheating, and the DC of preheated TECBF was found to be higher than that of the untreated group. Tauböck et al.[17] evaluated x-tra-fil (Voco), QuixFil (Dentsply De Trey), SonicFill (Kerr), and TECBF bulk-fill composites in their study and determined that the DCs of these materials were not affected by the preheating process. The researchers claimed that only TECBF was affected by preheating among the bulk-fill composites, possibly due to the Ivocerin added to its content. However, in our study, the DC of the preheated SonicFill 2 bulk-fill composite also increased. The SonicFill and SonicFill 2 composites are similar in their placement with the sonic activating device but have different contents. Therefore, this difference between the two materials might be due to the difference in the structure of their composite resins.

When the effect of preheating on the microhardness values of each composite was examined, it was determined that it did not cause a significant difference in the Vickers microhardness values of the top

surface. Theobaldo et al.[12] reported that preheating low-viscosity bulk-fill composites did not cause a significant difference in the top and bottom surfaces compared to those polymerized at room temperature. In our study, TECBF was the only composite affected by pre-heating in terms of bottom surface microhardness values, and the bottom microhardness values of the preheated group were significantly lower than the group at room temperature. The only difference between TECBF and TEC is Ivocerin. Therefore, the fact that TEC's bottom surface Vickers hardness value was not affected by preheating but TECBF was affected suggests that this situation was related to Ivocerin. The polymer chains formed during polymerization can be linear, branched, or cross-linked. The ratio of cross-link density in the polymer structure affects the surface hardness of the material. The fact that cross-links are more than branched and linear bonds ensures high surface hardness.[2] In this study, we think that the interaction of the heat applied to TECBF with Ivocerin causes differentiation in the organic matrix structure of the material and the formation of weak linear bonds instead of strong cross-links on the bottom surface where the light is less penetrating.

The DOCs of the composite resins are determined by proportioning the bottom surface Vickers hardness value to that of the top surface. Ideally, the bottom-to-top surface microhardness ratio is desired to be 100%, but 80% is accepted as an indication of effective polymerization.[19,36] In this study, the DOC of all composites cured for 10 s at room temperature or preheated by the manufacturers' recommendations remained below 80%. There was no significant difference between the DOCs of composites. In many studies with high-viscosity bulk-fill composites,[2,4,34,36,37-39], it was reported that the DOC of the composites cured for 10 seconds and remained below 80%. On the other hand, Nagi et al.[40] stated that the DOC of bulk-fill composites cured for 10 s was over 80%. In contrast, Ilie et al.[39] noted that the success of 10-s light applications varied in bulk-fill composites from different manufacturers.

In this study, only TECBF was affected by preheating in terms of the DOC, and it was observed that the DOC of the preheated group was lower than that of the unheated group. This is due to the bottom surface microhardness of the preheated group of TECBF being lower than the non-preheated group. As expected, the preheated group's cure was also lower when the bottom and top surface hardnesses were compared.

Regarding the effect of preheating on pulp temperature, preheated composite resulted in a temperature increase of 6˚C to 8˚C higher than room temperature material. Still, this temperature increase is not the critical factor that causes harm to the pulp.[41,42]

Conclusion

The DC of the evaluated bulk-fill composites was below the minimum rate of 55%, which was considered sufficient for clinical use at the layer thickness recommended by the manufacturer, and the DOC remained below 80%. Preheating bulk-fill composites increases their DC. The effect of preheating on the DOC varies according to the material. Considering these findings, it was recommended to be careful in the clinical use of bulk-fill composites with the layer thickness and light duration recommended by the manufacturer. In addition, since the effect of preheating on the depth of cure varies according to the material, it would be beneficial to evaluate the composites to be preheated in vitro before clinical use. The limitation of this study was that it might not entirely reflect the clinical performance of the evaluated composites since it was performed under in vitro conditions. In the study, the molds in which the composites were placed were at room temperature and might differ from mouth temperature. In addition, the light was applied to the composite from a distance of 1 mm in the experiments. In clinical practice, especially in Class II cavities, the distance of the light to the composite is longer. Therefore, results may differ in vivo.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

Bu makale, sempozyum ya da kongrede sunulan bir tebliğin içeriği geliştirilerek ve kısmen değiştirilerek üretilmemiştir.

Bu çalışma Zeynep Hale Keleş'in "Bulk-Fill Kompozit Reçinelerin Farklı Tekniklerle Uygulanmasının Monomer Dönüşüm Derecesi Ve Mikrosertlik Üzerine Etkisinin Değerlendirilmesi" başlıklı tezinden üretilmiştir.

Bu çalışmanın hazırlanma sürecinde bilimsel ve etik ilkelere uyulduğu ve yararlanılan tüm çalışmaların kaynakçada belirtildiği beyan olunur.

This article was not produced by improving or partially changing the content of a paper presented at a symposium or congress.

This article has been prepared from Zeynep Hale Keleş's thesis titled "Evaluation of the Effect of Application of Bulk-Fill Composite Resins with Different Techniques on Degree of Conversion and Microhardness".

It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı – ithenticate

Etik Bildirim / Ethical statement

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Çıkar Çatışması / Conflict of Interest

Yazarlar çıkar çatışması bildirmemiştir. | The authors have no conflict of interest to declare.

Yazar Katkıları / Author Contributions

Çalışmanın Tasarlanması | Design of Study: ZHK (%50), BT (%50)
Veri Toplanması | Data Acquisition: ZHK (%100)
Veri Analizi | Data Analysis: ZHK (%50), BT (%50)
Makalenin Yazımı | Writing up: ZHK(%70), BT (%30)
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