The Effect of LED Light on Depth of Cure and Microhardness of Three Types of Bulkfill Composite

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ABSTRACT

Background: To evaluate the ISO depth of cure of bulkfill composites and depth of cure which determined by Vickers microhardness test.
Materials and Methods: Bulkfill resin composite specimens (n=150) were prepared of three bulkfill composite materials (TetricEvo Ceram, Quixfil and SDR) and light cured by Flash max p3 for 3, 10, 20 seconds and by wood pecker for 10, 20 seconds respectively, a mold was filled with one of the three bulkfill composites and light cured. The specimens removed from the mold and scraped by plastic spatula and the remaining length (absolute length) was measured which represent the ISO depth of cure. After that the specimens were returned into the mold and a microhardness indentation device applied on the specimen and hardness measurements (Vickers hardness, VHN) were made at defined distance, beginning at the resin composite that had been closest to the light curing unit (i.e. at the top) and proceeding toward the uncured resin composite (i.e. toward the bottom) on the basis of the VHN measurement, Vickers hardness test generated for each group.
Results and Conclusion: ISO depth of cure of bulkfill composite materials is time and type of light curing protocol dependent rather than type of material of bulkfill composite while the depth of cure determined by Vickers hardness number is material dependent in addition to the light curing protocol.
Key words: Bulkfill composite light curing intensity, depth of cure. (J Bagh Coll Dentistry 2016; 28(1):36-40).

INTRODUCTION

Adequate polymerization is a crucial factor in obtaining optimal physical performance to improve the clinical performance of resin composite materials [(1)].

However, it is common sense that incomplete polymerization of composite restorations is one of the major clinical problems to be overcome because since inadequate resin activation compromises the restoration both mechanicallydegree of conversion of the resin composite material at increasing distance from the irradiated surface. When restoring cavities with light-curing resin composites, it has therefore been regarded as the gold standard to apply and cure the resin composite in increments of limited thickness has been generally defined as 2mm [(2)].

To achieve successful direct posterior composite restorations, the layering technique was the necessary procedure, requiring competence, proficiency and dexterity, a complex and sensitive technique procedure, one inadequately placed layer could result in an otherwise successful restoration and developing microleakage, causing postoperative sensitivity and leading to secondary caries [(3)].

Restoring cavities, especially deep ones, with resin composite increments of 2mm thickness is time-consuming and implies a risk of incorporating air bubbles or contaminations between the increments.

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Thus, various manufacturers have introduced new types of resin composites, so-called "bulk fill" materials, which are claimed to be curable to a maximal increment thickness of 4 mm (TetricEvo Ceram Bulk Fill Press Release. Ivoclar Vivadent, 2011). The manufacturers claimed that bulk fill materials can achieve a depth of cure of 6 mm (Venus bulk fill Technical Information 2011).

Although there have been numerous investigations of resin composites cured with LEDs, the results were varied considerably, probably because of the multiplicity of test configurations, the individual characteristics of each commercial unit and the assumption and approximations integrated into the experimental methodologies. Therefore, it is important to obtain additional data on the performance of newly developed LEDs with light intensities higher than 1000 mW/cm^2 [(4)] and biologically.

The non-polymerized components may influence the material's chemical stability, increasing it's susceptibility to degradation and leading to release of byproducts, such as formaldehyde and acid methacrylates, which increases the possibility of pulpal adverse reactions and decrease the wear resistance and color stability [(1)]. Energy of the light emitted from a light-cured unit decreases drastically when transmitted through resin composite leading to a gradual decrease in the current study was carried on three types of bulk fill composites to evaluate the performance of high power LED curing units in comparison to low power LED curing unit by using parameter related to photopolymerization such as hardness measurement by Vickers hardness number (VHN). The depth of cure also determined by the ISO 4049 method. Hardness measurement is a practical method to indirectly determine degree of conversion for a given resin composite, hardness profiles can be used to alternatively measure depth of cure which determined by the ISO 4049 method which was accurately reflected with bulk fill materials when compared to depth of cure determined by Vickers hardness number [5].

MATERIALS AND METHODS

Three bulkfill resin composites (Quixfil, TetricEvo Ceram and SDR) were used for evaluating the depth of cure by ISO and by Vickers hardness test (table 1). All bulkfill composites cured by LED (Flash max p3) with light power density 1600 mW/cm² for 3,10 and 20 seconds respectively and by LED (Wood pecker) with light power density 800 mW/cm² for 10 and 20 seconds respectively.

