Comparison of depth of cure sonic-activated bulk-fill composite, low viscosity, and high viscosity in different thickness

Doni, Pribadi Santosa, Tunjung Nugraheni
Department of Conservative Dentistry, Faculty of Dentistry, Gadjah Mada University, Yogyakarta, Indonesia

Abstract

Context: The polymerization quality of composite resin can be measured by measuring the cure depth. Vickers hardness ratio is an indirect method of measuring the depth of cure of the composite resin.

Aims: This study aimed to compare the effect of composite resin type and material thickness on the depth of cure of sonically activated bulk-fill composite resin (SonicFill, Kerr), low viscosity (Surefill SDR bulk-fill, Dentsply), and high viscosity (Tetric N Ceram bulk fill, Ivoclar Vivadent).

Settings and Design: The research is experimental laboratory.

Materials and Methods: The research samples were 36 cylindrical composite resin blocks with a thickness of 2 mm and 4 mm, which were divided into six groups (n = 6) based on sonically activated bulk-fill composite resin, low viscosity, and high viscosity. All samples were put in an incubator for 24 h. The microhardness ratio was performed using a Vickers microhardness tester with a weight of 100 g for 15 s, which calculated by the formula: Vickers hardness number bottom/top.

Statistical Analysis Used: The two-way ANOVA with Tukey post hoc test was used for statistical analysis (P < 0.05).

Results: The results of the two-way ANOVA test showed an effect of the type of composite resin on the depth of cure of the composite resin (P < 0.05); there was no effect of material thickness on the depth of cure of composite resin (P > 0.05). There was no interaction of composite resin type and material thickness to a resin composite depth (P > 0.05).

Conclusions: The depth of cure of sonic-activated and high-viscosity bulk-fill composite resin was greater than low-viscosity bulk-fill composite resin.

Keywords: Bulk-fill composite; depth of cure; microhardness; thickness; viscosity

INTRODUCTION

Composite resins’ polymerization is influenced by intrinsic and extrinsic factors. Intrinsic factors include the photoinitiator system, matrix, type and filler content, viscosity, color, and thickness. Extrinsic factors include intensity, light exposure time, the light spectrum, and tip distance of the light-curing unit (LCU) to material. Inadequate polymerization reduces the physical and mechanical properties of composite resins such as decreased elastic modulus and hardness, increased water absorption, and edge leakage.

Address for correspondence:
Doni, FKG UGM Jl,
Denta No. 1, Senolowo, Sinduadi, Kec. Mlati, Kab. Sleman,
Yogjakarta 55281, Indonesia.
E-mail: drg.doni@yahoo.com

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than incremental techniques. This composite resin can polymerize well at a thickness of at least 2.5–3 mm and a maximum of 4–4.5 mm to reduce working time, reduce porosity, and homogeneous consistency.

The various modifications made to bulk-fill composite resins using different fillers, photoinitiators, and monomers from conventional composites are expected to reduce contraction stress and increase composite resins’ polymerization. There are various types of bulk-fill composite resins based on their viscosity, namely, low, medium, and high viscosities and sonic-activated bulk-fill composite resins. The filler size in low-viscosity bulk-fill composite resin will reduce the spread of light between the filler and the matrix so that light penetration can be more in depth. High-viscosity bulk-fill composite resin, iowcerine, is used as a photoinitiator aiming to increase the degree of polymerization. Even now, an instrument has been developed to condense the material with a vibration technique on composite resin application; this method uses ultrasonic power.

The polymerization quality of the composite resin can be assessed directly or indirectly. The straightforward method for assessing a degree of conversion resonance imaging, optical microscopy, and Raman or Fourier transform infrared spectroscopy, whereas indirect methods include visual inspection, surface hardness consisting of ISO 4049 scraping method, and Vickers microhardness ratio. The Vickers microhardness method in this study was used to evaluate the depth of cure of bulk-fill composite resin because it is easier to apply than other methods. Microhardness measurements can be carried out on research samples with the Vickers test to obtain Vickers hardness ratio (VHR) data.

Several factors can influence DoC, namely, the light source used, intensity, wavelength, irradiation time, light tip size, irradiation method, chemical formulation of the organic matrix, distribution and amount of inorganic filler, type and amount of photoinitiator, and color of composite resin. The low DoC indicates the low polymerization quality that a lot of free or unreacted monomer during the polymerization process.

The surface hardness of the composite resin tested in this study was assessed using the Vickers hardness score which provides useful information about DoC when measured on the bottom surface and top surface of composite resins. Based on ISO 4049, if VHR is more than 80%, then the DoC composite resin is acceptable. This study aimed to compare the depth of cure of sonically activated bulk-fill composite resin, low viscosity, and high viscosity at different thicknesses.

