Influence of Curing Time and Color Shade on Diametral Tensile Strength of Bulk Fill Composite Resins

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Abstract

This study was conducted to evaluate the influence of curing time and color shade of bulk fill composite resins on their diametral tensile strength (DTS). Two commercially available bulk fill composite resins, Beautifil Bulk Restorative® (Shofu, Japan; shade A and Universal) and Tetric N-Ceram® bulk-fill (Ivoclar-Vivadent, Liechtenstein; shade IVA and IVW) were investigated. The disc-shaped specimens (3 mm of thickness; 6 mm of diameter) were divided into 3 subgroups for each shade according to curing time (10 s, 15 s, and 20 s). All specimens were polymerized using LED curing unit (Bluephase Style, 1200 mW/cm^2) and tested using Universal Testing Machine (Shimadzu, Japan) to determine the DTS. Data were statistically analyzed using Two Way ANOVA and Post Hoc Tukey HSD tests. The results showed that bulk fill composite resins with brighter color shades were statistically significant different (P<0,05) than darker shades in DTS. There was an increase in DTS with increased curing time and was statistically different (P<0,05). However, there was no statistically different interaction between curing time, and color shade. It can be concluded that color shade and increased curing time influence the diametral tensile strength of bulk fill composite resins.

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Introduction

The diametral tensile strength is one of the mechanical properties of the composite resins that depends on an adequate polymerization process.[1,2] Polymerization of composite resins is influenced by intrinsic and extrinsic factors. Size and shape of filler, filler loading, and color shade of the composite resins are intrinsic factors.[1-3] The extrinsic factors include the size of the tip and type of light curing unit (LCU) that used, the direction, distance, and duration of irradiation.[1-3] The most common type of LCU used in dentistry today is the LED, due to its narrow wavelength range. The lights generated by the LED are very close to absorption spectra of camphoroquinone initiator (470 nm).[3] In addition to color shade, other factor that may affect the polymerization of composite resins are the duration of irradiation.[1-3] Some studies suggest that the curing time of composite resins may affect polymerization because the longer the curing time, the more the monomers are polymerized.[4,5] The increase in curing time had a positive effect on the degree of conversion of bulk-fill composite resins so that the extension of curing time was suggested for the application of composite resins for deep cavities.[4,5] However, it is not known how long the appropriate curing time is needed to obtain optimal mechanical properties. Several studies have suggested that bulk-fill composite resins have limitations when applied to a cavity depth that is more than 4 mm, because it needs 2 times incremental technique application.[4,5] Thus, the curing time and the surface of the composite resins must have an effect on the physical and mechanical properties of the bulk-fill composite resins.

Although bulk-fill composite resin restorations have demonstrated some advantages in dentistry, studies that evaluate the mechanical properties of bulk-fill composite resins are still needed, particularly related to curing time, because they are still limited in number. Therefore, it is necessary to examine the effect of LED

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exposure time to the diametral tensile strength of the bulk-fill composite resins with darker and brighter shade.

Materials and methods

Materials that used in this study are Giomer Beautifil-Bulk Restorative® (shade Universal and A, Shofu, Japan) and Tetric N-Ceram® bulk-fill (shade IVW and IVA, Ivoclar-Vivadent, Liechtenstein) that showed in Table 1. The uncured material was inserted in a single bulk into molds of 6 mm in diameter and 3 mm in thickness and divided into 3 subgroups for each shade (n=10) according to curing times (10 s, 15 s, and 20 s). All specimens were polymerized using LED curing unit (Bluephase Style, 1200 mW/cm2) and then tested using Universal Testing Machine (Shimadzu AG-5000, Japan) with crosshead speed 0.5 mm/minute and load cell 250 kgf. The data analyzed statistically using Two Way ANOVA and Post Hoc Tukey HSD tests.

Results

The diametral tensile strength (DTS) mean value of bulk fill composite resins were presented in Table 2. There was statistically significant difference among all curing times (P<0.05), which means curing time significantly influenced DTS. There was statistically significant difference among all color shade (P<0.05), which means color shade had significant effect on DTS. However, there was no statistically significant difference between curing time and shade color interactions with DTS (P> 0.05) that showed in Table 3.

Bulk-fill Composite Resins and Manufacturers	Shade used	Monomers	Fillers	Filler content wt.%
Giomer Beautifil-Bulk Restorative®	- Universal (brighter) - A (darker)	Bis-GMA, UDMA, Bis-MPEPP, TEGDMA	S-PRG filler based on F-B-Al-Si-glass (0.8 µm)	87.0
Tetric® N-Ceram Bulk Fill	- IVW (brighter) - IVA (darker)	Dimethacrylates monomers BisGMA, BisEMA, UDMA	Barium glass filler (0.4-0.7 µm), ytterbium Trifluoride (200 nm), mixed Oxide (160 nm) and Polymer filler	78.0

Table 1. Bulk fill composite resins used.

