Effect of Different Light-Curing Sources on Diametral Tensile Strength of Bulk Fill Composite Resins

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Abstract

There are two common sources of light curing used to polymerize composite resins, the LED (Light Emitted Diode) and the QTH (Quartz Tungsten Halogen). This study aimed to evaluate the effect of using different light curing sources on diametral tensile strength of bulk fill composite resins. Three commercial bulk fill composite resins, Tetric N-Ceram Bulk Fill (Ivoclar-Vivadent, Liechtenstein, Germany), Beautifil-Bulk Restorative® (Shofu, Japan), and Filtek ™ Bulk-Fill (3M-ESPE, USA) were used to make disk specimens (6 mm in diameter, 3 mm in thickness) divided into two different polymerized groups (n=10), with LED for 20s and QTH for 40s light curing sources. Diametral tensile strength was tested using a Universal Mechanical Testing Machine (Shimadzu, Japan). Data were analyzed using one way ANOVA and Bonferonni post hoc tests. The results showed that diametral tensile strength mean value of all bulk fill composite resins polymerized using LED source were higher than QTH. There was no statistically difference between the group polymerized using LED and QTH ($p \geq 0.05$), except in Filtek ™ Bulk-Fill group ($p = 0.012$). It can be concluded that different light-curing sources can influence the polimerization effect of Bulk-Fill composite resin in their diametral tensil strength properties.

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Introduction

Composite resin (including bulk fill composite resin) polymerization requires a light source that can increase the conversion of monomers, so that the restorations will have good physical, chemical and mechanical properties.[1-3] Degree of polymerization depends on light intensity, wavelength and irradiation time of light curing unit.[1-3] The most common light sources used in dentistry are Quartz-Tungsten-Halogen (QTH) and Light-Emitting Diodes (LED). The QTHs have a wavelength between 400-500 nm which must pass through a filter to obtain a narrower wavelength range.[2,3] The LEDs have approximately the same wavelengths between 450-490 nm, but LEDs do not require filters and do not produce heat as large as QTH light source.[2-4]

LEDs are considered to be more efficient than QTHs because the wavelength range of the LEDs more closely match the camphoroquinone absorption spectrum of the composite resin.[3, 4] Since there are wide range of light curing units available on the market as an option for composite resin polymerization, it is certainly a challenge for clinical practitioners to choose the right light curing unit to increase the mechanical properties of composite resin. An important mechanical properties which is the diametral tensile strength, can simulate load of mastication. The aim of this study was to examine the effect of different types of light curing unit light source (QTHs or LEDs) on the diametral tensile strength of bulk-fill composite resins.

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Materials and methods

Specimens of Tetric N-Ceram Bulk Fill (Ivoclar Vivadent, Lichstenstein), Beautifil Bulk Restorative® (Shofu, Japan), and Filtek™ Bulk-Fill (3M-ESPE, USA) were used in this study (Table 1). Disk-shaped specimens (diameter 6 mm and thickness 3 mm) according to ADA Specification No. 27/1993 were made with a total of 60 specimens.

Bulk-fill Composite Resins and Manufacturers	Monomers	Fillers	Filler wt.%
Tetric® N-Ceram Bulk Fill (Ivoclar Vivadent, Liechtenstein, Germany).	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
Beautifil-Bulk Restorative® (Shofu, Japan).	Bis-GMA, UDMA, Bis-MPEPP, TEGDMA.	S-PRG filler based on F-B-Al-Si-glass (0.8 μm).	87.0
Filtek ™ Bulk-Fill (3M-ESPE, USA).	AUDMA, Bis GMA, AFM, DDDMA, UDMA.	agglomerate 100 nm Ytterbium trifluoride (YbF3), combination of a non-agglomerated/non-aggregated 20 nm silica, non-agglomerated/non-aggregated 4 to 11 nm zirconia, aggregated zirconia/silica cluster (comprised of 20 nm silica and 4 to 11 nm zirconia particles).	76.5

Table 1. The bulk-fill composite resin materials.

The specimens were then divided into 2 groups of light source with each group consisted of 3 different composite resin (n=10 specimens). The first group was polymerized using QTH light curing unit (400 mW/cm2, Litex® 680A Dentamerica, USA) for 40 seconds, and the second group polymerized with LED light curing unit (800 mW/cm2, Hilux Ledmax 450, Dentaurum, Germany) for 20 seconds, with the tip of light curing unit in contact to the composite resin through a mylar strip. All specimens were stored in distilled water for 24 h at 37°C. The specimens were tested using Universal Mechanical Testing Machine (Shimadzu AG-5000, Japan) with load cell of 250 kgf and crosshead speed 0.5 mm/minute. The data obtained were analyzed by One-way ANOVA and Post-hoc Bonferonni tests.

Results

The mean value of diametral tensile strength of the bulk-fill composite resins polymerized with QTH and LED light sources were shown (Table 2). There are no significant differences among all materials polymerized with QTHs (*P* value ≥ 0.05) (Table 3) and no significant differences within materials polymerized with LEDs (*P*-value ≥ 0.05) (Table 4). There are no significant differences of diametral tensile strength mean values between materials polymerized with QTHs and LEDs, except in Filtek ™ Bulk-Fill (*P* value < 0.05) (Table 5).