### MATERIALS AND METHODS

Sample is a composite resin block made using two reusable and custom-made stainless steel, mold A (an internal diameter of 4 mm and 2 mm in length/thickness) and mold B (an internal diameter of 4 mm and 4 mm in length/thickness) which consisted of three groups, namely, Group I (sonic-activated bulk-fill composite), Group II (low-viscosity bulk fill), and Group III (high-viscosity bulk-fill composite). Each group was divided into two subgroups, namely, subgroup A and subgroup B, with each group consisting of six samples. The total samples were 36. The procedure for making IA subgroup samples was carried out as follows: the screw opened the printing tool A, the top of the mold was removed, and then the celluloid strip is placed just below the two holes. Then, the top of the mold is placed and screwed back. The sonic-activated bulk-fill resin composite material was added to the syringe with one application. The composite resin is then coated with celluloid strips to flatten the mold surface. Then, the glass plate was removed and sampled to irradiation for 20 s on the top surface of the composite resin with the LCU tip attached to the celluloid strip.

Immediately after irradiation or light curing step, the sample was removed and marked 1 point in center of sample’s bottom surface with a black pen. Samples were then immersed in artificial saliva and put into an incubator at 37°C for 24 h. Thus, in the IIA and IIIA subgroups, it was carried out in the same way.

In contrast, the stages of making research samples in the IB, IIB, and IIIB subgroups were carried out using mold B. Samples were removed from the artificial saliva, then dried. In the middle of the top and bottom surface of the research sample, a point is marked with a black pen. A circle is made with a radius of 1 cm from that point as the area’s boundary to determine the location, indent three times using a sliding caliper. Microhardness measurements used a Vickers microhardness tester (Buehler, Germany) with a load of 100 g, which was applied through an indenter in 15 s. Data were analyzed using two-way ANOVA test with Tukey post hoc test. The confidence level used was 95% ($\alpha = 0.05$).

### RESULTS

The microscopic photographs can be seen in Figure 1 with Vickers hardness number (VHN) and DoC in Table 1. The highest surface microhardness value of sonic-activated bulk-fill composite resins are in samples which 2 mm and 4 mm thickness. The results of the two-way ANOVA test in Table 2 show (1) there is an effect of the type of bulk-fill composite resin on the DoC of composite resin ($P = 0.008 < 0.05$), (2) there is no...
effect of the thickness of the composite resin on the DoC of the composite resin ($P = 0.275 > 0.05$), and (3) there was no interaction between the type of bulk-fill composite resin and the thickness of the composite resin to the composite resin DoC ($P = 0.921 > 0.05$). The Tukey test results show that there is a significant DoC composite resin between sonic-activated bulk-fill composite resin compared with low-viscosity bulk-fill composite resin ($P < 0.05$), but there was no significant difference ($P > 0.05$) between sonic-activated bulk-fill composite resins compared with high-viscosity bulk-fill composite resins.

**DISCUSSION**

This research proves that the three materials studied are resin sonically activated high-viscosity bulk-fill composites; low viscosity and high viscosity meet the criteria for adequate depth of cure composite resin, namely ≥0.8.

The results of the two-way ANOVA test showed that there was an effect of the type of bulk-fill composite resin on the depth of cure of the composite resin. The compressive strength value of sonic-activated bulk-fill composite resin was significantly greater than that of other bulk-fill composite resins. The higher the filler composition, the higher the mechanical properties and microhardness of a composite. Cure bulk-fill composites can also be improved by increasing translucency and increasing the particle size of the filler.

Filler influenced the difference in the depth of cure and the characteristics of the bulk-fill composite in terms of size, volume, and weight. Comparison of microhardness of high-viscosity bulk-fill composite resin with filler volume yields a positive correlation. The sonic-activated bulk-fill composite resin had the highest microhardness value and the largest filler volume, namely, 83.5 wt%/83 vol%. In contrast, high-viscosity and low-viscosity bulk-fill composite resins had the number of fillers 80 wt%/57 vol % and 70.5 wt%/47.4 vol%.

The viscosity of the composite also correlates with the type of resin matrix. Bis-GMA, as the thickest, is also the least flexible, while UDMA and TEGDMA are the least viscous. The values of microhardness or VHN in this study (Table 1) are sorted from the highest to the lowest values. Furthermore, correlated with the type of matrix, namely, (1) sonic-activated high-viscosity bulk-fill composite resin with EBPADMA, (2) high-viscosity bulk-fill composite resin with UDMA and Bis-GMA, and (3) low-viscosity bulk-fill composite resin with TEGDMA.

The results showed that the composite resin’s thickness did not affect the polymerization quality of the three types of bulk-fill composite resin studied. The type of bulk-fill composite resin and composite resin thickness also did not interact with each other and affected the depth of cure of the composite resin. The results of this study are following previous studies that explain that low-viscosity bulk-fill composite resin is capable of polymerizing completely up to a material thickness of 4 mm.

**CONCLUSIONS**

Based on the results of the research that has been done, it can be concluded that there is an effect of the type of bulk-fill composite resin on the depth of cure of the composite resin. The depth of cure of sonic-activated bulk-fill composite resin was not different from high-viscosity bulk-fill composite resin but higher than that of low-viscosity bulk-fill composite resin. There was no effect of composite resin thickness on the depth of cure of the composite resin. There was no interaction between the type of composite resin and the composite
resin’s thickness on the depth of cure of the composite resin.

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Conflicts of interest
There are no conflicts of interest.

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