Depth of Cure by ISO 4049

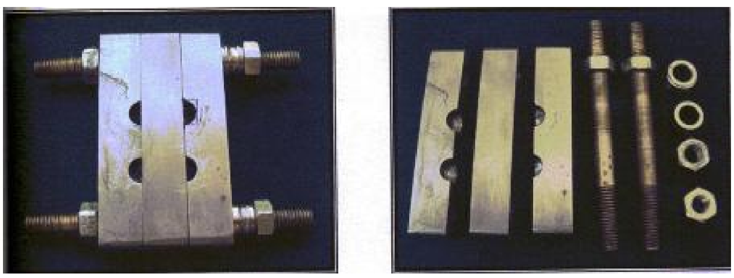
Depth of cure by ISO 4049 was performed with re-usable stainless steel molds according to ISO 4049:2000. The mold was filled in bulk with one of the three resin bulkfill composite then the top side of the mold was covered with a transparent strip and covered by glass slide which gently pressed under a load of 200 g for 1 minute. The glass slide was removed and the bulkfill resin composite was irradiated from the top through the celluloid strip in a way that the distal end of the light curing device tip was held in contact to the celluloid strip and the center was coincident with the long axis of the specimen. After light curing the specimens were pushed out of the mold and the uncured resin composite material was removed with a plastic spatula. The absolute length of the specimen of cured resin composite was measured with a caliper. The absolute length was divided by two and the latter value recorded as the ISO depth of cure.

Depth of Cure by Vickers Hardness Test

Specimens positioned within the mold and divided in 1 mm incremental depth with the caliper gauge of Vickers hardness tester. The hardness test was performed with the digital Vickers microhardness tester (TH 715) Beijing Time high technology. The specimens positioned beneath the indenter of the microhardness tester with a load 200g for 15 sec.

Table 1: Resin Composites Used

Resin composites	Type of resin composite (according to manufacturer)	Maximum increment thickness (mm) (according to manufacturer)	Shade	LOT-number
Quixfil Dentsply DeTrey GmbH Konstanz Germany	Posterior restorative	4	Universal	1307000933
Tetric EvoCeram Bulk Fill Ivoclar Vivadent, Schaan, Liechtenstein	Moldable posterior composite for bulk-filling technique	4	IVA	14900
SDR Dentsply Caulk, USA	Posterior bulk-fill flowable base	4	Universal	140326



a. Assembled **b. Apart**

Figure 1: The Metal Mold Used in the Present Study

RESULTS

The results show all types of bulkfill composite resin used in the study cured by Flash max p3 for 20 sec. pass ISO depth of cure while other groups did not pass.The results shows the highest VHN obtained for all types of bulkfill composites with high intensity LED (Flash max p3) for 20 seconds and the lowest VHN for all types of bulkfill composites with high intensity for 3 seconds.

The result also shows that the Quixfil bulkfill composite has the VHN value with all types of LED light curing protocol at all intervals.

ANOVA test used in this study showed high significant difference between groups.

After (ANOVA) LSD test revealed that curing with Flash max p3 for 20 seconds with all types of bulkfill composites used in this studyhave highest depth of cure ISO with high ANOVA analysis shows high significant difference between groups.

After (ANOVA) LSD test reveal that flash max p3 for 20 seconds shows the highest microhardness mean values with high significant difference in comparison to other groups of light curing protocol.

DISCUSSION

All types of bulkfill composites (TetricEvo Ceram, Quixfil and SDR) when cured with high intensity (Flash max p3) for 20 seconds pass the ISO 4049 and can be accepted because it has depth of cure ISO 3.5 mm which can be considered as acceptable value because the manufacturer stated that 4 mm depth as an acceptable depth and according to the ISO 4049 the depth of cure should be no more than 0.5 mm below the value stated by the manufacturer (ISO 4049) [(6)].

The depth of cure was affected by intensity and time of light curing protocol rather than the type of composite material because all composite material (TetricEvo Ceram, Quixfil and SRD) for each type of light cure intensity and time show the same depth of cure with for each type of light cure protocol used in this study. Therefore, the intensity of light cure and irradiation time are two factors affecting the depth of cure by ISO 4049 rather than type of composite material.

The high intensity light is necessary for complete polymerization and optimal mechanical properties [(7)]. The polymerization time of 20 seconds and bulk placement up to 4 mm can be recommended [(8)]. There is an adequate polymerization at the depth of 4 mm when bulkfill composite materials are used [(9)]. The doubling of curing time from 10 sec. to 20 sec. led to an average increase in ISO depth of cure of 17% [(6)] significance in comparison to other groups of light curing protocol.

Vickers hardness number (VHN) for TetricEvo Ceram bulkfill composite shows that Flash max p3 light curing for 20 seconds reveal highest microhardness mean values at all depth intervals followed by Flash max p3 for 10 seconds, Wood pecker for 20 seconds, Wood pecker for 10 seconds and Flash max p3 for 3 seconds respectively.

ANOVA analysis shows high significant difference between groups.

After (ANOVA) LSD test reveal that flash max p3 for 20 seconds shows the highest microhardness mean values with high significant difference in comparison to other groups of light curing protocol.

Vickers hardness number (VHN) for Quixfil bulkfill composite shows that Flash max p3 light curing for 20 seconds reveal highest microhardness mean values at all depth intervals followed by Flash max p3 for 10 seconds, Wood pecker for 20 seconds, Wood pecker for 10 seconds and Flash max p3 for 3 seconds respectively.

