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Original Study

Comparative evaluation of curing light intensity on depth of cure of bulk fill and conventional composites - in vitro study

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ABSTRACT

Introduction

Due to its superior looks and qualities, direct composite resin restorations have grown in popularity in modern dentistry treatment. The posterior bulk fill composites Filtek TM Bulk Fill Posterior and X-tra fil are said to achieve a 5 mm depth of cure with good strength. The depth of cure of commercially available packable bulk fill composites has not been adequately studied in the literature.

Aim

To determine how different curing light intensities affect the curing depth of bulk fill and traditional composite.

Materials and methods

Two packable bulk fill (Filtek Bulk Fill and X-tra fil) composites and a conventional composite (Tetric N Ceram) were used in the study and were divided into three groups and were cured using two light cure units having different light intensities (LED and QTH units). A total of 120 composite specimens were prepared. Depth of cure was evaluated using B/T ratio of Vickers hardness number.

Results

The hardness values of top and bottom surface values ranged between 49.9 to 99.7 VHN. The Filtek bulk fill composite cured with LED unit showed the maximum and B/T ratio which was significantly higher than Tetric N Ceram composite cured with QTH unit which showed the least B/T ratio ($p<0.05$)

Conclusion

The depth of cure of bulk fill composites is significantly influenced by the type of curing light used. The bulk fill composites employed in this investigation displayed a suitable B/T ratio of more than 0.80 suitable for clinical application.

***Keywords:** Bulk fill composites, Depth of cure, Vickers micro-hardness, Curing light intensity, B/T ratio*

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INTRODUCTION

Direct composite resin restorations are more popular in current day dental practice and are the restorative material of choice for most dentists and patients mainly due to its increased aesthetics and high strength. However, restoring deep cavities of posterior tooth with conventional composite requires an incremental build-up technique for adequate polymerization of the resin.[1] This method is time consuming with a possibility of air entrapment amid layers and contamination of composites which could lead to failure of the restoration.[2] Lately bulk fill composites have been introduced with a simplified procedure to speed up the restoration process and to overcome the potential drawbacks associated with the conventional composites. The manufacturers of these bulk fill composites claim that it can be placed at thickness of 4 to 5mm and light polymerized at a single stroke.

The depth of cure of composites is an important parameter which relates to the amount of monomer that gets converted to polymer. It directly translates to the mechanical properties, chemical stability, and longevity of the restoration.[3] The depth of cure of resin-based composites is greatly influenced by the intensity of the light cure unit. It can be measured by direct methods such as resonance imaging, Raman spectroscopy and indirect methods such as micro hardness test, scrapping method.[4]

Filtek™ Bulk Fill Posterior (3M, ESPE, USA) and X-tra fil (VOCO, Germany) are packable bulk fill composites that provide excellent strength and is claimed to achieve 5 mm depth of cure. Tetric N Ceram (Ivoclar Vivadent) is a conventional and globally used resin-based composite.
There is very little evidence available in the literature evaluating the depth of cure of commercially available packable bulk fill composites with conventional composites polymerized with different light intensities. This study aims to evaluate the effect of curing light intensity on the depth of cure of bulk fill and conventional composites.

MATERIALS AND METHODS:

Institutional ethical committee approval was obtained from SRM University (684/IEC) for the study

a) Materials Used:

For the investigation, three groups of one conventional composite and two packable bulk fill composites (shade A2) were created.

Table 1 : Composition

S NO	COMPOSITE	COMPOSITION	LOT NUMBER
1.	GROUP A Filtek Bulk Fill (3M ESPE, USA)	AUDMA, UDMA, 1,12 Dodecane DMA, Ytterbium Tri fluoride, Zirconia Nano clusters	N614236
2.	GROUP B X-tra fil (VOCO, Germany)	BIS GMA, UDMA, TEGDMA, Inorganic fillers	1506117
3.	GROUP C Tetric N Ceram (Ivoclar Vivadent, Schaan)	UDMA, Bis-GMA, Ethoxylated Bis-EMA, Barium glass, ytterbium trifluoride	Z010VF

The composite groups were further divided into two sub groups which were cured using two light cure units having different light intensities. The light intensities of the curing unit were measured using a Radiometer at the commencement of the study.