Materials	Shade	Mean (MPa)±SD		
		10 s	15 s	20 s
Giomer Beautifil-Bulk Restorative®	Universal (brighter)	40.02±3.87	40.34±4.41	41.99±4.87
	A (darker)	38.16±3.95	39.02±1.81	40.22±4.98
Tetric® N-Ceram Bulk Fill	IVW (brighter)	41.06±1.16	43.27±1.61	47.60±1.32
	IVA (darker)	33.95±0.99	35.90±1.67	38.15±1.25

Table 2. The mean value of diameter tensile strength of the bulk-fill composite resins.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	983.729[a]	5	196.746	16.264	0.000
Intercept	191745.684	1	191745.684	1.585E4	0.000
Time	279.278	2	139.639	11.543	0.000
Shade	694.853	1	694.853	57.440	0.000
Time * Shade	9.598	2	4.799	0.397	0.673
Error	1379.070	114	12.097		
Total	194108.483	120			
Corrected Total	2362.799	119			

Table 3. Tests of between-subjects effects. a. R Squared = ,416 (Adjusted R Squared = ,391)

Discussion

In this study, two bulk fill composite resins of different brands, namely Giomer Beautifil-Bulk Restorative® and Tetric® N-Ceram Bulk Fill were used. Both composite resins are composite resins in which the technique does not require layering technique (incremental technique), but requires only single bulk because the bulk fill composite resin is a new technology in composite resins such that it has a depth of cure up to 4 mm.[4,5] However, in both materials there is the difference in composition as shown in Table 1. Giomer Beautifil-Bulk Restorative® in its composition contains an S-PRG (surface pre-reacted glass ionomer) filler that the reaction is detected in surface-loans and are called surface reaction, and contain F-B-Al-Si-glass that increase its strength, and also can release F, Al, B, Na, Si and Sr ions. The Beautifil-Bulk Restorative® Giomer matrix contains Bis-GMA, UDMA, Bis-MPEPP, TEGDMA. In the matrix, there are diluent monomers such as TEGDMA and UDMA which can reduce the viscosity of the resin so as to increase the degree of polymerization.[6] While Tetric® N-Ceram Bulk Fill in its composition contains nanohybrid filler and there are also diluent monomers in its matrix. In addition, Tetric® N-Ceram Bulk Fill has an additional photoinitiator that is Ivocerin (derivatives dibenzoyl germanium) in addition to other photoinitiators such as champhorquinone and acyl phosphine oxide.[7]

This study was conducted to determine the influence of LED curing time and the color shade of the bulk-fill composite resins on the diametral tensile strength. Diametral tensile strength is an important mechanical force in the process of mastication.[8,9] The diametral tensile strength values obtained in this study illustrate the magnitude of the load in the form of tension and the maximum strain can be accepted by the composite resins until the material is broken.[8,9]

In this study, Giomer Beautifil-Bulk Restorative® bulk-fill composite resin with A shade (dark color) and Universal shade (bright color), and Tetric N-Ceram® Bulk-Fill composite resin with IVA shade (dark color) and IVW shade (bright color) were used. DTS value increased with increasing curing time. This was in line with study reported that mechanical properties such as DTS could increase when curing time was increased.[5] The increasing of curing time will cause more light energy that can be used to increase degree of conversion of monomers.[10,11]

Radiation exposure or so-called energy density is the total energy received by the surface of the composite resin during the irradiation process.[12] If radiation exposure increases, more photons are available for absorption by the photoinitiator. The more photons available, the more excited photoinisiator molecules to form free radicals.[12,13] Higher degree of conversion of the monomer to the polymer that indicating the number of methacrylate groups that have reacted to each other during the polymerization process can reach adequate and completely polymerization.[14] Large amounts of radiation exposure given by the LED curing unit for 20 seconds of irradiation can release free radical faster, so that the opening of double bonds in the methacrylate group will be more accelerated. It is supported by a previous study which states that the increasing of curing time of 10 seconds can significantly increase the degree of conversion and mechanical properties.[15] Other states that the degree of conversion is directly proportional to the strength of composite resin material, so the higher the degree of conversion, the mechanical properties will increase.[16] This is also shown in the results of this study, the increasing of curing time can increase the diametral tensile strength of the material.

In this study, both Giomer Beautifil-Bulk Restorative® and Tetric N-Ceram® Bulk-Fill composite resins with brighter shade showed higher diametral tensile strength value than darker shade. This is in line with previous research which reported that color shade may affect the polymerization of composite resin, which the composite resin with brighter color shows higher hardness value than the darker color.[17,18] This may occur because of the difference in the number of pigments contained in the composite resins with different colors.[16] This present study showed that Tetric N-Ceram® Bulk-Fill with brighter shade has higher diametral tensile strength value than Giomer Beautifil-Bulk Restorative® bulk-fill composite resin with brighter shade. This can be explained that Tetric N-Ceram® Bulk-Fill

contains Ivocerin that absorbs blue-visible light with a range of 370-460 nm and is much more reactive than camphorquinone or acyl phosphine oxide that increases the degree of conversion so that polymerization becomes adequate and faster with deeper depth of cure to produce higher diametral tensile strength.[7] However, in the darker shade, Giomer Beautifil-Bulk Restorative® bulk-fill has a higher diametral tensile strength value than Tetric N-Ceram® Bulk-Fill. This may be due to the amount of pigment in Tetric N-Ceram® Bulk-Fill more than in Giomer Beautifil-Bulk Restorative® bulk-fill and visually Tetric N-Ceram® Bulk-Fill is darker than Giomer Beautifil-Bulk Restorative® bulk-fill. There are several factors that can limit the transmission of light into composite resins, including light reflections that occur on the surface of the material and the absorption of light by the pigment or photoinisiator. The pigments added to composite resin is to give a darker color to the composite resin. The pigments have a tendency to absorb light, so that the greater the number of pigments, the penetration of the light into the composite resin becomes lessened. This will lead to decreased degree of polymerization. Composite resins with darker color require longer curing time to obtain higher strength values.[16]

Conclusions

Within the limitations of this study, it can be concluded that curing time and color shade can affect the diametral tensile strength. Increasing the duration of curing can increase the diametral tensile strength of bulk-fill composite resin. The brighter color shade bulk-fill composite resin has a higher diametral tensile strength than the darker color shade.

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