	Materials	N	Mean (MPa) ± SD
QTHs	Tetric® N-Ceram Bulk Fill	10	38,63 ± 2,37
	Beautifil-Bulk Restorative®	10	39,12 ± 1,79
	Filtek ™ Bulk-Fill	10	38,93 ± 2,78
LEDs	Tetric® N-Ceram Bulk Fill	10	42,03 ± 3,22
	Beautifil-Bulk Restorative®	10	41,90 ± 2,96
	Filtek ™ Bulk-Fill	10	43,50 ± 3,74

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

Materials	Tetric® N-Ceram Bulk Fill	Beautifil-Bulk Restorative®	Filtek ™ Bulk-Fill
Tetric® N-Ceram Bulk Fill		*	*
Beautifil-Bulk Restorative®	*		*
Filtek ™ Bulk-Fill	*	*	

Table 3. Significance of diametral tensile strength of bulk-fill composite resins polymerized with QTHs. * *P* value ≥ 0.05

Materials	Tetric® N-Ceram Bulk Fill	Beautifil-Bulk Restorative®	Filtek ™ Bulk-Fill
Tetric® N-Ceram Bulk Fill		*	*
Beautifil-Bulk Restorative®	*		*
Filtek ™ Bulk-Fill	*	*	

Table 4. Significance of diametral tensile strength of bulk-fill composite resins polymerized with LEDs. **P* value ≥ 0.05

LEDs QTHs	Tetric® N-Ceram Bulk Fill	Beautifil-Bulk Restorative®	Filtek ™ Bulk-Fill
Tetric® N-Ceram Bulk Fill	*		
Beautifil-Bulk Restorative®		*	
Filtek ™ Bulk-Fill			**

Table 5. Significance of diametral tensile strength of bulk-fill composite resins polymerized with QTHs and LEDs. **P* value ≥ 0.05, ***P* value < 0.05

Discussion

Diametral tensile strength is a mechanical property used to determine the properties of brittle material when exposed to tensile stress.[5] The diametral tensile strength becomes an important indication of the ability of restoration material to retain tensile stress produced during mastication process.[5] In this study, the mean values of diametral tensile strength of all materials with both light sources were in the range of 36-47 MPa which is in accordance with American Dental Association Specification No. 27/1993 that requires at least 24 MPa.[4,5] The results of this study were higher than the requirement of ADA Specification No. 27/1993.

In this study, materials which were light-cured with QTH used lower irradiancy of 400 mW/cm^2 for 40s, while the materials light-cured with LED used irradiancy of 800 mW/ cm^2 for 20s. The low irradiance can be offset by increasing curing time, whereas the higher irradiance needs shorter curing time to obtain optimal depth of cure of the composite resins.[6,7] It is shown that there is no statistically differences of diametral tensile strength mean values among materials polymerized with QTH, as well as with LED. The energy density of the light curing unit is calculated by multiplying the irradiance with curing time and was expressed in J/cm^2.[1,2,8] Both energy density produced by QTH and LED light source were 16 J/cm2. Clinical success of the restorations were determined by the polymerization of the composite resins. If polymerization is inadequate, various clinical conditions such as discoloration, pulp irritation and restoration failure may occur.[1,2] Transmission of light is influenced by light intensity, absorption, and scattering through filler particles and opacifiers and these factors are related to the degree of conversion and mechanical properties of the material.[1,2]

The mean values of diametral tensile strength of materials light-cured with LED were higher than those with QTH. This is in line with previous study reported that diametral tensile strength, flexural strength and hardness on composite resins light-cured with LED were higher than those of QTH.[4] In addition, other studies also showed that conventional composite resins light-cured with LED were harder than QTH.[9,10] Composite surface hardness has a positive correlation with its strength. The hardness of a material is related to the ability of the restoration to maintain its shape stability. Thus, if a restoration material has low hardness, the restoration will be easily deformed and fractured when excessive load is applied.

The QTH light source has a wider spectrum of 400-500 nm.[11] The efficiency of QTH light source in converting the energy into light is low so that it needs a filter to reduce the heat generated and to get a narrower wavelength range.[12] Only a fraction of the total energy can be converted into light and resulting in inadequate polymerization results.[6] Different from QTH, LED light source has a narrower wavelength range of 450-490 nm with a peak wavelength of 470 nm that is more suitable with camphoroquinone absorption of 468 nm.[6]

LED light source does not require filters to produce blue light and the energy converted into light is more efficient resulting less heat.[11, 13] The more appropriate wavelengths produced by the light curing unit with the peak absorption of camphoroquinone will further maximize the absorption of photons.[14] The larger the number of photons absorbed by the composite resin, the greater the number of camphoroquinone molecules excited and reacting with the amine to produce free radicals thus forming longer polymer chains.[8] Increased degree of conversion is associated with enhanced mechanical properties of composite resins.[10]

Comparison of both diametral tensile strength of all materials light-cured with QTH and LED showed no statistically differences except in Filtek™ Bulk-Fill. The matrix and filler composition of Filtek™ Bulk-Fill is complex. As shown in Table 1, the filler content of Filtek™ Bulk-Fill (Ytterbium trifluoride filler agglomerate (YbF3) and a combination of non-agglomerated /non-aggregated silica fillers, non-agglomerated/non-aggregated zirconia, and nanoparticle-aggregated zirconia/silica clusters) resulted larger filler loading, and lower viscosity of matrix monomers which can increase the degree of polymerization and produced higher mechanical properties.[2,15]

Conclusions

Within the limitation of this study, it can be concluded that the bulk fill composite resins light-cured with LED light source has higher diametral tensile strength than using QTH, although not statistically different.

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