SUB GROUP A: QTH unit (Dentsply, Intensity- 450 mW/cm^2)
SUB GROUP B: LED Blue phase (Ivoclar Vivadent, Intensity- 850 mW/cm$^{2)}$

Overall, 120 composite specimens were organized and divided into three groups of 40 samples each, based on the composite used. They were further divided into sub group A and sub group B based on the curing unit employed (n=20) for polymerization.

b) Composite sample preparation

A split stainless steel cylindrical jig measuring 4mm*4mm was used to prepare the composite cylinders. At the bottom of the composite mold mylar strip was placed and composite was condensed to fill the mould using a Teflon coated composite instrument. Using Mylar strip and a glass slide to close the top of the mould, light polymerization was performed by means of an LED unit (Bluephase N®; Ivoclar Vivadent, Schaan, Liechtenstein at 850 mW/cm2 (high curing light intensity) and a QTH unit (Dentsply Maillefer at 450 mW/cm2 (low curing light intensity) for 20 seconds. The light tip was held in contact with the glass (Fig 1).

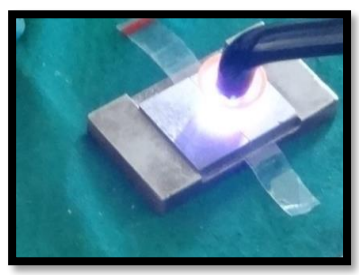

Fig 1- Mylar strip used to ensure smooth surface of the specimen.

Power intensity of the light cure unit was measured using a dental radiometer (Bluephase® meter; Ivoclar Vivadent, Schaan, Liechtenstein) for each group before polymerization. Subsequent to polymerization each specimen was detached from the mould and stored in light proof container having distilled water for 24 hours at room temperature[5,6]. The samples were aged in a thermo-cycler for 1500 cycles at 5°C and 55°C with a 10 second drip duration after storage.

c) Vickers Hardness testing:

Vickers micro hardness testing of the samples was done at SRM University, Chennai. The top and bottom Vickers micro hardness values were assessed using Vickers micro hardness testing machine (VMT-X). A Vickers diamond intending tool was applied three times with a load of 300 gm. at the top and bottom of each sample with a dwell time of 10 seconds. The hardness values were calibrated by the machine in VHN units. The same machine was used to check and measure the indentation at 40× magnification (fig 2).

At three points on each specimen the surface Vickers hardness was measured to minimize measurement errors within the specimen. The three-measurement micro hardness values on the bottom and top surfaces were averaged to attain a solitary value of Vickers micro hardness for that specimen.

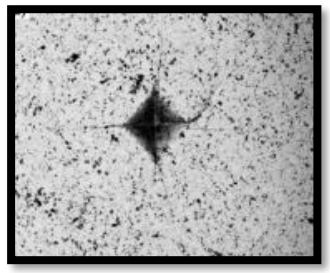

Fig 2- Indentation at 40× magnification measured using Vickers micro hardness testing machine

Vickers hardness of material is given by the formula-
(VHN) = (1.8544P)/D where VHN is the Vickers hardness of the material (kg/mm 2), P is the fixed load (kg) applied to the sample, and D is the average diagonal distance (mm) of the square produced by the indentation of the pyramid tip of the Vickers hardness tester5, 7, which was calibrated by the device.

STATISTICAL ANALYSIS:

For the samples of each group, the mean and standard deviation values were determined. One-way analysis of variance was applied to compare the mean values between the various study groups, and Tukey's honest significance difference test was used afterward (HSD). Using SPSS software, the level of significance was set at P <0.05. (SPSS 17.0 software, SPSS Inc. Chicago).

RESULTS:

The results of the study are shown in Table 2.

Table 2: Results

GROUP/ SUB GROUPS	**Sub Group A (QTH)**			**Sub Group B (LED)**		
	(Hardness Values in VHN)					
	Top hardness	Bottom hardness	B/T Ratio	Top hardness	Bottom hardness	B/T Ratio
Group A (Filtek Bulk fill)	64.2±1.2	56.5±0.9	0.88	99.7±1.0	92.3±0.9	0.92
Group B (X-tra fil)	61.1±0.7	54.2±1.0	0.85	96.4±1.2	85.9±1.0	0.89
Group C (Tetric N Ceram)	63.2±0.8	49.9±1.1	0.77	97.8±09	80.0±1.1	0.82

Group A (Filtek Bulk fill) displayed the highest bottom and top hardness values among the three test groups. Both Group A and Group B's B/T values for Group C were considerably lower (P 0.05). In terms of B/T values, there was no statistical difference between Group A and Group B. Subgroup B (LED curing unit) had noticeably greater bottom and top hardness values than Subgroup A (QTH units) for both groups of the two test subgroups (p 0.05). The hardness values of top and bottom surface values ranged between 49.9 to 99.7 VHN. The Filtek bulk fill composite cured with LED unit showed the maximum VHN and B/T ratio and Tetric N Ceram composite cured with QTH unit which showed the least VHN and B/T ratio. All test groups showed clinically acceptable B/T ratio of more than 0.80 except Tetric N Ceram cured with QTH units.