ANOVA analysis shows high significant difference between groups as shown in 4. After (ANOVA) LSD test reveal that flash max p3 for 20 seconds shows the highest microhardness mean values with high significant difference in comparison to other groups of light curing protocol.

Vickers hardness number (VHN) for SDR flowable bulkfill composite shows that Flash max p3 light curing for 20 seconds reveal highest microhardness mean values at all depth intervals followed by Flash max p3 for 10 seconds, Wood pecker for 20 seconds, Wood pecker for 10 seconds and Flash max p3 for 3 seconds respectively.

The bulkfill composite exhibit acceptable to high curing at the deepest portion of 4 mm increment and this showed that bulkfill material met the requirement stipulated in the ISO 4049 specification with light curing time 20 seconds[(10)].

There was a decrease in the microhardness mean value of all bulkfill composites used in this study with increasing depth despite the curing protocol. This may be probably attributed to the fact that the light cure intensity was greatly reduced while passing the bulk of the composite resin due to light scattering and absorptions decreasing polymerization effectiveness which lead to decreasing in the microhardness value at every depth of each material cured with different light curing protocol used in this study. The microhardness of the composites will reduce with increasing depth of resin as useable curing light intensity and wavelengths are attenuated in the resin and less camphorquinone will be activated[11].

The degree of cure of visible light activated dental resin is strictly dependent on the characters of the curing light. A curing light intensity output depends on many factors including light guide, condition of the bulb and battery power [12].

Energy of the light emitted from a light-curing unit decreases drastically when transmitted through resin composite leading to a gradual decrease in degree of conversion of the resin composite material at increasing distance from the irradiated surface [10].

The increase in radiant energy led to a significant increase in microhardness and depth of cure [13].

The narrow light spectrum of LEDs, with a peak intensity at 465-475nm, better fits the absorption peak of camphorquinone where LED units should be more efficient in curing activation. Where the transmittance of light through composites is wavelength-dependent, where the longer wavelength penetrates composite more deeply than do shorter ones and therefore result in greater curing depth [14].

The increased in curing intensity leads to a better conversion rate, assuming that the spectrum of the curing unit, irradiation time and light-guide tip diameter are very similar [15].

It is better to use high intensity curing mode to improve the physical properties of the composite[16].

The light intensity which was lower than 280 mW/cm² could not activate enough initiator molecules to start an adequate reaction [17]. The photopolymerization reaction of resin monomer is diffusion controlled after the gel point. Therefore after a critical threshold of light intensity-which is necessary for the initiation of the polymerization reaction in a resin composites- the gel point is reached in the first few seconds and any further increase in light intensity does not significantly enhance the degree of conversion [18].

Microhardness is dependent on depth of cure which is related to size of the incorporated fillers. The filler particles in the resin based composites scatter light. This scattering effect is increased as the particle size of the fillers in the composite approaches the wavelength of the activating light and will reduce the amount of light that is transmitted through the composite where the material with the smallest filler particle size (0.19-3.3µm) showed the highest values of overall light transmittance for all filler content, where as those with the large sized filler (0.04-10 µm) showed lower light transmittance for all filler contents [19].

On the other hand, materials with smaller filler particle size showed sharper angular distribution of diffuse light, indicating that less light scattered within the material. As light scattering is expected to increase with increasing filler particle diameter, the larger scattering causedby larger fillers thus resulted in higher transmittance loss in comparison with materials containing smaller filler particles [19].

In addition, other characteristics of the material may have contributed to these results, such as the organic matrix composition, as the polymerization level varies according to the amount of the monomer present in the composite resins [20]. The increase in time of cure of Flash max p3 and Wood pecker from 10 seconds to 20 seconds gives higher microhardness values and greater depth of cure for all types of bulkfill composites while the high intensity with short curing time (Flash max p3 for 3 seconds) revealed lowest microhardness value in comparison to other groups of light curing protocol.

The increase in irradiation time from 10 to 40 seconds at the surface the hardness increase from 70 to 110 VHN which it is related to increase the degree of conversion and the depth of cure by 1.5 fold due to decrease the irradiation with depth [21]. The depth of cure of composite resins is mainly dependent on exposure time of the light source to the composite resin [22].

The reduction of photoactivation time when use light curing units with high intensity such reduction of photoactivation time is based on the total radiant exposure concept that a certain dose (irradiance x time) of light is needed to adequately cure a specific material where the high irradiance combined with a short photoactivation time may reduce the degree of cure and the kinetic chain length and increase the frequency of cross-linking [23].

The insufficient curing light with very high intensity is likely to happen when too short an irradiation time is used because it is under higher irradiation the life time of free radicals is shorter[24].

The bulk fill composites exhibit acceptable to high curing at the deepest portion of a 4 mm increment and this showed that bulk fill materials met the requirements stipulated in the ISO 4049 specification even with a light curing time as short as 20 seconds [10]. The increased irradiation time resulted in an increase in hardness mean values [25].

As conclusion; depth of cure of bulkfill composite by ISO 4049 is irradiation condition dependent rather than type of the material while microhardness value of the bulkfill composite is irradiation condition and type of the material dependent.

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