DISCUSSION

Mechanical qualities of restorative materials are important predictors of the clinical longevity of a repair. The depth of cure of bulk fill composites as it relates to the quantity of unpolymerized resin remaining after polymerization was one of these parameters that was studied in the current investigation[8]. The two packable bulk fill composites employed in the investigation, as well as a conventional composite, are directly compared in this study for the first time. This comparison highlights the 4mm depth of cure of bulk fill composites above traditional composites.

Manufacturers of bulk fill composites claim that it can be light cured to a depth of 4 to 5 mm. This increased depth of cure of composites could be attributed to resin chemistry of composites along with intensity of curing unit employed for curing composite.[6-8] Generally, the filler size of these bulk composites is increased up to 20µm over conventional composites which decreases the overall volume of the fillers in the composites. Consequently, the amount of light scattering that occurs at filler matrix interface is reduced enabling more light to be transmitted to deeper sections of composite and thereby increasing depth of cure than conventional composites.

Most of the current bulk fill composites employ Benzoyl germanium (Ivocerin and Lucerin) as co-photo initiators apart from Camphoroquinone which is used in conventional composites. This enables better light penetration through deeper sections of bulk fill composites and thereby facilitating better depth of cure at deeper sections. According to Lima et al Ivocerin is categorized as type 1 photo initiator and does not require any co initiator for curing. Ivocerin has greater reactivity which is useful while curing large volumes of composite.

In the current study both bulk fill composites had a relatively similar resin matrix system (BISGMA, TEGDMA, and UDMA). However, the difference in hardness values between two composites for same curing light could be attributed to the filler composition, volume, and size.[9-11]Translucency of bulk fill composites is another factor, as more opaque the composites, light penetration to deeper sections get restricted[11]. Hence most of the bulk fill composites are available in translucent shades. In the current study all composites were A2 shade.

Stainless steel jigs were used in this study. As stainless steel is an opaque metal, it does not transmit light, like ceramic or other polymeric materials. Studies that used Teflon molds reported exaggerated depth of cure values as light could be transmitted through Teflon. The depth of cure of bulk fill composites has been assessed using a variety of laboratory techniques in the literature. Surface hardness tests as the ISO 4049 scraping method, Vickers micro-hardness test, Knoop Hardness test, and Raman spectroscopy and Fourier transform infrared spectroscopy can be used to detect it indirectly (FTIR). Micro hardness is a proximate indicator of how much a material has been converted. When the depth of polymerization (curing) is assessed on the bottom and top surfaces of a specimen, information is provided by all these tests. The scraping method ISO 4049 is the commonly used test that supports scraping of the unset materials, directly after light polymerization, and gauging the length of the set specimen. Flury et al. in his study stated that ISO 4049 scraping method misjudged the depth of cure as related to the Vickers hardness testing[12, 13]. Therefore, in the present study Vickers micro hardness method was advocated to evaluate the depth of cure.

In the current study Filtek bulk fill showed higher hardness values for both bottom and top surfaces compared to X-tra fil and Tetric N Ceram. This may be credited to the superior resin chemistry and increased filler particle dimension of Filtek bulk fill composites. The study findings are in accordance with previous study by Kelic et al.[14, 15]

In the current study, composites cured using LED curing units showed higher hardness values than composites cured with QTH group. This may be reasoned to the increased light intensity emitted by LED units. The light intensity used by QTH lamps, according to Lima et al., may be adequate to polymerize a 2 mm increment of conventional composite resin, but it appears insufficient to polymerize bulk fill composites. Also, to be noted that in the current study employed LED curing light with poly-wave technology which is sensitive to wider range of photo initiators than QTH was used.[10,16]

The current study's findings supported a prior study by Zorzin et al. that found a stronger impact of curing light intensity on the polymerization characteristics of composites. Two curing light intensities were employed in his investigation to assess the mechanical properties of four bulk-fill composites that were commercially available. It was determined that when curing these composites, enough energy must be released to cure fully at a depth of 4 mm.[17–19] All trial groups, apart from the Tetric N Ceram treated with QTH units [20], displayed a clinically acceptable B/T ratio of 0.8.

The limitations of the study include that only one shade (A2) composite was evaluated. The results obtained cannot be generalized to other shades of bulk fill composites. The study was carried out under laboratory conditions which do not mimic the mimic the oral environment. Future studies can be performed under in vivo conditions to get more reliable results.

CONCLUSION

Within the constraints of the investigation, the subsequent inferences can be drawn:
1) The type of curing light used significantly affects the depth of cure of bulk fill composites.
2) The bulk fill composites (Filtek bulk fill and X-tra fil) employed in the current study demonstrated appropriate B/T ratios of greater than 0.80 suitable for clinical application.
3) Additional research is necessary to assess these materials in clinical settings using various composite colours.

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Conflicts of interest - There are no conflicts of interest.

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